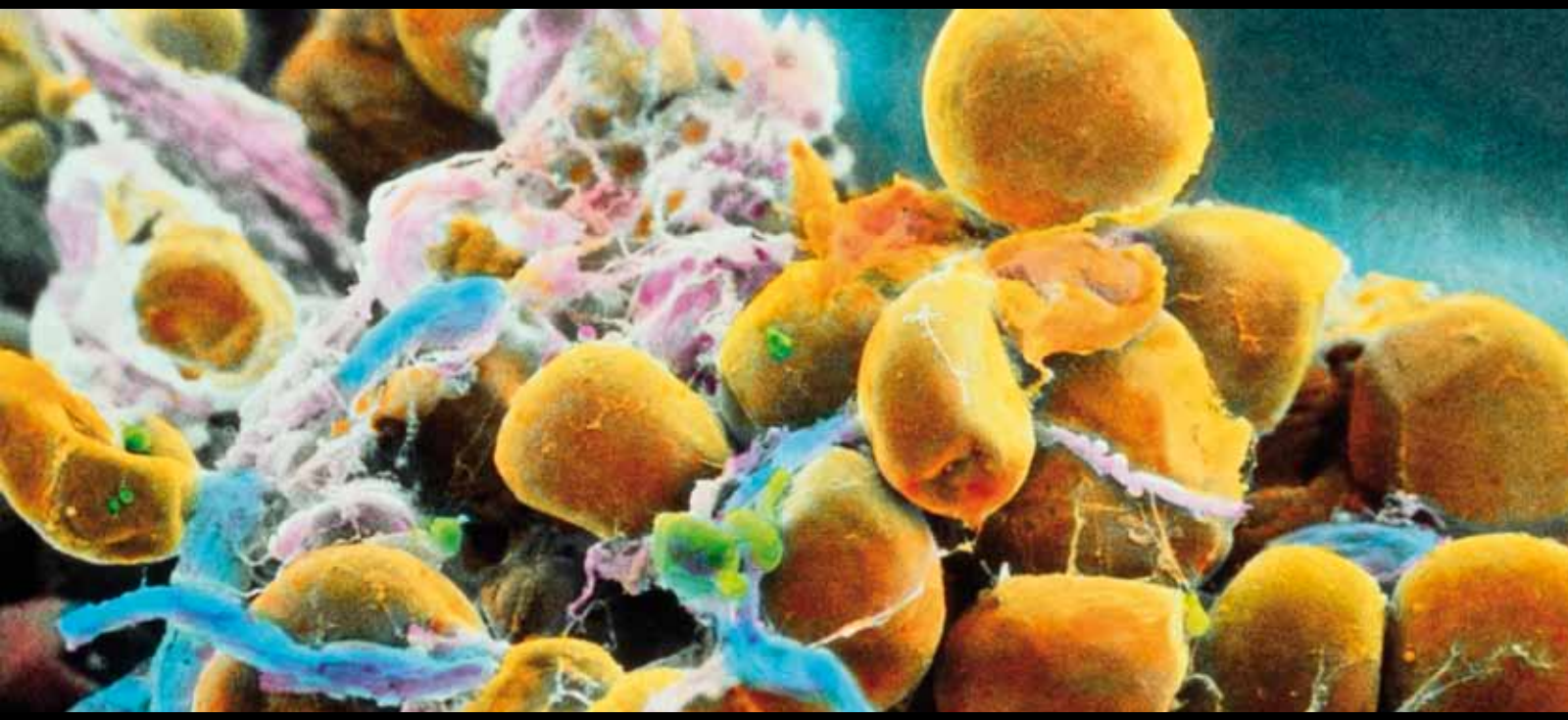
Journal of Obesity

Childhood Obesity: Today and Tomorrow's Health Challenge

Guest Editors: Roya Kelishadi, Sarah D. de Ferranti, Reza Majdzadeh, Jennifer A. O'Dea, Ajay K. Gupta, and Khosrow Adeli



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Editorial Board

Contents

Association of Serum Ceruloplasmin Level with Obesity: Some Components of Metabolic Syndrome and High-Sensitive C-Reactive Protein in Iran, Seyyed Morteza Safavi, Rahele Ziaei, and Mohammad Reza Maracy
Volume 2012, Article ID 951093, 5 pages

Hindawi Publishing Corporation
Journal of Obesity
Volume 2013, Article ID 208392, 2 pages
http://dx.doi.org/10.1155/2013/208392

Editorial

Childhood Obesity: Today and Tomorrow's Health Challenge

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In the current special issue different aspects of childhood obesity and metabolic syndrome (MetS) are being discussed. Childhood obesity is becoming an emerging health problem at individual and public health level. The problem is no more limited to high-income countries and is rapidly growing in low- and middle-income countries [1, 2]. Its early- and late-onset complications warrant studying more about this important issue [3].

Nowadays, the obesity epidemic and its associated complications as MetS, type 2 diabetes mellitus, cardiovascular diseases, and nonalcoholic fatty liver disease are considered as a global health problem. Its etiology is multifactorial consisting of the interaction between genetics and environmental factors, lifestyle behaviors, and sociodemographic background. Risk factors of chronic diseases originate from early life and are tracked from childhood to adulthood [4]. Therefore, prevention, screening, and early control of excess weight and related risk factors might help tailoring intervention strategies against the excess burden of noncommunicable diseases (NCDs) [5].

Health policies for prevention and control of childhood obesity have to be made by developing action-oriented intervention strategies, mainly by community participatory activities in each population. The role of families, notably parents and grandparents, should be highlighted in this regard, and family centered interventions should be encouraged [6].

The rapidly increasing trend of childhood obesity and MetS is alarming and provides information for policymakers and health care providers for interventional preventive programs. Public health and clinical aspects should be considered for evidence-based solutions to the current challenges in health promotion and disease prevention.

The current issue presents papers that seek to define the determinants as well as prevention and treatment of childhood obesity and its various complications in various potential topics including recent developments on the etiology of childhood obesity and metabolic syndrome, reports on determinants of overweight/obesity in the pediatric age group in different countries, action-oriented preventive measures against excess weight in children, and reports on short-term and long-term complications of childhood obesity, as well as therapeutic modalities in this field.

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Reza Majdzadeh
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Review Article

Exergaming as a Strategic Tool in the Fight against Childhood Obesity: A Systematic Review

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Improper use of electronic media is considered a major contributing factor to childhood obesity. However, exergames, a new generation of active games, have made it possible to combine electronic entertainment with physical exercise. The purpose of this systematic review was to analyze the use of exergaming as a strategic tool in the fight against childhood obesity. Information was retrieved from the databases SciELO, LILACS, Pubmed, Ebsco, and Science Direct, using the search words "egames," "exergames," "exergaming," "new generation of video games," "active video games," "energy expenditure," "body composition," and "physical activity" in English and Portuguese, covering the period January 2008 to April 2012. Nine articles met the inclusion criteria. Exergaming was found to increase physical activity levels, energy expenditure, maximal oxygen uptake, heart rate, and percentage of physical activity engaged in and to reduce waist circumference and sedentary screen time. Thus, exergaming may be considered a highly relevant strategic tool for the adoption of an active and healthy lifestyle and may be useful in the fight against childhood obesity.

1. Introduction

Within the context of the technological advances of the 21st century, improper use of electronic media has become a major contributing factor to the growing problem of childhood obesity [1].

Recent studies have shown a positive relation between time spent in front of TV and increasing adiposity among school children. Thus, according to Baughcum et al. [2], sedentary behaviors associated with electronic entertainment (computers, TV, and video games) contribute to increasing the prevalence of overweight and obesity in children.

The number of hours spent in front of TV may be directly related to the increase in body mass index (BMI), cholesterol levels, smoking prevalence, and loss of fitness [3]. Similar results were reported by Carvalhal et al. [4] who found time spent with video gaming to be directly proportional to the increase in BMI in 7–9-year-old children.

In a cross-sectional population-based study involving 4,964 school children aging 4–10 years, Corso et al. [5]

observed a significant association between the presence of overweight/obesity and daily time spent in front of the computer.

Nevertheless, in view of this problematic, a more health-friendly entertainment technology has been developed with the purpose of associating video gaming with physical fitness [6].

Some authors have proposed the use of interactive digital tools in the form of serious games focused on rehabilitation and promotion of healthy habits. These tools have been shown to result in significant learning and transference of contents to real-life scenarios [7, 8].

Serious games are interactive digital tools based on design principles which go beyond mere entertainment and make use of the recreational motivation behind games to convey a message, teach contents and practices, rehabilitate users, or provide useful experiences. Entertainment and fun are not their primary purpose; instead, serious games are given a meaning and a practical objective in order to solve specific real-life problems [9].

The use of serious games for purposes of rehabilitation, health promotion, physical fitness, and health monitoring may be relevant for overweight or obese children in need of nutritional reeducation or physical rehabilitation, by way of game-related motor skill training and health indicator evaluation and analysis [7].

Health professionals are consequently beginning to use serious games as a strategy to promote health education and well-being, for example, by distracting patients during painful medical procedures, managing therapeutic interventions, and designing simulations of rehabilitation and motor skill training. Other serious games are intended to build healthy habits and behaviors related to food and physical exercise [9].

In the realm of physical exercise and fitness, a new technological concept has emerged referred to as exertainment or exergaming. According to Sinclair et al. [10], quoted by Vaghetti and Botelho [11], these expressions are portmanteaus combining the words "game," "exercise," and "entertainment" in an attempt to make physical exercise more attractive by association with video game imagery [9].

Thus, the combination of interactive video games and physical exercise constitutes an innovative tool in the fight against childhood obesity as it stimulates and reinforces the habit of physical activity in an environment that is both entertaining and purposeful. The benefits include increased levels of physical activity, reduced consumption of low-nutrition foods, and increased energy expenditure, with direct repercussions on the main variables associated with childhood obesity [12].

Given this context, this highlights the need to deepen the knowledge of an innovative and unexplored way to combat childhood obesity. Thus, the purpose of the present systematic review was to evaluate the use of exergaming as a strategic tool for the promotion of healthy behaviors in the fight against childhood obesity.

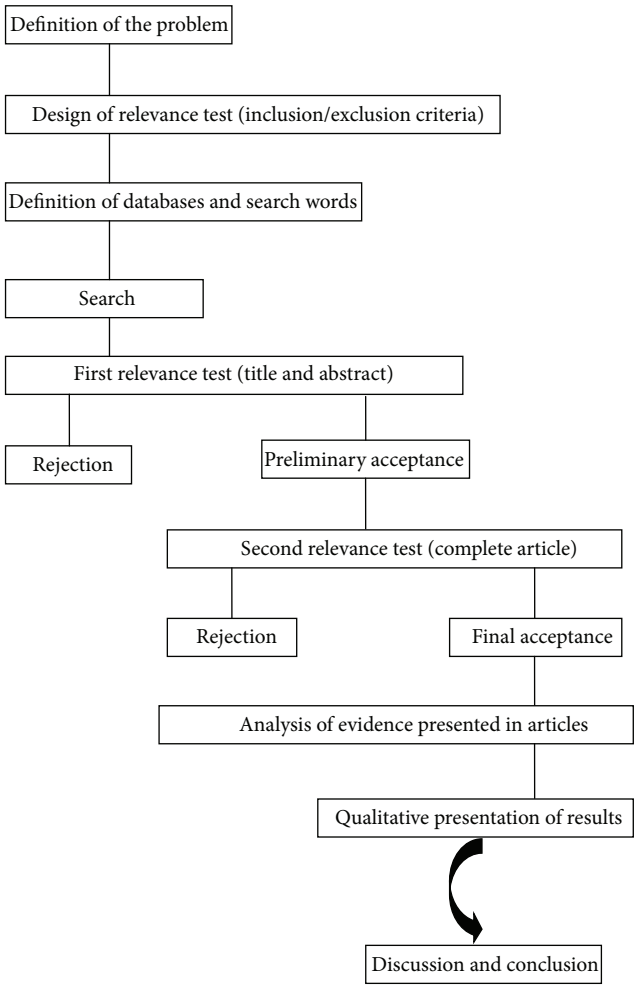

Figure 1: Flowchart of the systematic review.

2. Materials and Methods

This is a systematic review of the scientific literature on exergaming as a strategic tool for the promotion of physical activity, followed by critical analysis and synthesis [13].

Information was retrieved from the databases SciELO (Scientific Electronic Library Online), LILACS (Literature in the Health Sciences in Latin America and the Caribbean), Pubmed, Ebsco, and Science Direct, using the search words and phrases "egames," "exergames," "exergaming," "new generation of video games," "active video games," "energy expenditure," "body composition," and "physical activity." These terms are key words rather than health descriptors due to the novelty of the innovative concepts employed in the field.

The study was carried out following the steps illustrated in Figure 1. Initially, the problem was defined, followed by the establishment of inclusion/exclusion criteria and the selection of databases and search words. Then, the databases were searched for relevant articles. The title and abstract were used initially to determine the relevance, followed by the reading of the complete text of the selected articles. Finally, the articles were analyzed with regard to methodology and results, and the findings were summarized in Table 1.

Table 1: Summary of the findings of the selected studies with regard to body composition, energy expenditure, and physical activity levels of children and adolescents.

Author and year	Study objective	Study population	Methodology	Variables	Results
Graves et al., 2008 [14].	Compare the energy expenditure when playing sedentary and new-generation active computer games.	11 adolescents aging 13–15 years.	Four types of games were played: 1 sedentary (XBOX 360) and 3 active (Wii Sports), 15 min each.	Height, body mass, BMI, and energy expenditure.	Energy expenditure was greater when gaming than at rest ($P < 0.001$). Active gaming expended significantly more energy than sedentary gaming ($P <$ **0.001**).
Ni Mhurchu et al., 2008 [15].	Analyze effect of exergaming on anthropometric profile and level of physical activity.	20 children aging 10–14 years.	The intervention group ($n = 10$) played active games; the control group ($n = 10$) played sedentary games. Study duration: 12 weeks.	Height, body mass, physical activity questionnaire for children (PAQ-C), accelerometer, and waist circumference.	Compared to the controls, children in the intervention group were physically more active ($P < 0.05$), played fewer sedentary games, and had reduced waist circumference ($P <$ **0.05**).
Mellecker and McManus, 2008 [16].	Evaluate energy cost and cardiovascular response to active gaming and sedentary gaming.	18 children aging 6–12 years.	Intervention: 5 min familiarization, 5 min resting, 5 min playing while seated (bowling), 5 min exergaming (XaviX Bowling), 5 min resting, and 5 min exergaming (XaviX J-Mat Jackie's Action Run).	BMI, energy cost (rest versus sedentary gaming versus exergaming), and heart rate.	Exergaming required greater energy expenditure than sedentary gaming ($P <$ **0.001**).
Maloney et al., 2008 [17].	Evaluate the ability of DDR to increase physical activity and decrease sedentary screen time.	60 children aging 7-8 years.	Intervention group ($n = 40$) played DDR compared to wait-list control group ($n = 20$). Study duration: 28 weeks.	BMI, heart rate, blood pressure, and level of physical activity (accelerometer).	The groups did not differ significantly with regard to physical activity, but sedentary screen time decreased in the intervention group ($P <$ **0.05**).
Graf et al., 2009 [18].	Evaluate energy expenditure for two exergames (DDR and Wii Sports) in relation to treadmill walking.	23 children aging 10–13 years.	During 4 weeks (2 visits per week), the participants played DDR (1st visit) and played Wii and walked (2nd visit).	Height, body mass, body fat, IMC, energy expenditure, heart rate, accelerometer, blood pressure, and arterial elasticity.	Exergaming increased energy expenditure equivalent to moderate-intensity walking.
Haddock et al., 2009 [19].	Compare energy expenditure of stationary cycling connected to a video game and stationary cycling alone.	23 children aging 7–14 years with BMI ≤ the 85th percentile.	Following familiarization, the participants used the bicycle for 20 min with or without the video game connected.	Height, body mass, BMI, heart rate, oxygen consumption, and energy expenditure.	The energy expenditure was greater when riding the bike + video game than when riding the bike by itself ($P < 0.01$); no significant difference in the rating of perceived exertion was observed ($P > 0.05$); level of exertion was classified as moderate intensity.
Bailey and McInnis, 2011 [20].	Evaluate relative effect of exergaming on body composition and energy expenditure in different BMI ranges.	39 children aging 9–13 years.	Participants played 6 types of exergames.	BMI, energy expenditure at rest and during exercise, and, body composition (% fat, fat mass, and fat-free mass).	The evaluated exergames elevated energy expenditure to moderate or vigorous intensity ($P <$ **0.05**) and represent a good alternative for children in different BMI ranges.

Table 1: Continued.

Author and year	Study objective	Study population	Methodology	Variables	Results
Maddison et al., 2011 [21].	Evaluate effects of active video games on body composition, physical activity, and fitness.	322 children aging 10–14 years.	Intervention group (n = 160) played active games; control group (n = 162) played sedentary games. Study duration: evaluation after 12 and 24 weeks of intervention.	Height, body mass, bioelectrical impedance, and shuttle run ($\dot{V}O_2$ max).	Small but significant differences were observed between the groups with regard to BMI (P = **0.02**) and body composition, for % fat (P = **0.02**) and fat mass (P = **0.005**), in overweight and obese children.
Shayne et al., 2012 [22].	Compare the effects of exergaming and traditional physical education on physical activity.	Four boys.	The children had regular physical education classes (sports and fitness challenges) and exergaming classes with six types of equipment.	Percentage of session engaged in physical activity, and percentage of session with opportunity for physical activity.	The percentage of physical activity was significantly greater for exergaming. So was the percentage of physical activity engaged in when given the opportunity.

BMI: body mass index; PAQ-C: physical activity questionnaire for children; DDR: Dance Dance Revolution; and $\dot{V}O_2$ max: maximal oxygen uptake.

The search was limited to scientific papers in Portuguese and English, published between January 2008 and April 2012, in relevant and high-impact journals. No grey literature was used.

To be eligible, the studies should adopt the following:

(i) focus on children and adolescents aging 6–15 years;

(ii) be cross-sectional and experimental;

(iii) evaluate energy expenditure during exergaming;

(iv) discuss the association between active games and chealth behavior;

(v) evaluate changes in the level of physical activity, body composition, musculoskeletal system, and cardiovascular system.

Studies that were not eligible were those which

(i) were not available in full-text format;

(ii) focused on the use of exergaming for rehabilitation or cognitive therapy;

(iii) did not quantify the following variables: health behavior, energy expenditure, body composition, musculoskeletal system, and cardiovascular system.

Using the above search criteria, 223 potentially relevant publications were initially identified. The first screening of relevance reduced this number to 37 articles (SciELO = 0, LILACS = 0, Pubmed = 23, Ebsco = 10, and Science Direct = 4), and, following a complete text analysis, a final sample of 9 articles was defined. The remaining articles were excluded for a number of reasons: being on the adverse effects of the misuse of video games, focusing on adult subjects, using interactive video games for therapeutic purposes, analyzing variables not included in the present study, and unavailability of the full text.

The quality of the selected studies was determined based on the impact factor of the respective journals, all of which ranking above B3 in the Qualis System (CAPES), indicating the potential importance of the studies to the present review.

A final full-text analysis of each of the 9 selected articles was carried out by four independent reviewers using a standardized instrument. Finally, the information extracted from each article was discussed among the four reviewers until a consensus was reached.

The aspects considered included the folowing: (i) the year of publication, (ii) the relevance of the study objective to the present review, (iii) the participants (including sample, age range, and functional and physical conditions), (iv) methodology, (v) variables employed, and (vi) main findings. The significance level and effect size were mentioned in the main findings.

The selected studies were cross-sectional, longitudinal, and interventional (covering at least four weeks of intervention), and they involved children of both genders.

The findings were summarized in Table 1 with the following headings: author and year, study objective, target population, methodology, variables, and results.

3. Results

Nine articles met the inclusion criteria and were included in the analysis. All were published in English in the period 2008–2012.

From the papers selected, we chose not to use statistical analysis to evaluate the information, at this moment, because the proposal was to identify, select, and critically analyze studies relevant substantial thematic established. Therefore, Table 1 shows these publications in chronological order.

The study "Energy expenditure in adolescents playing new generation computer games" [14] compares the energy expenditure of adolescents when playing sedentary (XBOX 360) and new-generation active computer games (Wii Bowling, Wii Tennis and Wii Boxing). The authors found energy expenditure (expressed in kl/kg/min) to be significantly greater when playing active games (bowling: 190.6; tennis: 202.5; boxing: 198.1) than when playing sedentary games (125.5) or when at rest (81.3) ($P < 0.001$). However, the exercise associated with the active games was not of high-enough intensity to contribute towards the recommended daily amount of exercise in children. Nevertheless, given the current prevalence of childhood overweight and obesity, positive behaviors such as exergaming should be encouraged.

In the experimental study "Couch potatoes to jumping beans: a pilot study of the effect of active video games on physical activity in children" [15], the effect of exergaming on children's anthropometric profile and level of physical activity was evaluated. The participants were randomized to play either active video games ("EyeToy active games" and "dance mat") or conventional sedentary games (control group). After 12 weeks, the children in the intervention groups displayed higher levels of physical activity (+194 counts/min) (95%, CI 32, and 310 counts; $P = 0.04$) measured with an accelerometer, while the mean difference in waist circumference between the groups was −1.4 cm (95%, CI −2.68, and −0.04 cm; $P = 0.04$).

The experimental study "Energy expenditure and cardiovascular responses to seated and active gaming in children" [16] examined children's energy cost and cardiovascular response to active gaming, using the following protocol: 5 min for familiarization, 5 min resting, 5 min playing while seated (bowling), 5 min exergaming (XaviX Bowling), 5 min resting, and 5 min exergaming (XaviX J-Mat Jackie's Action Run). The energy expenditure was significantly higher during gaming in general than during rest (0.96 $\text{kcal}\cdot\text{min}^{-1}$) ($P < 0.001$) and significantly higher ($P < 0.001$) during active gaming (XaviX Bowling: 1.89 $\text{kcal}\cdot\text{min}^{-1}$; XaviX J-Mat Jackie's Action Run: 5.23 $\text{kcal}\cdot\text{min}^{-1}$) than during seated gaming (1.31 $\text{kcal}\cdot\text{min}^{-1}$). With regard to cardiovascular response, the cardiac rate increased significantly ($P < 0.001$) in all games when compared to mean resting values (81 beats/min). Rates were also significantly higher ($P < 0.001$) for exergaming (XaviX Bowling: 102 beats/min; XaviX J-Mat Jackie's Action Run: 160 beats/min) than for seated gaming (89 beats/min) [16].

Maloney et al. [17] evaluated the effect of another type of exergame ("Dance Dance Revolution") in a study entitled

"A pilot of a video game (DDR) to promote physical activity and decrease sedentary screen time." The children in the intervention group were requested to play the exergame (DDR) at home for 28 weeks. The intervention group and the control group did not differ significantly with regard to sedentary, light, moderate, and vigorous physical activity, but a significant increase ($P < 0.0005$) in vigorous activity was observed in the intervention group at 10 weeks when compared to baseline [17]. In the first ten weeks, sedentary screen time decreased in the intervention group (from 10.5 ± 5.5 to 9.3 ± 4.9 h/week) ($P < 0.05$) and increased in the control group (from 9.3 ± 5.7 to 12.3 ± 7.2 h/week) ($P < 0.09$). In the same period, both groups registered increases in BMI (intervention: from 17.1 to 17.4; control: from 18.0 to 18.3) and systolic blood pressure (intervention: from 102.9 to 107.8 mmHg; control: from 99.6 to 110.2 mmHg) [17].

In a study by Graf et al. [18] entitled "Playing active video games increased energy expenditure in children," energy expenditure rates were evaluated for children playing exergames (DDR and Wii Bowling and Boxing) in relation to treadmill walking. Both gaming and treadmill walking were associated with significantly higher energy expenditure rates, maximal oxygen uptake ($\dot{V}O_2$), and heart rate (HR) when compared with watching television. However, among the exergames, DDR (skill level 2) involved the highest levels of energy expenditure (3.3 times resting levels), followed by Wii Boxing (2.9 and 3.3 times resting levels for boys and girls, resp.). Wii Boxing produced the greatest changes in heart rate (boys: 127 bpm; girls: 140 bpm), but DDR (skill level 2) performed best at raising the expired ventilatory rate (boys: 18.9 L/min; girls: 17.6 L/min), $\dot{V}O_2$ (boys: 15.8 mL/kg/min; girls: 13.2 mL/kg/min), and rating of perceived exertion (boys: 13; girls: 16, Borg scale).

In 2009, Haddock et al. published "The addition of a video game to stationary cycling: the impact on energy expenditure in overweight children." During the 20 min experiment, energy expenditure was significantly higher ($P < 0.01$) while riding the bike as it controlled the video game (4.4 ± 1.2 Kcal/min) than when riding the bike by itself (3.7 ± 1.1 Kcal/min). The peak $\dot{V}O_2$ was 21.9 ± 6.2 $mL \cdot kg^{-1} \cdot min^{-1}$ with the game added and 19.3 ± 5.7 $mL \cdot kg^{-1} \cdot min^{-1}$ without the game, indicating a significant ($P < 0.05$) difference. However, no statistically significant difference was observed in heart rate (bicycle + game: 146.0 ± 21.4 bpm, equivalent to 70% of age-predicted maximum HR, versus bicycle alone: 142.4 ± 18.8 bpm, equivalent to 68% of age-predicted maximum HR) nor in the rating of perceived exertion (bicycle + game: 3.2 ± 2.8; bicycle alone: 3.6 ± 2.3, Omni scale) [19].

In the study "Energy cost of exergaming," by Bailey and McInnis [20], all of the exergames evaluated, (Cybex Trazer, LightSpace, Sportwall, DDR, Nintendo Wii and Xavix) elevated energy expenditure to moderate or vigorous intensity when compared to rest ($P < 0.05$). Energy cost was the highest for XaviX Jackie Chan Alley Run and Sportwall, followed by LightSpace Bug Invasion, Cybex Trazer Goalie Wars, Dance Dance Revolution, and Nintendo Wii Boxing. Nevertheless, no difference in energy cost was observed between children with BMI below and above the 85th percentile, regardless of the game evaluated [20].

In "Effects of active video games on body composition: a randomized controlled trial," Maddison et al. [21] evaluated the effect of exergaming (Play3, Kinetic, and Sport e Dance Factory) on the body composition and physical fitness of 322 overweight and obese children. The participants were requested to play exergames (intervention group) for 60 minutes of moderate-to-vigorous physical activity on most days of the week or to play conventional video games (control group). At 24 weeks, significant differences were observed between the groups with regard to BMI (−0.24; 95% CI: −0.44, 0.05; $P = 0.02$) (intervention: 24.8 ± 3.6 versus control: 25.8 ± 4.2), percentage body fat (−0.83%; 95% CI: −1.54%, −0.12%; $P = 0.02$) (intervention: 29.8 ± 7.2% versus control: 31.1 ± 6.3%), and fat mass (−0.80 kg; 95% CI: −1.36, −0.24 kg; $P = 0.005$) (intervention: 19.0 ± 7.1 kg versus control: 20.3 ± 6.3 kg).

In a recent study, "The effects of exergaming on physical activity in a third-grade physical education class," Shayne et al. [22] compared the effects of exergaming and traditional physical education on physical activity among 4 active children who were not overweight. Physical activity was significantly greater for exergaming than for physical education (Charlie 24% versus 6%; Hugo 33% versus −5%; Desmond 31% versus 7%; and Sawyer 41% versus 6%). A similar pattern was observed for the percentage of physical activity engaged in when given the opportunity (Charlie 32% versus 14%; Hugo 42% versus 10%; Desmond 37% versus 11%; and Sawyer 47% versus 14%). The exergames associated with the highest levels of activity, were Monster 434 and DDR. Interestingly, in exergaming students engaged in physical activity 82.5% of the time they had an opportunity to do so, as opposed to 48.8% in physical education [22].

4. Discussion

One limitation of our study was the small number of articles that met the selection criteria. Certainly, this failure was due to unusual and innovative character.

Childhood obesity is among other things associated with discrepancies between energy consumption and expenditure, resulting in a positive energy balance and, consequently, increased fat mass [23]. The adoption of a healthy lifestyle through a combination of diet and physical activity can potentially improve the anthropometric profile and body composition.

The studies show that the problem is potentiated by the lack of opportunity for physical activity in the current school setting due to the emphasis laid on professionalizing education in detriment to activities with energy expenditure compatible with the needs of children of school age [4, 24, 25].

In fact, in articles that were studied, it has been suggested that 70%–80% of children and adolescents of both genders do not follow the minimum recommendations for daily physical activity [26, 27] and that physical inactivity is highly prevalent in this population [28]. Not surprisingly, there is evidence that low levels of physical activity are strongly associated with the development of childhood obesity [29].

Influenced by their environment, children and adolescents are leading increasingly sedentary lives using gadgets for everyday tasks which previously required more physical activity. Seen in this light, technology appears to have a negative impact on health in several published studies.

However, the advent of exergaming technology may usher in a change of paradigm by associating entertainment with health promotion and, potentially, contributing to the fight against childhood obesity [6].

To do so, children of school age must engage in moderate-to-vigorous physical activity at least 60 minutes a day. Activities should be fun, stimulating, and challenging, involving diversified tasks [30]. Research shows that the association of tasks with pleasure and recreation increases adherence to interventions [31–33]. The playful nature of exergaming makes it possible to go beyond purely physical and biological aspects and attribute a meaning to the activity [34].

Exergaming technology offers users a different reality, one in which everything is faster and more attractive [35, page 132] and chances of success are greater. Here, children can have the experience of practicing sports with actual excitement, inserted in an arena surrounded by cheering crowds, overcome limits by breaking records, and simulate a sports award ceremony [35].

Within this context, as pointed out by Sinclair et al. [10], quoted by Vaghetti et al. [36], exergaming may constitute attractive, entertaining, and efficient means of engaging in physical activity while gaining fitness and improving motor skills.

In addition, according to Daley [37], exergaming increases energy expenditure during free time, making children more active and replacing sedentary time with healthy behaviors. Unlike conventional sedentary video games, exergames require full-body involvement in a number of different ways [38]. The fact that games can be played at home, with the participation of the whole family, is of no small relevance in the fight against childhood obesity.

Despite the relevance of the present review to health promotion and, more specifically, the fight against childhood obesity, this study is limited by the small number of publications currently available for a meaningful review of the literature, by the novelty and innovative nature of the health concepts involved, and by the absence of statistical analysis.

However, exergaming offers new and exciting horizons to be explored by researchers and healthcare professionals engaged in the fight against childhood obesity. The use of exergaming helps children and adolescents adopt a more active lifestyle which retains the fun, magic, and pleasure associated with play. However, the adoption of these practices should be rational and, if possible, overseen by a physical educator to prevent repetitive strain injury and osteomuscular disorders.

5. Conclusions

Based on a systematic review of the literature, exergaming, a modality of serious games, was found to lead to a more active lifestyle by increasing the level of physical activity, energy expenditure, and cardiorespiratory function and by reducing body fat and sedentary behaviors. In this light, technology may be viewed as an effective strategy for the encouragement of active and healthy behaviors and as an aid in the fight against childhood obesity. Exergaming technology appears to have a considerable potential in this respect, encouraging positive behaviors. However, more discussion is needed on strategies employing attractive interventions to fight the growing problem of childhood obesity around the world.

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Research Article

Obesity, Diet, and Activity in relation to Asthma and Wheeze among Rural Dwelling Children and Adolescents

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Aims and Objectives. We investigated associations between weight status, activity level, and diet with asthma or wheeze as well as the interrelationship between these factors. *Methods*. We conducted a case-control study of 6–18-year olds from 2005 to 2007. Cases ($n = 87$) were subjects reporting episodes or breathing medication use along with doctor-diagnosed asthma or wheeze in the past 12 months. Controls were randomly selected ($n = 208$) and without asthma or wheeze. Data regarding health outcomes, diet, and activity were obtained from questionnaire. Objectively measured height and weight were collected. *Results*. In the adjusted analysis, there was a trend ($P = 0.07$) towards an increased risk of asthma or wheeze associated with high fast food and/or pop consumption. Among cases, a significantly lower proportion (66%) classified as overweight participated in hard exercise in ≥9 of the past 14 days compared to those who were not overweight (86%). This pattern was not seen among controls (76% participating in hard exercise versus 78%, resp.). However, based on perceived weight status by the parent, the patterns were similar regardless of case-control status. *Conclusions*. Overweight status may negatively impact activity level among those with asthma or wheeze. Efforts should be made to encourage healthy food choices, and activity programming must consider the needs of overweight children with asthma.

1. Introduction

Asthma is a chronic inflammatory disorder of the airways that can be characterized by symptoms such as episodes of wheezing, breathlessness, chest tightness, and coughing with wheeze being the most common physical finding [1]. It is most prevalent among children [2, 3]. Childhood asthma results in a large amount of health care utilization and associated resource use leading to a huge impact on society [2, 4]. At an individual level, persons with asthma demonstrate lower quality of life compared to those without asthma [5, 6]. Part of this results from reduced participation and activity limitation, including school or work absenteeism. Among children, geographic trends in asthma prevalence have been reported with higher prevalence of asthma observed in westernized nations [7, 8] and in urban [9] and nonfarming [10] locations. In addition, there is evidence of temporal trends with increases in asthma prevalence occurring over the past few decades [3, 11].

The reason for geographic and temporal variation is unclear. The environmental factors have been considered as possible explanations for these trends, but a less examined and potentially important explanatory factor includes health behaviours and obesity. Associations with obesity have been the most studied of these alternate explanations. As with asthma, rates of obesity have been rising in recent years

[12]. There is also evidence that being overweight or obese is associated with an increased risk of asthma or wheeze [9, 13, 14].

Various components of a child's diet have been associated with asthma or wheeze. Some foods, such as fish products [15] or vegetable and milk consumption [9], have been suggested to be protective of asthma, while other foods, such as hamburger consumption or "fast foods," have been suggested to increase the risk of asthma [16]. Finally, there is conflicting evidence on whether physical activity is associated with asthma [17–19].

Despite these findings, few studies have examined the interrelationship between diet, physical activity, and weight status with regard to children with asthma or wheeze. What is more, these investigations in relation to asthma and wheeze are rarely considered in rural populations despite there being differences in obesity and health behaviours between urban and rural dwellers [20]. As mentioned, results of several studies suggest that farming or rural exposure is protective of asthma and allergic disease [10, 21, 22] although this is not entirely consistent [23]. Within Canada, the protective effect of rural or farm dwelling has ranged from negligible [24] to more than a 50% reduction in risk [25] as well as an inverse dose-response association [9]. Thus, there are substantial gaps in knowledge regarding weight status, diet, and activity and their interrelationships in rural areas, where health care access is lower, and there are different exposure patterns compared to urban areas.

In this study, some of these issues were investigated using the data collected from Humboldt, Saskatchewan, and the surrounding area, which has been the site of four previous cross-sectional studies on lung health. The primary objective was to examine weight status, diet, and activity level in relation to asthma or wheeze among a rural dwelling population of children and adolescents. The specific research questions considered in our study were (1) what is the profile of weight status, diet, and activity levels among children with and without asthma? (2) Are characteristics of a child or adolescent's weight status, diet, or activity levels associated with having active asthma or wheeze? (3) How do health behaviours and weight status interrelate among children and adolescents with and without asthma?

2. Methods

2.1. Study Design and Population. The methods used in this study have been described elsewhere [26, 27]. In brief, we conducted a case-control study of children and adolescents living in and around the rural community of Humboldt, Saskatchewan, Canada, during the fall and winter seasons from 2005 to 2007 with some extended data collection in the spring. Rural schools in the same school district as schools within the community boundary of Humboldt were approached. Subjects were recruited from a previously conducted population-based cross-sectional survey of respiratory health of 6 to 18-year old children and adolescents completed in 2004. Potential cases comprised all subjects reporting either (1) wheeze in the past 12 months or (2) report of doctor-diagnosed asthma and at least one of health care utilization for asthma in the past 12 months, asthma medication use in the past 12 months, or asthma episodes in the past 12 months. Thus, the cases considered here were current asthma or wheeze cases.

For each case selected, two potential controls were randomly selected from among children who were not considered cases. Once selected, an invitation letter was mailed, and potential participants were contacted by telephone a maximum of seven times. Following contact, case and control status was confirmed by a screening questionnaire that enquired about asthma diagnoses, recent asthma, or wheeze events including symptoms, episodes, and breathing medication use.

Data collection for the current analysis was based on an interviewer-administered case-control questionnaire, data from the original cross-sectional questionnaire, and saliva samples to assess exposure to tobacco smoke. The Health Research Ethics Board—Panel A (University of Alberta) and the Biomedical Research Ethics Board (University of Saskatchewan) approved the study as did the local school boards. Prior to taking part, parents and children completed consent and assent forms, respectively.

2.2. Questionnaires and Operational Definitions. The questionnaires were based on previously validated and standardized questionnaires [7, 28, 29] and those used in previous respiratory health studies in Saskatchewan [30–32]. Information was collected on respiratory health, sociodemographic factors, general health, family history, birth characteristics, lifestyle, housing characteristics, and environmental exposures.

Weight status was considered by two methods. The first was actual weight status. This was based on objectively measured height and weight. Height was measured against a wall using a fixed tape measure with subjects standing in socks on a hard floor. Weight was measured using a calibrated spring scale with subjects in socks and dressed in normal indoor clothing. From these measures, body mass index (BMI) was calculated based on the equation (BMI = weight (kg)/height $(m)^2$) [33]. Weight status was classified based on categorization of body mass index (BMI) using values described by Cole et al. [34] which base the cut-off value as the predicted adult equivalent of 25 for overweight.

The second method of classifying weight status was based on weight status perceived by the parent. This was considered by the question "Do you consider your child to be: Underweight/Just about right weight/Overweight?." If a parent responded with overweight, the child's perceived weight status was "overweight." This question was based on a question used in the United States National Health and Nutrition Examination Survey III [35].

Physical activity level was classified based on parental response to the question: "How many of the past 14 days has your child done at least 20 minutes of exercise hard enough to make him/her breathe heavily and make his/her heart beat fast? (hard exercise includes, e.g., playing basketball, jogging, or fast bicycling and includes time in physical education class): None/1 to 2 days/3 to 5 days/6–8 days/9 or more days." This was based on the Modifiable Activity Questionnaire for

Adolescents [36]. Children were categorized as <9 days versus ≥9 days (High activity level).

Classification of diet was based on questions used in the International Study of Allergy and Asthma in Childhood questionnaire for dietary assessment [37] as well as an additional question on soft drink consumption. Dietary questions were based on "In the past 12 months, how often, on average, did your child eat or drink the following... Never/Occasionally/Once or twice per week/3 or more times per week" with a number of food categories considered. Soft drink consumption was based on the question "On average, how many soft drinks or pops does this child drink in a week?" Regular consumption of a given food was considered to occur if the child ate that food at least once or twice per week on average. The foods considered were based on findings from previous studies [9, 15, 16] and included vegetables, fruits, milk, and fish (including seafood). High soft drink consumption was considered to occur if the child drank 2 or more soft drinks or pops per week on average (the 75th percentile). As an indicator of poor diet, if the child was considered to have either regular soft drink or fast food consumption, then they were classified in the "Regular fast food/soft drink consumption group."

The classification methods for each of the following potential confounders have been used in previous studies by our group when examining pediatric asthma [9, 24, 26, 27]. Subjects were classified into age groups (≤12 years versus >12 years) to be comparable with other childhood asthma studies where age ranges were typically between 6 and 12 years, [31, 38]. Season of testing was defined by the date of the home visit and was recorded as spring (March, April, and May), fall (September, October, and November), and winter (December, January, and February) to account for the potential differences in endotoxin and allergy levels by season.

2.3. Collection and Analysis of Saliva Samples to Quantify Cotinine Levels. Tobacco smoke exposure was determined by salivary cotinine levels. Subjects were asked to spit into a specimen container without the use of gum, Teflon, or other materials that would stimulate the flow of saliva. Up to 5 mL of saliva was collected. Analysis for cotinine was conducted using saliva cotinine microplate enzyme immunoassay kits (Cozart plc, UK). Levels of cotinine (ng/mL) were categorized as high and low post analysis based on the median cotinine level (1.24 ng/mL) due to a highly skewed distribution of results that could not be normalized after log transformation.

2.4. Statistical Analysis. Analysis was completed using SPSS version 20. Throughout the analysis we considered statistical significance based on an alpha level of <0.05. Initially we described weight status and health behaviours descriptively to develop a profile of these characteristics in a rural population. This was completed through examination of agreement between the perceived weight status and actual weight status using percent agreement, Kappa statistics, and descriptive comparisons of mean BMI. We also considered frequencies and proportions among cases and controls to describe the population and used chi-squared tests to make statistical comparisons between these two groups.

Next we measured the association between case-control status and dietary characteristics, activity level, and weight status using logistic regression. A multiple logistic regression model was used to adjust for potential confounders. Variables were chosen to be included in the model based on clinical and biological importance from the literature, statistical significance, or the effect that the removal of that variable had on the beta coefficient of the other variables in the model. To avoid colinearity, we fitted several models but only included one variable of a certain type of diet or weight status while adjusting for the other variables. The strength of the association was quantified using the odds ratio (OR) and 95% confidence intervals (CI). Statistical significance was assessed by comparing the observed P value to the aforementioned alpha level.

In our final set of analyses we considered the interrelationship between each of the following health behavior variables: diet, weight status (actual and perceived), and activity level first descriptively then using chi-squared tests for proportions. Following this, we tested for statistical significance by using multiple logistic regression to adjust for potential confounders. These final sets of inter-relationship analyses were stratified by case-control status. Models were fitted to avoid colinearity between diet variables and included one diet variable at a time (Adjusted models 1 to 4). Also, models were fitted with one of actual weight status based on BMI (adjusted models 1 and 2) or perceived weight status (adjusted models 3 and 4) independently.

3. Results

Among eligible cases and controls, 322 children or adolescents and their parents agreed to participate in the study (participation rate = 43.4%). Of these, 208 were controls and 87 were cases. The remaining 27 children were excluded due to either missing data ($n = 12$) or they were cases who had asthma that was no longer considered current ($n = 15$). When analyses considering perceived weight status were conducted there were an additional 22 fewer participants due to missing data in this specific variable. Characteristics of cases and controls are presented in Table 1.

A high proportion of cases and controls were overweight based on objective measurements with a much lower proportion of parents perceiving their children to be overweight (Table 1). Among cases, there was 72.8% agreement between actual weight status and perceived weight status but with 25.9% of parents perceiving their children to not be overweight when in fact they were considered overweight by objective measures. This was similar among controls where there was 72.4% agreement between actual weight status and perceived weight status, with 25.5% of parents perceiving their children to not be overweight when in fact they were measured as overweight. This resulted in Kappa statistics of 0.28 for cases and 0.19 for controls indicating a poor agreement. When cases were adjusted for age, mean BMI in the actual overweight group was 24.5 and 26.6 in the perceived overweight group. Among controls, mean BMI in the actual overweight group was 24.9 and 25.4 in the perceived overweight group after adjusting for age.

Table 1: Characteristics of the cases and controls.

	Controls $n = 208$	Cases $n = 87$	P value
Personal characteristics			
Female (%)	60.6	35.6	<0.001
Parents with > high school (%)	39.4	37.9	0.81
With allergic disease (%)	33.2	73.6	<0.001
Family history of asthma (%)	7.2	23.0	<0.001
Maternal smoking during pregnancy (%)	9.1	20.7	0.006
Early respiratory illness (%)	8.7	18.4	0.02
High tobacco smoke exposure (%)	51.0	49.4	0.81
Age, years (mean, SD)	11.5 (3.2)	11.1 (2.9)	0.31
Weight status			
Actual overweight based on BMI (%)	29.8	33.3	0.55
Perceived overweight (%)	7.8	9.9	0.58
Activity levels			
Higher activity level (%)	77.4	79.3	0.72
Dietary intake			
Regular fast food and/or soft drink consumption (%)	54.3	65.5	0.08
Regular seafood consumption (%)	26.4	25.3	0.84
Regular vegetable consumption (%)	99.0	98.9	0.88
Regular fruit consumption (%)	99.5	98.9	0.52
Regular milk consumption (%)	95.2	96.6	0.60

There were no statistically significant differences between cases and controls in weight status, perceived overweight status, activity level, or dietary intake (Table 1) although there was a trend towards statistical significance with cases reporting a higher proportion with regular fast food/soft drink consumption than controls (65.5% and 54.3%, resp.; $P = 0.08$). Given the high proportion of having a regular diet of fruit, vegetable, and milk consumption, these variables were not considered in subsequent analyses. After adjusting for potential confounders, there were no statistically significant associations ($P > 0.05$) between any of the health behaviours or overweight status with case status (Table 2). While the directions of the associations were as expected, they tended to be weak based on the OR, with the exception of fast food and/or soft drink consumption. This was after fitting independent models to avoid potential co-linearity between weight status and dietary intake (models 1 to 4). Again, there was a trend towards an association for regular fast food/soft drink consumption (OR = 1.67, 95% CI = 0.95–2.95, $P = 0.08$).

When considering the interrelationships between the health behaviours and weight status including actual and perceived weight status, there was no statistically significant association between poor diet (regular fast food/soft drink consumption) and any of the other measures among cases or controls (Table 3). As seen in Figure 1, when considering physical activity levels, among cases, a higher proportion of children had high activity levels if they were classified not overweight compared to if they were classified overweight regardless of if the weight status was based on objective measures or perception, although this was not statistically significant when considering perceived weight status ($P = 0.11$). However, among controls, when using objective measures of weight status, there was not a statistically significant difference between those who were overweight and those who were not with regard to having high activity levels. There was a significantly lower proportion of controls with high activity levels when they were perceived to be overweight compared to when they were not perceived to be overweight (Figure 1).

4. Discussion

We sought to describe and examine weight status, diet, and activity levels in relation to asthma and wheeze among children and adolescents in a rural setting. We found that a large proportion of children and adolescents were overweight when considering objective measures of height and weight, yet a low proportion of parents perceived their child as being overweight. Health behaviours and weight status in this population did not show strong associations with asthma or wheeze, and children and adolescents with asthma who were also considered overweight were less likely to have a high activity level.

We found that close to one-third of children and adolescents in our study population were overweight or obese when using BMI to classify weight status. This is similar to levels found in previous studies looking at national samples of Canadian children and adolescents which report the prevalence of overweight and obesity to be between 18% and 39% depending on age, sex, and location of residence [12, 20]. This high prevalence of overweight classification should be

Table 2: Prevalence of lifestyle characteristics and unadjusted and multiple logistic regression* results examining the associations between weight status and health behaviours with asthma or wheeze.

	Unadjusted OR (95% CI)	Adjusted models			
		Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)
Weight status					
Not overweight	1.00	1.00	1.00		
Overweight	1.17 (0.69–2.01)	1.15 (0.63–2.10)	1.15 (0.63–2.08)		
	$P = 0.55$	$P = 0.65$	$P = 0.66$		
Perceived weight status					
Not overweight	1.00			1.00	1.00
Overweight	1.29 (0.53–3.18)			1.63 (0.59–4.53)	1.59 (0.57–4.41)
	$P = 0.58$			$P = 0.35$	$P = 0.38$
Hard activity levels					
<9 days in two weeks	1.00	1.00	1.00	1.00	1.00
≥9 days in two weeks	1.12 (0.61–2.06)	1.37 (0.69–2.72)	1.38 (0.70–2.72)	1.42 (0.69–2.93)	1.43 (0.70–2.95)
	$P = 0.72$	$P = 0.36$	$P = 0.36$	$P = 0.35$	$P = 0.33$
Fast food and/or soft drink consumption					
Low	1.00	1.00		1.00	
Regular	1.60 (0.95–2.69)	1.67 (0.95–2.95)		1.55 (0.86–2.79)	
	$P = 0.08$	$P = 0.08$		$P = 0.15$	
Fish and seafood consumption					
Low	1.00		1.00		1.00
Regular	0.94 (0.53–1.67)		0.84 (0.45–1.58)		1.00 (0.52–1.92)
	$P = 0.84$		$P = 0.60$		$P = 1.00$

* All models are adjusted for sex, presence of a home air filter, maternal smoking during pregnancy, bare floor in the bedroom in the first year of life, age group, season of testing, tobacco smoke exposure, and each of the variables listed in the column.

addressed given the long-term negative health consequences of childhood obesity [39].

We also confirm previous studies that showed that parents generally underestimate the weight status of their children [35, 40]. Our results extended these previous findings to rural populations and found that parents of children with asthma or wheeze and those without asthma or wheeze do this similarly. In our study, approximately 80% of children who were overweight based on objective measurements were not perceived to be overweight by their parents. This discrepancy is higher than that observed in previous studies [35, 40]. Rural populations may be at increased risk for misclassifying children's weight status. Failure to recognize children as being overweight or obese could have serious health implications as action taken to address or prevent this condition and subsequent health effects cannot occur without first identifying that there is a problem.

With regard to activity level and diet, it is more difficult to compare other studies given the large number of indicators and methods available. We found that the majority of the current study population engaged in high levels of physical activity. The level was higher than expected based on previous studies which found that approximately 50% to 57% of adolescents took part in high levels of activity [41]. However, regular physical activity levels in a separate study of Canadian adolescents were approximately 80%, which is similar to the levels we found in the current analysis [20]. Finally, it was difficult to assess dietary status as there appeared to be low sensitivity in the measures we used, possibly due to the small number of categories. Despite this, we were able to determine that over half of this population consumed fast food or high levels of soft drinks regularly.

We did not find strong associations between being overweight or obese, activity levels, or diet with asthma or wheeze although there is some indication of increased risk of asthma or wheeze associated with poor diet. Associations between obesity and asthma have been reported but often depend on personal characteristics such as sex and onset of puberty, with associations typically seen among females and those with earlier onset of puberty [13, 42]. The associations between physical activity with asthma and wheeze have been infrequently studied and with inconsistent results [17–19]. Results from the few diet studies have been inconsistent but have shown some foods to be protective [15], while other foods may increase the risk of asthma or wheeze [16]. The potential explanation for the increased risk of asthma or wheeze associated with poor diet in our study could be due to increased dietary sodium intake [43] and the increased systemic inflammation that

Table 3: Interrelationship between fast food and soft drink consumption, weight status, and activity level by case-control status*.

	Controls		Cases	
	Low fast food and soft drink consumption (n = 95) %	High fast food and soft drink consumption (n = 113) %	Low fast food and soft drink consumption (n = 30) %	High fast food and soft drink consumption (n = 57) %
Hard activity level				
<9 days in two weeks	24.2	21.2	20.0	21.1
≥9 days in two weeks	75.8	78.8	80.0	78.9
Weight status based on BMI				
Not overweight	70.5	69.9	66.7	66.7
Overweight	29.5	30.1	33.3	33.3
Perceived weight status				
Not overweight	91.0	93.2	89.3	90.6
Overweight	9.0	6.8	10.7	9.4

*There were no statistically significant associations.

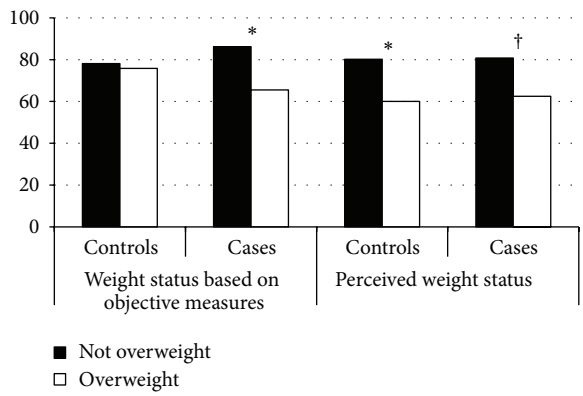

Figure 1: Proportion of children and adolescents with high activity levels who are defined as overweight based on body mass index and based on their parent's perception of overweight by case-control status. *$P < 0.05$ comparing overweight to not overweight after adjusting for sex, home air filter, maternal smoking during pregnancy, bare bedroom floor in the first year of life, age group, season of testing, tobacco smoke exposure, and high soft drink or fast food consumption. †$P = 0.11$ comparing overweight to not overweight after adjusting for sex, home air filter, maternal smoking during pregnancy, bare bedroom floor in the first year of life, age group, season of testing, tobacco smoke exposure, and high soft drink or fast food consumption.

results from eating items such as fast food regularly or in high quantities. It has been shown that higher levels of C-reactive protein are associated with a reduction in lung function [44], and a single high fat meal has been shown to significantly increase cholesterol and triglyceride levels as well as exhaled nitric oxide, a marker of airways inflammation [45]. We recently investigated the association between obesity and health behaviours with asthma in a national sample of adolescents in Canada [9]. In that study we found an increased risk of asthma associated with weight status and physical activity with a reduced risk of asthma associated with whole milk consumption and vegetable consumption. In the current study we did not find similar associations. Reasons for the differences may be that the earlier study focused only on adolescents, different outcome definitions were used because respiratory health was not the focus of the earlier study, and the earlier study included both urban and rural populations from across Canada. Despite these differences, most of the other associations were in the same direction between the two studies with several of them being similar in strength. Similarly, reasons for the differences in results between our current study and those of others could be the differences in exposure variables considered, study population, or study design. Given the large number of indicator variables available and differences in populations in these investigations, differences in results could occur through differential variability in exposures or outcomes or mechanisms of exposure-outcomes at different ages.

We found that children and adolescents who have asthma or wheeze and who are considered overweight or obese were less likely to participate in high levels of activity. This was regardless of weight status based on objective measures or parent perception. In contrast, lower activity levels were only present among controls when overweight was defined by parent perception. Children and adolescents whose parents perceived them to be overweight had a higher mean BMI than those children who were classified as overweight based on objective measures. It could be that higher BMI could result in physiologic limitation leading to reduced activity among children. Children and adolescents with asthma may experience these changes at a lower level of BMI, resulting in differences between cases and controls. Although there is some inconsistency, children with asthma have been reported to have lower activity levels than children without asthma [46]. Among adults, increasing BMI was associated with reduced likelihood of exercise defined by a number of methods and consistently in a dose-response manner [47]. Studies to date have not considered the characteristics of overweight/obese and asthma status in a combined fashion among children.

Our findings suggest that this is a population deserving special attention for activity programming. As it is, asthma is a barrier for exercise in children [46]. This especially true since being overweight/obese can worsen asthma outcomes. If asthma is less controlled or outcomes worsen, there is the possibility that children with asthma will be even less likely to participate in activity, potentially further increasing overweight/obese status.

This study addresses notable gaps in knowledge in that few studies have investigated health behaviours and overweight/obesity in rural populations, especially in relation to asthma or wheeze despite indication that rural dwellers are at increased risk of being overweight or obese. In an earlier study we found the prevalence of overweight or obese in an adolescent Canadian population to be approximately 23% overall, and the prevalence of overweight or obese in rural areas was significantly higher (approximately 28%) than in large metro areas (approximately 19%) [20]. Given the high prevalence of being overweight or obese and the higher levels in the current study population who reside in rural areas, we highlight the need to recognize and address overweight and obesity issues in rural regions. Rural dwellers are a unique population with different exposures, social structure, socioeconomic structure, and access to health care, and specific focus should be made to promote healthy lifestyles in these regions.

The major limitation in this study is the lack of temporality. Due to the cross-sectional nature of the data, we are unable to determine if poor weight status resulted from lower activity levels or if lower activity levels resulted from poor weight status. Similarly, we are unable to comment on whether asthma or wheeze preceded the lower activity levels among those with a poorer weight status or if lower activity levels with poor weight status preceded asthma or wheeze. Regardless the temporal relationship, it is clear that children and adolescents who are overweight and who have asthma or wheeze represent a group of children with lower activity levels, and this should be considered a public health focus. Another limitation is that this was a secondary analysis based on data collected for a children's lung health study. Because of this, some variables of interest may not have been collected and alternate methods of assessing health behaviours and weight status were not used which may have resulted in misclassification. However, we did use objectively measured height and weight as well as standardized measures of perceived weight status and activity where the question we used for activity has been well validated. Our dietary measures may not have had as much sensitivity as desired but have been used in other assessments of diet and asthma. We did not have information on puberty status, another potential confounder. Data regarding this stage of life was not collected and unfortunately we were unable to control it. While we controlled age, we cannot rule out that there may be some results explained by confounding by puberty status.

In conclusion, we report on several findings that warrant further examination and should be further addressed in the population. First, we found that there are high levels of being overweight in this rural population and parents often do not accurately perceive their children to be overweight or obese. Identifying children who are overweight or obese is the first step in addressing the condition, which can have long-term negative health consequences. Second, efforts should be made to encourage children to avoid unhealthy food choices. Finally, we found that overweight status may negatively impact activity levels and that this may be especially true among children with asthma or wheeze. As such, activity programming should consider the needs of overweight children with asthma specifically. Health behaviours and weight status of children in rural areas are an area in need of further research and practical application.

Conflict of Interests

There is no known conflict of interests.

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Research Article

Comparative Effectiveness of After-School Programs to Increase Physical Activity

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Background. We conducted a comparative effectiveness analysis to evaluate the difference in the amount of physical activity children engaged in when enrolled in a physical activity-enhanced after-school program based in a community recreation center versus a standard school-based after-school program. *Methods*. The study was a natural experiment with 54 elementary school children attending the community ASP and 37 attending the school-based ASP. Accelerometry was used to measure physical activity. Data were collected at baseline, 6 weeks, and 12 weeks, with 91% retention. *Results*. At baseline, 43% of the multiethnic sample was overweight/obese, and the mean age was 7.9 years (SD = 1.7). Linear latent growth models suggested that the average difference between the two groups of children at Week 12 was 14.7 percentage points in moderate-vigorous physical activity ($P < .001$). Cost analysis suggested that children attending traditional school-based ASPs—at an average cost of \$17.67 per day—would need an additional daily investment of \$1.59 per child for 12 weeks to increase their moderate-vigorous physical activity by a model-implied 14.7 percentage points. *Conclusions*. A low-cost, alternative after-school program featuring adult-led physical activities in a community recreation center was associated with increased physical activity compared to standard-of-care school-based after-school program.

1. Introduction

Childhood obesity remains one of the most serious threats to the public's health, with 1 in 3 children and adolescents overweight or obese (body mass index (BMI) ≥ 85th percentile) [1]. Childhood obesity is particularly problematic because it is resistant to treatment once established [2]. Accordingly, public health authorities are focusing on prevention. There is limited evidence for effective behavioral prevention interventions [3]. To fill this gap, the Institute of

Medicine [4], the *Strategic Plan for NIH Obesity Research* [5], Shaping America's Youth [6], and the White House Task Force on Childhood Obesity [7] have called for community-engaged, family-centered approaches to pediatric obesity prevention. These approaches are thought to have the greatest potential for sustained efforts and effects in our obesogenic environment.

In parallel, comparative effectiveness research is being discussed within the national health reform debate as a mechanism for improving healthcare quality and decreasing healthcare spending [8]. Clinical research typically examines the effectiveness of one prevention or treatment method at a time. Comparative effectiveness research compares multiple methods to determine the effectiveness of an intervention relative to alternatives. Identifying the most effective and efficient interventions has the potential to reduce unnecessary treatments, which should lower costs.

It is estimated that 8.4 million children attend after-school programs (ASP), and an additional 18.5 million would do so if a program was available [9]. The purpose of this study was to evaluate the comparative effectiveness of a community-driven ASP designed to combat physical inactivity versus a standard-of-care school-based ASP available to working parents. The community ASP was derived directly from local input and sustained through the collaboration and sharing of resources by the parks department and the public school system (Davidson County, TN, USA). This community-engaged effort has the potential to serve as a new model for youth obesity prevention because (1) it systematically addresses the top four barriers, identified by Shaping America's Youth, that prevent children from being active (lack of access to safe and appropriate places to be active, parental time constraints, cost of programs, and lack of parental motivation [6]) and (2) it engages multiple sectors of society to support program attendance and sustainability.

There is limited published research on ASPs designed to increase physical activity. Systematic reviews suggest that it is possible to improve activity levels, physical fitness, body composition, and blood lipids in the after-school setting [10] and that limitations in study design, lack of statistical power, and problems with implementation have hindered the evaluation of most ASPs to date [11].

To assess the comparative effectiveness of this community-driven ASP as a pediatric obesity prevention intervention, we compared it to the routine aftercare available to working parents in the community and asked two research questions: (1) Are children in the alternative ASP more physically active than children in the standard ASP? (2) Do the operating costs associated with these programs differ?

2. Materials and Methods

This study was guided by principles of community-based participatory research (CBPR). CBPR is an important research approach that equitably involves community members who are affected by the issue being studied in all phases of the research process [12]. The community ASP was developed by the parks department to address the community's need for an affordable ASP. Families provided input about their needs and preferences (e.g., transportation from school to the community center, flexibility in pick-up times, homework time, reduction of screen time, and increased physical activity). The city's public school system changed its policy around permissible bus stops allowing buses to deliver students to the community recreation center to support program attendance. The leadership and staff of the parks department were involved in all aspects of this research project: grant acquisition, study design, implementation, interpretation of results, and dissemination.

2.1. Study Population and Design. The study design was an observational prospective cohort study and a natural experiment in Nashville, TN, USA. The "naturally occurring" event, the parks department's new ASP, was the intervention, and children attending this community ASP formed the intervention group ($N = 54$). Comparison participants ($N = 37$) were recruited from an ASP located in the same (low income) school district and operated by a national company that operates a high proportion of school-based ASPs in the city, making it de facto standard-of-care for the majority of the city's school-aged children with working parents. Children were eligible for the study if the following was true: (1) age ≥5 and <13 years; (2) attended one of the Glencliff [neighborhood] cluster of public elementary or middle schools; (3) enrolled in the community or school-based ASP. Parents of eligible children underwent a 15-minute oral consent process before providing written consent for their child. Children provided assent. The consent/assent process was conducted in the preferred language of English or Spanish. The study was approved by the Vanderbilt University Institutional Review Board (#090986).

The two ASPs followed similar formats, and operated from 3–6 PM every day public schools were open. Both ASPs included time for snack, homework, and play and did not focus on a single activity (e.g., tutoring, chess, and team sport). The community ASP was set in a community recreation center and involved staff-led games. The school-based ASP was set in a school cafeteria and involved opportunities for arts and crafts and playing on the playground. The main differences between the two ASPs were (1) format of active play time (adult-led versus unstructured) and (2) location (community recreation center versus public school). Refer to Table 1 for a direct comparison of ASP structure and process.

2.2. Data Collection. All measures were collected at the ASPs at three time points over approximately 12 weeks (February–May 2010), with six weeks separating each wave of measurement. The measurement period was selected based on the Cochrane Review that states that obesity prevention interventions should last at least 12 weeks for behavior change to be observed [13].

2.3. Measures

2.3.1. Physical Activity. Physical activity was assessed using ActiGraph GT1M accelerometers (ActiGraph, Pensacola, FL, USA) only during ASP programming time. Accelerometry is

Table 1: Comparison of after-school programs.

	Community (intervention)	School-based (comparison)
Location	(i) Community recreation center	(i) Public school cafeteria
Who	(i) Ages 5–14 yrs	(i) Only open to students at that elementary school (5–10 yrs)
Program format	(i) 3–6 PM (ii) Transportation from neighborhood public schools to the community center (iii) Parents pickup from the community center (iv) Snacks provided (v) Homework help provided (vi) Staff-led activities (children select activity)	(i) 3–6 PM (ii) Transportation not necessary (iii) Parents pickup from school (iv) Snacks provided (v) Homework help provided (vi) Unstructured play time (children select activity)
Stated physical activity goal	(i) 60 minutes of activity/day	(i) 45 min of moderate activity 3/week (ii) 45 min of vigorous activity 2/week
Physical activities (always available)	(i) Staff leads students through activities: (a) basketball scrimmage, (b) dance, (c) cross country, (d) swimming, (e) recreational games (e.g., flag tag, 4 square, and scooter relays)	(i) Staff supervises for safety: (a) playground, (b) gymnasium
Nonphysical activities (always available)	(i) Arts and crafts	(i) Arts and crafts (ii) Reading (iii) Board games, blocks
Physical activity resources (used during the after-school program)	(i) Playground (ii) Gymnasium with basketball court (iii) 2 playing fields (iv) Running trail (v) Swimming pool	(i) Playground
Cost	(i) Free of cost to families (ii) Department of Parks and Recreation assumed operational costs (iii) Public school system assumed transportation costs	(i) $46.50/week paid by family (ii) Financial assistance available

considered an objective measure of physical activity [14] and has been used with children [15, 16], including Latino and African-American children, with high reliability: $r = 0.93$ [17]. The ActiGraph is a small monitor that is worn on an elastic waist belt and measures the intensity of physical activity associated with locomotion. Monitors were programmed to record in continuous 10-second epochs to capture the short, spurt-like activity characteristic of children. At each measurement period, the children wore monitors for five consecutive days, from the time they signed into the ASP until they were picked up. Measurement start and stop times were recorded by study staff at each site; these were used as precise wearing cut-off points, eliminating the need for wearing/nonwearing time analysis. Data were retained in analysis if the child wore the accelerometer a minimum of 3 days of the given measurement period [18, 19].

Freedson's age-dependent cut points were used to determine time spent in sedentary, light, moderate, and vigorous activity [20]. Trost's validation study comparing various accelerometer cut points for predicting physical activity in children supports the application of Freedson equations in field-based studies of school-aged children. In particular, Trost found that, for classification of MVPA (moderate-vigorous physical activity), Freedson cut points exhibited excellent classification accuracy [21]. The analyses described below were also conducted using Pate's cut points and resulted in similar findings (not reported here) [22].

Daily percentage of time spent in each level of physical activity (i.e., sedentary, light, moderate, and vigorous) was determined by dividing the minutes spent in each activity level by the sum of minutes the ActiGraph was worn in a day (i.e., time in attendance at the ASP). Children spent varying amounts of time in ASPs depending on their family needs. Thus, the continuous outcome measures were the proportion of time spent in LMVPA (light-moderate-vigorous physical activity) or MVPA (moderate-vigorous physical activity) out of total time in attendance, rather than the number of minutes the program was open, to allow for a meaningful comparison within individuals and across groups. Daily percentages were averaged across days to create individual participants' physical activity (PA) scores at each measurement period.

2.3.2. Body Mass Index (BMI). Body weight was measured after voiding while children wore light clothing without

shoes. Calibrated digital scales (Detecto, Webb City, MO, USA, Model#758C) were accurate to the nearest 0.1 kg. Body height without shoes was measured to the nearest 0.1 cm with the scale's stadiometer. BMI percentile, adjusted for age and gender, was calculated using these measurements [23]. Weight categories were defined by BMI percentile, according to Centers for Disease Control growth charts: underweight: <5th percentile; healthy weight: 5th to <85th percentile; overweight: 85th to <95th percentile; obese: ≥95th percentile [23].

2.3.3. Body Fat Percentage. Body composition was measured by the RJL Systems BIA Quantum II (RJL Systems, Clinton, MI, USA) after voiding. Standard procedures for whole body bioelectrical impedance measurement were used [24], along with the vendor-provided child-specific regression equation to estimate percent fat mass from total body water.

2.3.4. Fitness. Children were asked to complete a 1/2 mile run as fast as possible on a running track [25]. Time of completion was recorded to the nearest second.

2.3.5. Demographics. Parents completed a survey asking about child's date of birth (used to calculate age), gender, race/ethnicity, and name of school.

2.4. Statistical Analysis

2.4.1. Analysis of Preexisting Site Differences. Because children were not randomly assigned, preexisting differences between groups were potential confounders. Therefore, we compared children enrolled in the ASPs to test for differences on basic demographic and process variables, using bootstrap t-tests that controlled for the familywise false discovery rate [26].

2.4.2. Physical Activity Data Analysis. To assess change in PA over time, a conditional linear latent growth model was used with random intercepts and slopes that were free to covary and time varying error variances. The model was estimated using Mplus version 6.11 [27]. This approach offers important advantages over older analysis of variance (ANOVA) models [28], such as (a) better accuracy in assessing change over time, (b) graceful handling of missing values and unequal time intervals between waves and participants, and (c) repeated measurements that increase statistical power [29]. The key result is a group by time interaction, which shows whether groups differ in their slopes/rates of change in PA. Centering time zero at the first measurement let us answer two questions: (1) Did the groups start out equally? And (2) did their time slopes differ? The analysis assumed data were missing at random and used full information maximum likelihood to maximize sample size by including all participants with at least one wave of data.

2.4.3. Cost-Effectiveness Analysis. We used the cost analysis guidelines for research evaluation proposed by Levin and McEwan [30]. Using the ingredient method, we estimated the implementation costs, without estimating indirect costs or externalities associated with the programs, to indicate how much it would cost to replicate each ASP. Instead of accounting expenditures paid during the implementation, we valued resources using standard costs to society. All personnel time (including volunteer time) was valued by using the median earning per hour of a comparable worker published by the Bureau of Labor Statistics 2010 [31]; thus, differences in human capital endowment did not affect our estimates of implementation costs.

3. Results and Discussion

Of the 91 children who attended the ASPs, baseline demographics were obtained from parents of 83 children. The analytic sample included the 82 children with PA data from at least one time point; one child in the school-based ASP did not provide at least 3 days of PA data in any measurement period and was not included in the analyses. Of the 82 participants, 62 had data for all three time points, 16 had data for two time points, and 4 had data for only one time point.

3.1. Demographics and Process Measures. The baseline sample was 65% female and 7.9 years of age (SD = 1.7) on average; 57% were healthy weight, 23% overweight, and 20% obese; 40% were African-American, 40% White, and 20% Latino. On average at baseline, children spent 77.4% (SD 10.3%) of the ASP in LMVPA and 27.5% (SD 14.3%) in MVPA. At baseline, children in the two ASPs did not differ in gender, age, BMI, percent body fat, fitness (Table 2), or physical activity level (Table 3). However, children in the community ASP were less likely to be white than children in the school-based ASP (P = .027, Table 2). At baseline, children spent approximately 30% of their ASP time in MVPA (SD = 15.6).

3.2. Change in Physical Activity over Time. The linear latent growth model implied that, on average, children in the community ASP became more active over time (average change between Baseline-Week 6 and Week 6-Week 12), compared to the children in the school-based ASP (Table 3). Children in the school-based ASP reduced their total physical activity (LMVPA) by an average of 3.4 percentage points over each measurement period (P = .002), for a total 6.8 percentage point decrease over the 12-week study period. In contrast, children in the community ASP increased their total physical activity (LMVPA) by an average of 3.0 percentage points over each measurement period (P = .006), for a total 6 percentage point increase over the 12-week study period (Figure 1). Most of this increase in activity was in high intensity activity. Children in the school-based ASP did not significantly change their MVPA on average (P = .12). However, children in the community ASP increased their MVPA by an average of 2.8 percentage points over each measurement period (P = .006), for a total 5.6 percentage point increase over the 12-week study period (Figure 2). Taken together, the model-implied average difference between the two groups of children at Week 12 was 15.4 percentage points in LMVPA (P < .001) and 14.7 percentage points in MVPA

Table 2: Between-group comparison of baseline and process measures.

	Community ASP (n = 47)				School-based ASP (n = 36)				P^*	
	Mean/%	SD	Min	Max	Mean/%	SD	Min	Max	P_{raw}	P_{boot}
Child characteristics										
Male	43%				25%				0.10	0.44
Hispanic ethnicity	26%				11%				0.10	0.45
Black	47%				31%				0.14	0.57
White	26%				56%				**0.005**	**0.027**
Age at baseline (yrs)	8.79	1.67	5.57	12.08	7.96	1.55	5.45	10.34	0.023	0.12
BMI percentile**	74.74	23.60	8.40	99.60	73.87	21.03	11.60	99.40	0.86	1.00
Body fat percentage	29.26	11.27	5.80	54.30	29.92	8.08	15.90	48.60	0.77	1.00
Fitness (1/2 mile run time in min)	6.29	1.09	4.23	9.41	6.08	1.13	4.23	8.51	0.40	0.99
Process measures										
Waves of data collection per child	2.83	0.52	1.00	3.00	2.92	0.37	1.00	3.00	0.40	0.94
Minutes activity monitor worn per measurement period	108.74	20.37	57.60	143.00	105.83	27.02	33.20	149.25	0.59	1.00

*To control for multiple testing we show the raw probability of alpha along with a bootstrap simultaneous alpha based on 100,000 resamples with replacement.
**Underweight: <5th percentile; healthy weight: 5th to <85th percentile; overweight: 85th to <95th percentile; obese: ≥95th percentile.

Table 3: Between-group comparison of time spent in physical activity (model-implied estimates).

	Community ASP		School-based ASP		Group difference	
	% Time at activity level	P (difference from 0)	% Time at activity level	P (difference from 0)	% Time at activity level	P (for group difference)
Baseline						
LMVPA	78.4	<0.001	75.8	<0.001	2.6	0.30
MVPA	30.1	<0.001	24.2	<0.001	5.9	0.06
Change per measurement period (6 weeks)*						
LMVPA	3.0	0.006	−3.4	0.002	6.4	<0.001
MVPA	2.8	0.006	−1.6	0.12	4.4	0.002

*Average change between Baseline-Week 6 and Week 6-Week 12.

(P < .001), favoring the activity-enhanced community ASP. However, as a more conservative indicator, the observed average difference between the two groups of children who had data at Week 12 was 10.8 (P = .001) percentage points in LMVPA and 13 percentage points in MVPA (P < .001).

3.3. Cost-Effectiveness Analysis. The community ASP served 54 children; the school-based ASP served 37 children. Total implementation costs (valued in 2010 dollars) for the 12-week study period were $1,184 per child ($19.25 daily per child) for the community ASP, compared to $1,087 per child ($17.67 daily per child) for the school-based ASP (9% difference; Table 4). The facility cost represented 66% and 65% of the total implementation costs to run the community ASP and school-based ASP, respectively. The main source of cost differential between programs was the child to staff ratio (6 : 1 at the community ASP, 12 : 1 at the school-based ASP). To run the ASPs for 12 weeks, the personnel cost was $380 per child for the community ASP compared to $314 per child for the school-based ASP (21% difference).

3.4. Implications. With more than 23 million parents of school-aged children employed full-time [32], ASPs are ideal for systematic interventions to increase physical activity. This study demonstrated that, compared to a standard-of-care school-based ASP, an ASP set in a community recreation center with activities directed by recreation staff significantly increased total physical activity in a multiethnic sample of public school children by 6 percentage points over 12 weeks. Most (5.6%) of this increase was in MVPA, which is the type of physical activity that has the greatest health benefits [33–35]. The incremental cost of implementing the activity-enhancing ASP compared to the traditional ASP was $1.59 per day per child. The main source of cost differential between programs was their child to staff ratios.

Assuming the improvement in activity was solely due to the intervention; these findings suggest that children attending traditional school-based ASPs, already costing an average of $17.67 per day, would need an additional daily investment of $1.59 per child over 12 weeks to increase their LMVPA by 15.4 percentage points or their MVPA by a model-implied 14.7 percentage points. Cost-effectiveness analyses

Table 4: Total implementation cost per participant and program (2010 dollars).

	Community ASP (serving 54 children with 9 staff members/volunteers)	School-based ASP (serving 37 children with 3 staff members)
*Facilities*** (space used in sq ft)	$781	$706
Personnel (hours per day, days worked, and hourly rate of staff/art teacher/volunteers)	$380	$314
Snacks	$17	$62
*Recreational equipment**** (e.g., games, toys, sports gear, and art supplies)	$6	$4
Total direct cost per participant for 12 weeks	$1184	$1087
Daily direct cost per participant	$19.25	$17.67

**The facilities used by the community ASP covered a larger area compared to those used by the school-based ASP (111,130 sq ft, versus 68,940 sq ft). The space available for these programs was valued based on $1 per sq ft, assuming participants used 50% of the available space while the other 50% continued to be available to the public. We estimated the cost of using the facilities during 3 hours per day over the 61.5 days of study period.
***The school-based ASP reported a 100% depreciation rate within one year. The community center program also reported 100% depreciation rate for light recreational equipment within one year and a 5-year life span on electronics and large equipment.

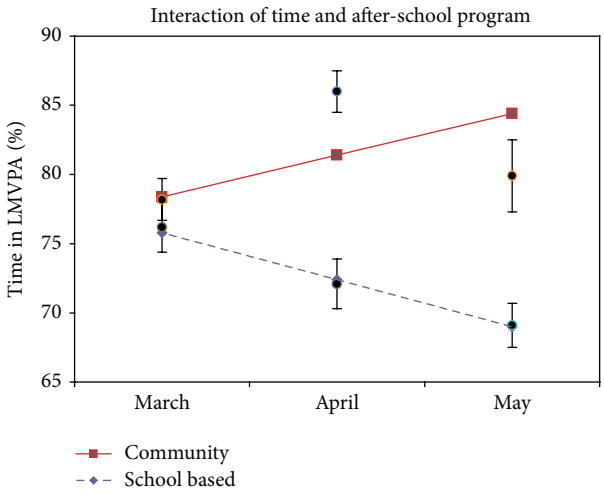

Figure 1: Percent of time spent in physical activity (LMVPA) after-school. Notes: lines show mixed model outcome slopes; points show observed means ± standard error.

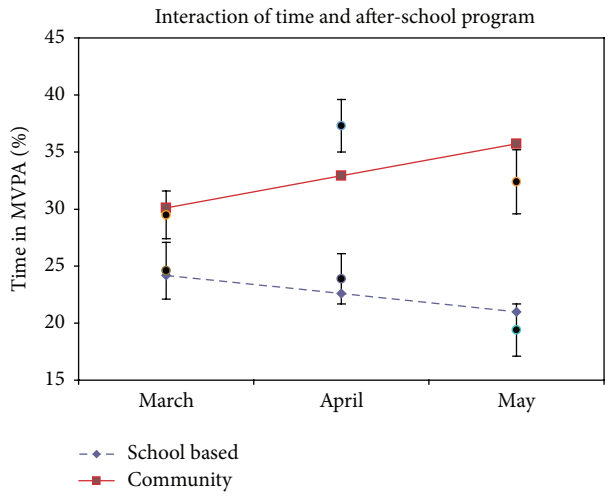

Figure 2: Percent of time spent in moderate/vigorous physical activity (MVPA) after-school. Notes: lines show mixed model outcome slopes; points show observed means ± standard error.

are often lacking for community-based prevention efforts. The annual cost of childhood obesity-related health expenses in the US is $14.1 billion for outpatient care and $237.6 million for inpatient care which translates to about $5 in healthcare expenses per day per child, without including other relevant long-term costs related to school performance, labor market involvement, quality of life, welfare needs, and so forth [36]. Given this, providing structured PA programming by qualified staff in a community recreation center in the after-school hours could be a reasonable low-cost investment.

ASPs have long played a critical role in supporting academic achievement, safety, discipline, and avoidance of risky behaviors [37]. They could now be leveraged as part of a broader approach to address physical inactivity. Community centers operated by local parks and recreation departments (20,000 nationally) provide an ideal venue for structured PA programming for children [38] in large part because these centers, in conjunction with school transportation departments, can address community-based barriers [6] to increasing children's activity levels. It is noteworthy that the parks staff initiated and led this program on their own. Their intimate knowledge of the community and the respect they commanded from both the children and adults in the community likely contributed to the program's success. We speculate that the combination of the built environment that supported activity, low child to staff ratio, and intentional

activity leadership resulted in the increased PA levels. The school-based ASP could have let children play in the school's gymnasium if there had been additional staff available to supervise. Thus, we speculate that importing adult-led activities with lower child to staff ratios into school-based ASPs might be a cost-effective approach to increasing activity in that setting as well. This would need to be tested.

3.5. Limitations. First, accelerometers do not adequately measure body movements of upper and lower extremities, but they are considered the gold standard for measuring PA under free-living conditions. This should not have biased our results since the limitation of accelerometry was the same across groups. Second, our sample was small but having three waves of data increased statistical power and was sufficient for detecting a significant increase in PA under free-living conditions. Third, despite efforts to select a comparable comparison group and measure potential confounders, we cannot rule out all systematic differences between the two groups. We did rule out the most important possible confounds in the literature: body composition, fitness, age, and gender. It is possible that the difference in racial composition of the groups could explain baseline variance [39] but is unlikely to explain change over time in activity levels.

Fourth, for the community ASP, there were significant differences between the observed and model-implied averages at Weeks 6 and 12. These discrepancies highlight the fact that the final specified model did not perfectly recreate the observed data. This could have been partially due to missing data for this group at either time point. The discrepancies could also have arisen because the community ASP's growth rate was not linear; yet, a model with only three time points does not have the degrees of freedom to investigate more sophisticated growth parameter specifications (e.g., quadratic). Nonetheless, applying latent growth models has provided further insight into how ASPs might impact children's PA over time (e.g., what effect does ASP type have on PA change over time? What is the typical growth rate of PA for children over time? Do some programs increase the growth rate of certain types of PA (e.g., light, moderate, or vigorous) more than others? What is the functional form of PA change over time?)

4. Conclusion

An ASP set in a community recreation center and led by recreation staff incorporating structured physical activity opportunities was associated with significant increases to physical activity during ASP time in a multiethnic sample of public school children in 12 weeks, compared to a standard school-based ASP. Utilizing community recreation centers' built environment and staff could be a promising low-cost proposition to improve health trajectories among school-aged children.

Conflict of Interests

The authors declare that no competing financial interests exist.

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Clinical Study

An Adaptive CBPR Approach to Create Weight Management Materials for a School-Based Health Center Intervention

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Purpose. From our previous clinical work with overweight/obese youth, we identified the need for research to create an effective weight management intervention to address the growing prevalence of adolescent metabolic syndrome. Formative assessment through an adaptive community-based participatory research (CBPR) approach was conducted toward the development of a nutritional and physical activity (DVD) and clinician toolkit for a school-based health center (SBHC) weight management intervention. *Methods*. We first conducted parent and adolescent interviews on views and experiences about obesity while convening a community advisory council (CAC) recruited from two participating urban New Mexico high schools. Thematic findings from the interviews were analyzed with the CAC to develop culturally and developmentally appropriate intervention materials. *Results*. Themes from the parent and adolescent interviews included general barriers/challenges, factors influencing motivation, and change facilitators. The CAC and university-based research team reached consensus on the final content of nutrition and physical activity topics to produce a DVD and clinician toolkit through six monthly sessions. These materials used in the SBHC intervention resulted in a greater reduction of body mass index when compared to adolescents receiving standard care. *Conclusions*. Formative assessment using an adaptive CBPR approach resulted in the creation of culturally and age appropriate weight reduction materials that were acceptable to study participants. This trial is registered with ClinicalTrials.gov NCT00841334.

1. Introduction

An unfortunate consequence of the childhood and adolescent obesity epidemic is the emergence of metabolic syndrome, a condition that was historically seen in adults. Thirty percent of obese adolescents in the United States meet criteria for metabolic syndrome [1] and the prevalence is increasing [2]. Consistent with adult rates, prevalence of metabolic syndrome in adolescents is highest among Hispanics, followed by African Americans when compared to non-Hispanic whites [3], while type 2 diabetes is increasing among American Indian adolescents more than any other racial/ethnic group in the United States [4].

Weight loss through behavioral modification is an appropriate first step in the primary care treatment of metabolic syndrome [5]. Nevertheless, almost 80% of pediatricians report frustration with their ability to make an impact on obesity [6] and many providers feel they do not have the tools to effectively address lifestyle modification for weight loss [7]. Schools, where children and adolescents spend the majority of their time, are promising venues for intervention work [8]. A recently released Institute of Medicine report strongly endorsed this perspective, citing schools as a "national focal point" in efforts to address obesity in children and adolescents [9]. As several systematic reviews demonstrate, however, there is a paucity of obesity intervention research in high

school settings targeting older adolescents and even less in school-based health centers (SBHCs) [10–12]. Located in the school setting, SBHCs offer a unique opportunity for health care delivery. SBHCs have several compelling features for a successful lifestyle intervention program to treat overweight/obesity and prevent development of metabolic syndrome: (1) SBHC clinicians have more access to adolescents than community health care providers; (2) adolescents have better compliance and followup in school-based clinics (both of which are needed for weight loss and maintenance); and (3) SBHCs focus on early identification of high-risk problems [13–18].

In response to the obesity epidemic and adolescents' interest in promoting physical activity and healthy eating, our research was built on a long-standing partnership between the University of New Mexico School-based Health Center Program and an urban school community. Through previous engagement with school-based clinicians and adolescent students, we reached consensus on collective interest to create a DVD to help adolescents achieve weight loss and a clinician tool kit to assist providers in their motivational interviewing efforts [19]. This partnership led to the creation of a culturally and developmentally appropriate overweight/obesity intervention program, Adolescents Committed to Improvement of Nutrition and Physical Activity (ACTION). Consistent with American Academy of Pediatric Expert Committee recommendations regarding the treatment of adolescent overweight/obesity, the ACTION intervention featured eight sessions with a health care provider using motivational interviewing to encourage behavior change toward active living and healthful eating [20]. This paper describes the use of an adaptive community based participatory research (CBPR) process through which formative research data were collected for development of an SBHC intervention for prevention of metabolic syndrome in multiethnic high school students.

2. Methods

2.1. Overall Design: Formative Assessment Using a CBPR Approach. Formative research is used to understand people's beliefs, perceptions, and behaviors for the purpose of developing culturally appropriate behavioral change programs [21]. Health researchers typically include a formative "stage" of research in their study designs to ensure that the identification of such cultural attributes and contextual factors can be integrated into intervention activities [22–24]. Given our interest in developing intervention tools (DVD and Toolkit) to help school-based providers and multiethnic adolescents, we designed this study to ground formative assessment through a CBPR partnership [25, 26]. Our review of the literature revealed that use of CBPR in formative research is quite limited and we have not found examples of other manuscripts reporting this type of approach in the context of an SBHC study [27]. We provide further detail showing the link between CBPR principles and our research steps in Table 1.

To maximize time for development and completion of the DVD and toolkit in one year, recruitment for semistructured interviews with overweight/obese adolescents and parents of overweight/obese adolescents was concurrent with recruitment of overweight/obese adolescents and their parents to the Community Advisory Council (CAC). Adolescents and parents were recruited from the two participating urban high schools with long-standing school-based health centers. Interviews with participants unknown to the CAC were conducted to obtain fuller disclosure of sensitive information about living with obesity that the University research team felt may have been too sensitive to discuss openly among the CAC members. In the second year of the study, the intervention was implemented using these materials. The study protocol was approved by the University of New Mexico Human Research Protections Office and the Urban Schools' Research, Development, and Accountability Department.

2.2. Student and Parent Interviews

2.2.1. Participant Recruitment. A purposeful sampling strategy that reflected the culturally diverse school population was used to recruit overweight/obese adolescent and parent dyads. Given the intent to understand perceptions of obesity and barriers/facilitators to weight loss, we focused recruitment efforts on overweight/obese adolescents. We also conducted "extreme case" sampling to identify adolescents who self-reported success in achieving weight loss (Table 2). We believed that these more unusual cases would lead to insights relevant to our intervention development. All of the adolescents were referred to the research team by participating school-based health center providers and partnering school staff (e.g., counselors, school nurse, and teachers). We interviewed parents most responsible for food preparation in the household. The research team coordinated recruitment efforts with collaborators at the participating high schools including the Activity Directors, School Health Advisory Council members, Student Senate members, and SBHC clinicians.

2.2.2. Data Collection. Adolescent and parent interview guides were designed to assess concordance of perspectives in the following areas: media use and information seeking strategies, definitions of health, health concerns (weight related), strategies/approaches to weight loss, barriers/facilitators to health in the school and home environment, and suggested content and style for the DVD. The interview guide was designed to be neutral to potentially stigmatizing perspectives about adolescent obesity and contributing factors. Adolescents and parents were interviewed separately and interviews were conducted at times and locations convenient for the family, mostly in their homes and some at the University. Consent/assent forms were mailed in advance for review and respondents were formally consented at the start of each interview. Most interviews lasted approximately one hour and each respondent received a $20 reimbursement for their time.

2.2.3. Analytic Process. Following an iterative analytic process, the multidisciplinary research team—including a medical anthropologist, adolescent medicine physician, primary care nurse practitioner, health communications researcher,

Table 1: Research activities associated with CBPR Principles.

CBPR principle	Research Activities
Acknowledging the school community as a unit of identity	Interact with full range of school representatives including administrators, SBHC personnel, students, and teachers
Building on strengths and resources within the school community	Intervention developed from prior work in target schools; use available resources (SBHC)
Facilitating collaborative partnerships in all phases of research	Meet regularly with all key stakeholders in participatory design
Fostering colearning and capacity building among all partners	Iterative process to review emergent themes and reach consensus on intervention strategies
Focusing on local relevance of the public health problem of obesity	ACTION study focus derived from key school system stakeholders
Involving a cyclical and iterative process	Each stage of research codeveloped, reviewed and, approved by partners
Involving a long-term process and commitment to sustainability	Members of the university team (UNM SBHC staff and PI) have over a decade of involvement in the school settings

Table 2: Demographic characteristics of student and parent interviewees.

	Students ($N = 7$)	Parents ($N = 8$)
Participating schools		
Intervention	2	3
Control	5	5
Sex		
Female	4	6
Age (mean years)	16	45
Ethnicity		
Hispanic	3	3
African American	2	2
American Indian	1	1
Non-Hispanic white	1	1
Other	0	1
Employment status		
Full time	0	4
Part time	3	2
Not employed	4	2

and community based participatory research practitioner—reviewed sets of 3 to 4 transcripts independently, identifying key themes relevant to the subsequent creation of the intervention materials. The team reviewed emergent themes and developed a preliminary analytic framework. We specifically focused on responses between adolescents and parents, seeking both complementary and divergent perspectives on key elements for the DVD and provider toolkit materials including content, messaging, and context of use. Ongoing data collection and analysis continued until 15 interviews had been conducted (7 students, 8 parents; the sample consisted of 6 parent-child pairs), at which point the research team reached consensus that the full range of interpretive themes had been identified. At that point, the medical anthropologist (ALS) coded each interview in the qualitative data analysis software program NVivo 8 to facilitate text retrieval and create summary reports [28]. Further demographic details of the student and parent interviewees are presented in Table 2.

2.3. Acceptability and Satisfaction with ACTION Components. Following the intervention and as part of a broader process evaluation effort designed to examine a range of implementation issues, we assessed adolescent and parent views of acceptability and satisfaction with the materials developed in the formative phase.

2.3.1. Data Collection. Intervention students were each asked to fill out questionnaires with Likert scale ratings of the ACTION DVD, toolkit handouts, and overall satisfaction with the intervention. Parent questionnaires focused on materials they received as part of the ACTION intervention, including a parent newsletter as well as views of the toolkit handouts and overall satisfaction with their child's participation in ACTION.

2.3.2. Data Analysis. Descriptive summaries of the questionnaires for each group were assessed. Frequencies, confidence intervals, and summary statistics were calculated for all variables.

2.4. CBPR Process: Formation of the Community Advisory Council. Once the interviews and a preliminary analytic summary had been developed, we convened the Community Advisory Council (CAC) as a forum in which to translate themes from the interviews into specific strategies and materials to be used in the intervention. Our goal was to form a group with similar demographic characteristics to the targeted study population: Hispanic, African American, and American Indian overweight/obese students and their parents. Given our expectation of attrition, we recruited a total of 16 participants (divided equally between students and parents, including four parent-child pairs).

We began a series of six consecutive monthly meetings from December 2008 to May 2009 at the University of New Mexico during which the DVD and toolkit were developed. The CAC met on a less frequent basis throughout the second year of the study (August 2009 to May 2010) to provide implementation guidance and feedback. Meetings were held in the evenings to accommodate work and school schedules.

We provided a full dinner, free parking, and reimbursement for travel expenses ($10) for all participants immediately following each meeting. CAC members were also informed that all would receive the DVD resulting from their efforts as well as a personal DVD player.

Sessions were typically comoderated by the DVD producer and study coinvestigator (ALS). However, when meetings were focused on topics of nutrition and/or physical activity, sessions were led by the research team registered dietician and fitness expert. This approach addressed a central CBPR principle in fostering information exchange between community members and the research team. The meetings were designed to be cyclical and iterative as a way to reach consensus and tailor evidence-based strategies to ensure the cultural and age appropriateness of the DVD and toolkit materials as well as stylistic elements (e.g., music and images). Given the flexible, participatory nature of these meetings, CAC members shaped the process by volunteering to test potential data collection methods (e.g., maintaining a food diary) and requesting further information of the research team to facilitate colearning (connections between obesity and health).

3. Results

Overview. We have organized the presentation of results to reflect the sequential process of data collection leading to the creation of the ACTION intervention materials. We first present the thematic findings from key informant interviews that provided guidance to the research team and the CAC. We then describe how the CAC translated this input into the DVD and provider toolkit. Lastly, we include process evaluation measures reflecting adolescent and parent views of these materials following the ACTION intervention.

(I) Key Interview Themes

(1) Media Use. Adolescents consistently indicated use of the internet as a primary source for both entertainment and information seeking. Most students reported easy access to the internet either at home and/or during school. As one adolescent female indicated

> *"A lot of people get on the internet. A lot of teenagers I know use the internet and look up information that way. If it's something that looks interesting they'll go look at it."*

Further, most adolescents described using the internet as a way to gather health information about a range of issues, including diet and exercise. They viewed the internet as a reliable source of information that could be accessed in private. Another female adolescent described using the internet for health information and as a basis for discussion with her doctor:

> *"They have that pyramid, I'm not sure what it's called. And you can look at how many calories you're supposed to take in a day and I looked at those and I just started doing that last month with my doctor."*

(2) "Functional" Definition of Health. In each of the interviews, we asked adolescents how they define health and what that means to them. In some cases, they identified the association between being overweight/obese and the future development of health problems such as diabetes and heart disease. Several of these teens were aware of these risks given family members dealing with these conditions. However, the most striking theme to result from these interviews related to how being overweight/obese limited adolescents activities in the present. Overall, they were less concerned with the long-term consequences and referred to a "functional" definition of health that focused on the degree to which their weight impacted the ability to engage in activities of interest. One male adolescent, echoing the response of several others, responded to the question "what does it mean to be healthy?" by stating "Being healthy to me is being active."

(3) Barriers to Weight Loss in the School. Not surprisingly, both teens and parents reported a wide range of challenges related to their struggles with food choices and physical activity in their weight control efforts. Teens consistently noted that healthful foods/drinks were not available in the school setting. Adolescents regularly purchased foods from vendor carts but were frustrated by the lack of healthful options such as water rather than soda. In addition to expressing a need for healthier snacks from vendors, the teens also pointed to unhealthful meal choices at school. As a potential way to address this problem, one teen stated

> *"...mostly not sell as much pizza, 'cause like everywhere you go they sell pizza and burritos, like breakfast burritos and sometimes even regular burritos at lunch. Even if they change the menu up a little bit that'd be better because it wouldn't be the same thing every day—just burritos, burritos or pizza, pizza, pizza."*

Parents consistently agreed with adolescents about the need for schools to offer foods that are both appealing and offer higher nutritional value.

Another challenge identified by both the teens and the parents is the lack of opportunity for exercise in the school setting. Teens emphasized the need for more physical activities not related to formal participation on sports teams. Parents focused their concern on curricular issues such as the need to require a gym class for all four years of High School rather than just one semester.

(4) Strategies to Achieve Weight Loss. Several adolescents interviewed reported success in their efforts to lose weight. Although a range of strategies were described—mostly involving diets and increases in physical activity—adolescents expressed the importance of internal motivation as the essential element in weight loss initiation efforts. Consistent with the "functional" definition described above, students identified personal goals such as making a sports team or improving their appearance for a significant school event such as the prom as a reason to make physical activity and nutritional changes. Similarly, there was consensus

among the parents that it was their obligation to serve as a principal source of motivation. As one parent said

> *"I would have to say it (motivation) would have to be left on the parent's shoulders. I think if they see the parents motivated to want to exercise and take care of their body and eat healthy then the children are going to see that and that's going to help them. 'Okay, mom's doing this, maybe we should do this, too.'"*

(5) Parent Views on Changing Home Environment. While we mostly focused these interviews on the school environment, we specifically engaged parents about the challenges they confront in weight loss efforts at home. The goal of these discussions was to elicit strategies that could be included in the home-based component of the ACTION intervention. Parents echoed the adolescents in recognizing the broad importance of motivation as a way to initiate health behavior changes. As one mother indicated

> *"Some ideas on how to motivate your kids…ideas on how to keep them wanting to live a good lifestyle, you know, healthy lifestyle and full of exercise. That's a real big one for me, motivation. And then just trying to change their mentality, change their way of thinking so that it's stuck in their head. My goodness, it's hard."*

We also asked parents for suggestions of informational needs about nutrition and/or physical activity that would be useful to them at home. Another mother described interest in having a list of practical comparisons of food choices:

> *"I always find it interesting…when they do comparisons like which is actually the healthier (food) and you're going, 'I don't know, they're actually both kind of bad, but which is actually the better choice?'"*

(6) Input on DVD Content. Lastly, the interviews provided a rich opportunity to gather input on content and stylistic elements of the proposed DVD. Consistent with the theme of internal motivation, most adolescents requested that the DVD content did not scare or threaten by presenting adverse health consequences of overweight/obesity. Instead, they emphasized the importance of featuring teens in the DVD that were currently overweight/obese so that adolescents would relate more to the content:

> *"Include overweight people…and show that they're really working hard and then show them successfully doing it and get in a normal (weight) range."*

Reflecting common elements of teen culture, most of the teens suggested using popular activities as a vehicle through which the messages could be promoted. This included differing forms of dance, kickboxing, use of appropriate music, and presenting these activities with careful attention to style through rapid cutting to different camera angles and shots. When asked what should be in the DVD, one male adolescent quickly responded

> *"Dancing, I'm pretty sure 'cause everyone loves to dance; say if you want to learn how to fight and get in shape and defend yourself there's kickboxing, so pretty much those things."*

(II) Translating Themes to DVD and Toolkit with the Community Advisory Council. As the research team finalized the analysis of the parent and adolescent interviews, we convened the CAC and held the first of six consecutive monthly sessions. The first session was primarily an orientation to the project and subsequent meetings were led by content expert moderators from the research team to identify and refine intervention content. Below, we provide a list of the major themes and the resulting strategies that were integrated into the DVD and toolkit. Table 3 provides a summary of these themes and strategies.

(1) Media Use and Information Seeking. Interviewed adolescents expressed reliance on using the internet for a range of informational needs. CAC participants confirmed this and agreed with a proposal to include websites in the intervention materials for adolescents to access nutritional and physical activity information. During one of the sessions, we reviewed potential websites for inclusion (ranging from purely informational to highly interactive) with the CAC and our final selection was based on feedback pertaining to ease of use and clarity of presentation.

(2) "Functional" Definition of Health. We presented the "functional" definition of health articulated during the adolescent interviews and the CAC concurred with the preference to encourage individual autonomy and goal setting rather than emphasize negative outcomes associated with poor health. The CAC adolescent participants were clear that the kids in the DVD needed to be "real teens" (both overweight/obese and not overweight/obese teens) dealing with challenges of weight. This strategy was incorporated into the DVD by having CAC participants and friends appear in the DVD and briefly describe their struggles as well as the internal sources of motivation that inspired them to make changes.

(3) Barriers to Weight Loss in School. The CAC recognized the challenge to achieving weight loss in the school environment. The group advocated that the DVD contain practical nutritional information to help them make healthier choices amongst likely food offerings (e.g., pizza, burritos, bagels, etc.). Websites containing further information were also referenced in both the DVD and health care provider toolkit.

(4) Strategies to Achieve Weight Loss. As described above, teens indicated that any effort to achieve weight loss had to begin with an individual identifying some type of internal motivation and, ideally, having a supportive network of friends and family to sustain the effort. While the CAC agreed with this perspective and specific strategies were included in the DVD to encourage recognition of this internal motivation, the group also advocated for the inclusion of physical activities to "jumpstart" the process. Therefore, following the input of both the interviewees and the CAC,

Table 3: Key informant themes and resulting intervention strategies.

Theme	Resulting Strategies
Media use	Include healthy weight and physical activity web sites in DVD and provider toolkit
"Functional" definition of health	(i) Include "real kids" (overweight/obese and non-overweight/obese) in DVD (ii) Documentary-style interviews with adolescents discussing their reasons for eating healthier and being physically active in DVD
Barriers to weight loss in schools	(i) Add practical nutritional information in DVD and toolkit that match food offerings in schools to facilitate better nutritional choices (ii) Food displays in clinic to facilitate discussions on how to choose healthier options
Strategies to achieve weight loss	(i) Promote emphasis of weight loss as consistent with personal, internal sources of motivation (ii) Incorporate brief instructional segments in DVD consistent with adolescent interests (e.g., dance, kickboxing, strength/resistance training)
Parent views on changing home environment	(i) Create mechanism for communication between health care provider and parents to provide regular updates and reinforce ACTION themes (ii) Distribute parent newsletter and healthful recipes
Input on DVD content	Ensure that DVD featured three sections: (1) adolescent motivation for change; (2) strategies targeting energy balance and nutritional quality; and (3) physical aerobic dance and strength/resistance training segments

brief instructional segments featuring dance, kickboxing, and weight lifting were added to the DVD.

(5) Parent Views on Changing the Home Environment. Adolescents and parents in the CAC agreed that it was not sufficient to only focus on the school environment. The group offered a series of strategies for involving parents in a practical and appropriate way during the ACTION intervention. This included having the school health provider call the parent to provide regular updates, distribution of a short parent newsletter, and ideas for affordable and quick healthy recipes for busy families.

(6) DVD Content. Toward the conclusion of the six CAC sessions in the first year of the study, the group reached consensus on three sections to feature on the DVD: (1) adolescent motivation for change, (2) strategies targeting energy balance and nutritional quality, and (3) physical aerobic dance and strength/resistance training instructional segments. The CAC reviewed each of the elements to be included in the DVD as well as offered stylistic suggestions relating to background music and video editing techniques to appeal to adolescents.

(III) Use of the ACTION DVD and Toolkit. At the conclusion of the six CAC sessions, coordination and filming of the DVD were led by the video producer. Many of the CAC members—teens and parents—participated in this process and appear in the final DVD either sharing their own personal stories or presenting the nutrition or physical activity strategies. The ACTION Toolkit contained a parent newsletter and adolescent session tools (e.g., goal setting, internet resources, activity/food journal, etc.).

(IV) ACTION Outcomes and Satisfaction Results. While the focus of this paper is to report on the process of developing the ACTION intervention materials, we are also able to offer a brief overview of process evaluation findings related to participant satisfaction with these components as well as the primary outcome measure.

Health outcome measures for the ACTION study showed that students receiving the intervention had greater pre-postimprovements in BMI percentile ($P = 0.04$) and waist circumference ($P = 0.04$) as compared to the standard care control group. BMI median percentile decreased 0.3% in the intervention group while the standard care control group's BMI median percentile increased by 0.2%. Mean waist circumference in the intervention group remained unchanged and there was a 1.7 cm increase in the standard care group. While these outcome measures are important, we also conducted process evaluation aimed at elucidating factors that may help us to better understand how the use of this adaptive CBPR approach relates to these results.

Students reported high levels of satisfaction with the materials used in the intervention. On a scale of 0 (not at all useful) to 5 (very useful), students were asked to rate the usefulness of the DVD ($N = 26$; mean score 3.1), the clinician toolkit handouts ($N = 27$; mean score 4.0), and their overall satisfaction with the intervention ($N = 28$; mean score 4.4). Similarly, parents expressed satisfaction with their involvement in the ACTION project. Parents favorably rated the usefulness of the parent publication ($N = 18$; mean score 3.6), the usefulness of the clinician toolkit handouts ($N = 23$; mean score 3.7), and their overall satisfaction with the intervention ($N = 25$; mean score 4.4). Lastly, process evaluation findings reveal high rates of retention among participants in both the intervention group (90%) and standard care control group (79%).

4. Discussion

We used formative assessment research guided by an adaptive CBPR approach to create an SBHC obesity intervention program. The student and parent interviews generated initial thematic findings that were used to guide discussions in the subsequent CAC sessions toward the development of the intervention DVD and clinician toolkit. This approach enabled us to accomplish the following goals in the first year of this study: (1) gain a better understanding of the school setting with regard to barriers to physical activity and healthful food choices, (2) create strategies/materials to address these barriers, and (3) develop culturally appropriate intervention materials and approaches based on input from study participants. This intervention led to promising health outcomes and satisfaction with materials.

We identified several elements that may be useful in subsequent efforts to develop and/or further refine obesity intervention materials in school-based settings. Adolescents emphasized the importance of media, particularly use of the internet, as a primary source for most informational needs. We also observed that these culturally diverse (Hispanic, American Indian, and African American) adolescents expressed mostly similar views about the types of barriers and proposed solutions to addressing overweight/obesity both at home and in the school. There was strong consensus regarding a "functional" definition of health that focused on identifying internal sources of motivation to achieve goals and engagement in activities as opposed to one based on more standard biomedical measures of health (e.g., blood pressure or cholesterol levels). Partnering with these teens and adolescents was essential in order to ensure not only the appropriate content in the ACTION intervention but also the stylistic elements that maximize appeal and likelihood of use. We believe that the high levels of satisfaction reported by ACTION participants, as well as the promising results in the primary outcome measures, are attributable to this adaptive CBPR process.

4.1. Implications for School-Based Obesity Research. Over the past several years, increasing attention has been directed toward schools settings as promising venues for obesity prevention and treatment interventions. The recently released Institute of Medicine report identified schools as catalysts in our efforts to accelerate progress in obesity prevention [9]. A growing body of literature supports the value of directing programmatic and research resources to school-based interventions. Prior research has demonstrated the efficacy of a quality improvement initiative aimed at enhancing SBHC provider implementation of obesity treatment guidelines [29]. Another recently published study reports findings from an adolescent obesity screening program conducted through a school-based health center [30]. In this study, following a medical evaluation, adolescents determined to be outside "healthy ranges" were referred to healthcare services. While these types of quality improvement and screening and referral projects are consistent with the need to engage schools in obesity prevention efforts, there is still a gap in the development and implementation of obesity interventional research through SBHCs. We believe the ACTION study is the first to actually create and test such an intervention through a partnership with key stakeholders located in the school community.

Conducting research in partnership with the SBHCs, the school administration, the students, and their families poses a set of logistical and study design challenges. The ACTION study involved each of these key stakeholders in different ways and at different stages to both maintain relationships that preceded this project and establish new ones to sustain our efforts going forward. The adaptive CBPR design employed in the ACTION study may offer useful guidance to other researchers conducting research in school settings. While much CBPR is oppositely structured—forming the community advisory group first—in this two-year study it was imperative that the formative research and production of the intervention materials (DVD and clinician toolkit) are completed by the start of the intervention, coinciding with the school calendar. Our goal was to incorporate the core principles of CBPR while operating in a compressed timeframe imposed by the research funding. As evidenced from both the process evaluation findings and health outcome measures, we believe that these adaptations were essential to create an authentic partnership while adhering to a timeline that may not have been feasible using a more traditional CBPR approach. While use of CBPR appears to enhance the effectiveness of interventions, there exists a lack of clarity regarding how different types of partnership configurations and processes contribute to these outcomes [26].

4.2. Limitations. We have identified a few limitations to this study. The first relates to the limited generalizability of these findings to other populations and school-based settings. Our purpose in this paper, however, is to demonstrate the applicability of an adaptive CBPR process through which researchers can identify locally and contextually relevant factors in their school-based obesity interventions. The second limitation involves the relatively small sample size of interviews in the formative assessment phase. The iterative process of data collection and analysis led to data saturation at an early stage and the consistency of thematic responses enhanced the confidence of findings from ethnoracially diverse students and parents.

5. Conclusion

CBPR partnerships with school-based communities represent an important opportunity for researchers seeking to address a broad spectrum of adolescent health problems. There is an urgent need to find innovative, cost-effective, and sustainable strategies to reach underserved communities. We found that conducting formative assessment using an adaptive CBPR process with a range of school-based stakeholders was an effective way to develop culturally appropriate and tailored intervention materials and approaches in these multiethnic school settings. We demonstrated that researchers can adapt their study designs in ways that best maximize limited resources and time constraints without compromising the

core principles of CBPR. More encouraging were promising results from this intervention in this compressed time period.

Disclosure

The authors have indicated they have no financial relationships relevant to this paper to disclose.

Conflict of Interests

The authors have indicated they have no conflict of interests relevant to this paper to disclose.

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Research Article

Prevalence of Childhood and Adolescent Overweight and Obesity from 2003 to 2010 in an Integrated Health Care Delivery System

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An observational study of the Kaiser Permanente Northern California (KPNC) BMI coding distributions was conducted to ascertain the trends in overweight and obesity prevalence among KPNC members aged 2–19 between the periods of 2003–2005 and 2009-2010. A decrease in the prevalence of overweight (−11.1% change) and obesity (−3.6% change) and an increase in the prevalence of healthy weight (+2.7% change) were demonstrated. Children aged 2–5 had the greatest improvement in obesity prevalence (−11.5% change). Adolescents aged 12–19 were the only age group to not show a decrease in obesity prevalence. Of the racial and ethnic groups, Hispanics/Latinos had the highest prevalence of obesity across all age groups. The KPNC prevalence of overweight and obesity compares favorably to external benchmarks, although differences in methodologies limit our ability to draw conclusions. Physician counseling as well as weight management programs and sociodemographic factors may have contributed to the overall improvements in BMI in the KPNC population. Physician training, practice tools, automated BMI reminders and performance feedback improved the frequency and quality of physician counseling. BMI screening and counseling at urgent visits, in addition to well-child care visits, increased the reach and dose of physician counseling.

1. Introduction

From 1970 to 2000, the number of obese children in the USA tripled. From 2000 to 2010, no statistically significant linear trends in body mass index (BMI) were detected; however, 30.4% of children and adolescents aged 2 through 19 years were overweight or obese in 2009-2010 [1]. Obese children are at increased risk for cardiovascular disease, type 2 diabetes, and other health conditions [2]. As a consequence of the expected increase in chronic conditions, some experts are predicting a shortened lifespan for this generation of America's youth compared with that of their parents [3]. Obesity and the associated risks, including stigma, can also result in a lower quality of life [4]. Hospital costs for children with conditions caused or worsened by obesity have increased [5]. Overweight children often grow up to be overweight adults [6], and the medical care costs of adult obesity in the United States were estimated to be as much as $147 billion in 2006 [7]. Including lost productivity, obesity costs California $21 billion each year [8].

Although some studies suggest that child obesity is less prevalent in California than in other states [9, 10], BMI data collected in California public schools reveals great disparities in obesity prevalence and trends in different counties. A study looking at BMI trends in California schools from 2001 to 2008 found a declining prevalence of obesity in some populations, but not in others [11]. Another study looked at BMI trends in California schools from 2005 to 2010. The prevalence of overweight and obese children declined by 1.1% from 2005 to 2010; however, the prevalence in many Northern California counties served by Kaiser Permanente Northern California (KPNC) increased over that time period [12].

In 2001, KPNC began a multifaceted initiative to address childhood obesity in Northern California. This initiative had 3 components: medical office visit interventions, weight management interventions, and environmental changes (Figure 1) [13]. We initiated our study to examine the effect of these approaches on the change in obesity prevalence in the pediatric population of KPNC. To this end, we examined changes in BMI among KPNC members aged 2–19 from 2003–2005 to 2009-2010. The study had the following goals.

(1) Identify existing patterns amongst age and racial/ethnic groups.

(2) Assess progress towards reversing the childhood obesity epidemic.

(3) Identify areas or population segments to target for future interventions.

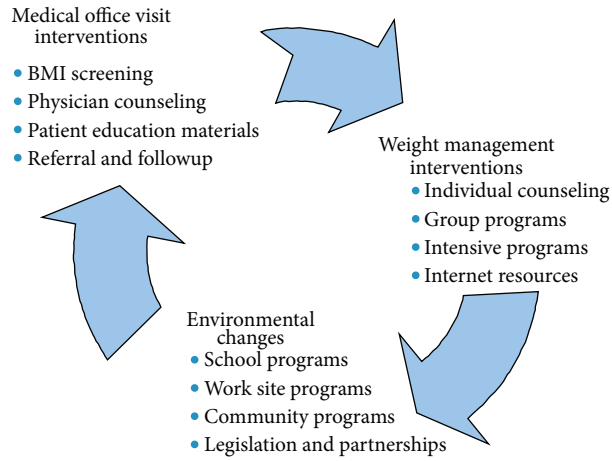

Figure 1: KPNC's approach to childhood obesity.

2. Methods

KPNC is an integrated, prepaid, nonprofit health care delivery system in Northern California. KPNC has 3.3 million members, which represents 35–40% of the insured market in the Northern California catchment area. The median income of the membership parallels that of the general population, with fewer members at both the high and low extremes [14, 15]. Distributions of BMI category prevalence were calculated on 2 sets of cross-sectional aggregate data (2003–2005 and 2009-2010, $n = 254,007$ and $n = 426,667$, resp., e.g., size comparability between the two cohorts). The population in this study included Medi-Cal and Kaiser Permanente health plan members who had a visit with either their family medicine or pediatric provider. Age, sex, race/ethnicity, and pediatric BMI category (BMI percentile <5, 5–84, 85–94.9, and ≥95) were collected for each member. Sex and race/ethnicity were self-reported by members and entered into HealthConnect, Kaiser Permanente's national electronic health record (EHR). Race/ethnicity categories included Asian, Black, Hispanic/Latino, White, or Other. If no value was entered or the patient declined to state, the variable was marked as "unknown."

In 2003–2005, BMI was captured primarily at well-child visits and coded in the EHR, whereas in 2009-2010, BMI was captured at well-child and urgent care visits and coded in the EHR. Young adults aged 18 and 19 were included to be consistent with the National Health and Nutrition Examination Survey (NHANES) analysis [1].

To compare distributions of BMI categories between the time periods, races, and/or age groups, it was necessary to adjust the distributions for sample comparability. For example, differences in the prevalence rates of obesity at two different times could be due to the programs implemented between the two times, temporal trends in the community, or differences in the characteristics of the sample of people at the two time points. To account for differences in the characteristics of the samples, prevalence rates were directly adjusted for age, gender, and race/ethnicity [15]. The reference population was all children from both time periods and from all service areas. Because the rates in each study group are applied to the same reference population, the predicted prevalence rates were not affected by differences in demographic distributions over time, thus ensuring comparability over time and between age and race/ethnicity groups.

To compare the rates of obesity and overweight within KPNC to those in the surrounding regions, we used prevalence rates amongst 5th, 7th, and 9th graders from the counties of Alameda, Contra Costa, Fresno, Madera, Marin, Merced, Sacramento, San Francisco, San Joaquin, San Mateo, Santa Clara, Solano, Sonoma, Stanislaus, and Yolo in 2005 and 2010 [12]. Given the geographic mapping of KPNC service areas, not all service areas are captured via these listed counties. The KPNC sample for this comparison consisted of members aged 6–19 in 2003–2005 and in 2009-2010.

To test for statistically significant differences over time (2003–2005 period versus 2009-2010 period), a set of 4 logistic regression models were fit, one for each BMI category. In each model, the independent variables were age, sex, race/ethnicity, time (2003–2005 versus 2009-2010), and the interactions between time and each of the other variables. When an interaction was statistically significant ($P < 0.05$), results could not be interpreted for either of the main effects in the interaction. In these cases, the models were refit, stratifying on one of the statistically significant interaction variables. The variable of the most interest in this report is change over time. The stratified model was tested for a time effect within each combination of age and race. Results are reported as odds ratios (ORs) with their 95% confidence intervals (CI).

This study was done as a quality improvement effort to inform KPNC's approach to reduce the prevalence of overweight and obesity in its pediatric population and therefore did not require IRB review.

3. Results

3.1. Demographics. The samples from the 2 study periods were similar with regard to age and sex distribution (Table 1). However, the 2009-2010 sample had a higher prevalence of Hispanics/Latinos.

Table 1: Age, sex, and race/ethnicity distributions at each time period.

	2003–2005 *n* (%)	2009-2010 *n* (%)
Ages, years		
02–05	85,804 (33.8%)	137,479 (32.2%)
06–11	82,464 (32.5%)	140,815 (33.0%)
12–19	85,739 (33.7%)	148,383 (34.8%)
Sex		
Male	128,598 (50.6%)	218,249 (51.1%)
Female	125,404 (49.4%)	208,423 (48.9%)
Race/ethnicity		
Asian	34,413 (13.6%)	63,947 (15.0%)
Black	23,179 (9.1%)	34,175 (8.0%)
Hispanic/Latino	25,959 (10.2%)	55,977 (13.1%)
White	98,449 (38.8%)	153,714 (36.3%)
Other	21,660 (8.5%)	40,918 (9.6%)
Unknown	50,342 (19.8%)	76,941 (18.0%)
Total	254,007	426,677

3.2. Prevalence by Weight Category. We compared the directly adjusted BMI category prevalence rates for the 2 study periods (Table 2). Overall, encouraging patterns have emerged, with improvements in the proportion of the population of healthy weight (+2.7% change) and a decrease in the proportion who are overweight (−11.1% change). The prevalence of obesity decreased regionwide (−3.6% change) and among all age groups except for those ages 12–19 years (1.6% change). Children aged 2–5 had the greatest improvement in obesity (−11.5% change). An increase in the underweight category was observed in all age groups, but the prevalence is low, and further analysis is needed to inform the discussion.

BMI category prevalence rates were directly adjusted for each combination of age and race/ethnicity separately for the 2 time periods (Table 3). Of the racial and ethnic groups, Hispanics/Latinos had the highest prevalence of obesity across all age groups.

All age groups and races showed a statistically significant decrease (OR > 1) in overweight prevalence. Asians, whites, and unknown races aged 2–11 and other races aged 2–5 showed a statistically significant decrease (OR > 1) in obesity prevalence.

3.3. External Benchmarking. In 2009-2010, childhood overweight and obesity prevalence rates in KPNC were lower than national prevalence rates for children aged 2–19 [1] (Table 4).

Obesity is more prevalent in KPNC Hispanics and Latinos aged 2–19 than it is in a national cohort [1] (Table 5). Obesity is less prevalent in KPNC blacks and whites than in the national cohort.

The overall overweight and obesity prevalence rates in KPNC for ages 6–19 years compare favorably with the overweight and obesity prevalence rates for school-age children in the counties served by KPNC [12] (Table 6). However, differences in methodology limit our ability to draw conclusions.

4. Discussion

In the pediatric population of KPNC, obesity and overweight decreased between 2003 and 2010, in contrast to comparator populations in the same geographic location and nationwide. Although our datasets captured only those members who came to a KPNC facility for a visit during the time periods 2003–2005 and 2009-2010, the sample sizes ($n > 200,000$ for each cohort) are sufficiently large to allow these data to be generalized to the KPNC pediatric population.

Improvements in overweight and obesity among KPNC members may be attributable to sociodemographic differences and/or differences in the clinical care received by KPNC members versus nonmembers. The KPNC adult membership does not significantly differ from the adult population of Northern California with regard to age, sex, or race/ethnicity. However, compared to nonmembers in Northern California, the KPNC adult membership does have significantly lower percentages of men and women with household incomes <200% above the federal poverty line, with incomes of ≤$25,000, and who have not graduated from high school [14]. Families with low income and low educational attainment are more likely to have overweight children [16, 17]. The KPNC adult population has a significantly higher percentage of people who are employed at least 20 hours/week compared to the Northern California population, for both men and women. Several studies have found that a child is more likely to be overweight if his or her mother worked more hours per week over the child's life [18, 19].

KPNC members may have received clinical care that nonmembers did not receive. From 2002 to 2004, training was provided for all KPNC pediatricians and family practitioners to measure BMI and provide family-centered nutrition and physical activity counseling at well-child care visits (Figure 2). Training occurred over multiple sessions and was provided at the clinic and by teleconference. Supplemental training on motivational interviewing was also available in group sessions and online. Medical assistants were trained to measure and plot BMIs on growth charts showing BMI percentile for age. Office system tools to support BMI screening and counseling, including BMI wheel calculators, exam room posters, and patient education materials, were provided at no charge to clinics. The exam room poster had 4 key messages and was used to provide family education as well as to facilitate physician counseling. In 2003, electronic data collection of BMI category began, and departments received feedback on their rates of BMI measurement at well-child visits. Provider counseling on BMI and associated health risks may influence a parent's perception of the child's weight as unhealthy and may potentially increase parent readiness to take action [20, 21]. For obese patients, providers were encouraged to arrange for a follow-up visit to provide more intensive family-centered counseling and to review lab test results if indicated. Follow-up visits with physicians and dieticians have demonstrated modest improvements in BMI [22, 23]. By 2005, BMI screening and physician counseling for nutrition and physical activity were provided at over 90% of KPNC well-child care visits, and this performance was maintained through 2010. BMI screening was tracked

Table 2: Directly adjusted BMI category distribution by weight category, age, and time.

	Underweight (<5th percentile)				Healthy weight (5–84.9th percentile)				Overweight (85–94.9th percentile)				Obese (≥95th percentile)			
	2003–2005[a]	2009-2010[a]	Percentage point difference	Percent change[b]	2003–2005[a]	2009-2010[a]	Percentage point difference	Percent change[b]	2003–2005[a]	2009-2010[a]	Percentage point difference	Percent change[b]	2003–2005[a]	2009-2010[a]	Percentage point difference	Percent change[b]
Ages 02–05 N = 223,279	2.2% (2.1, 2.3)	2.9% (2.8, 3.0)	**+0.7**	**+31.8%**	75.5% (75.2, 75.8)	77.3% (77.1, 77.6)	**+1.8**	**+2.4%**	11.0% (10.8, 11.2)	9.7% (9.5, 9.8)	**−1.3**	**−11.8%**	11.3% (11.1, 11.5)	10.0% (9.9, 10.2)	**−1.3**	**−11.5%**
Ages 06–11 N = 223,275	1.5% (1.4, 1.6)	1.8% (1.8, 1.9)	**+0.3**	**+20.0%**	62.3% (61.9, 62.6)	65.1% (64.8, 65.3)	**+2.8**	**+4.5%**	15.9% (15.7, 16.2)	13.8% (13.6, 14.0)	**−2.1**	**−13.2%**	20.3% (20.0, 20.6)	19.3% (19.1, 19.5)	**−1.0**	**−4.9%**
Ages 12–19 N = 234,120	1.5% (1.4, 1.5)	1.6% (1.5, 1.7)	+0.1	+6.7%	63.2% (62.9, 63.5)	64.3% (64.1, 64.6)	**+1.1**	**+1.7%**	16.4% (16.1, 16.6)	14.8% (14.6, 15.0)	**−1.6**	**−9.8%**	19.0% (18.8, 19.3)	19.3% (19.1, 19.5)	+0.3	1.6%
All N = 680,674	1.7% (1.7, 1.8)	2.1% (2.1, 2.2)	**+0.4**	**+23.5%**	67.0% (66.7, 67.1)	68.8% (68.7, 60.0)	**+1.8**	**+2.7%**	14.4% (14.3, 14.6)	12.8% (12.7, 12.9)	**−1.6**	**−11.1%**	16.9% (16.8, 17.1)	16.3% (16.1, 16.4)	**−0.6**	**−3.6%**

[a] Values are shown as mean (95% CI).
[b] Percent change = percentage point difference/percent weight category in 2003–2005.
Bold indicate statistically significant ($P < 0.05$) time effects.

Table 3: Directly adjusted BMI category distribution by weight category, age, race/ethnicity, and time.

	Percent overweight BMI 85–94.9th percentile			Percent obese BMI ≥ 95th percentile		
	2003–2005[a]	2009-2010[a]	OR (95% CI)	2003–2005[a]	2009-2010[a]	OR (95% CI)
Asian						
Ages 02–05	8.6% (8.2, 9.1)	7.7% (7.4, 8.1)	**1.13 (1.04, 1.22)**	9.6% (9.1, 10.1)	8.1% (7.8, 8.4)	**1.21 (1.12, 1.30)**
Ages 06–11	15.0% (14.3, 15.7)	12.8% (12.3, 13.3)	**1.20 (1.13, 1.29)**	17.3% (16.6, 18.0)	15.3% (14.8, 15.8)	**1.17 (1.10, 1.24)**
Ages 12–19	15.0% (14.3, 15.7)	13.7% (13.2, 14.2)	**1.11 (1.03, 1.18)**	14.1% (13.4, 14.7)	13.8% (13.3, 14.3)	1.00 (0.94, 1.08)
Black						
Ages 02–05	12.5% (11.7, 13.3)	10.5% (9.9, 11.1)	**1.22 (1.11, 1.34)**	13.0% (12.2, 13.8)	12.2% (11.6, 12.9)	1.08 (0.98, 1.18)
Ages 06–11	16.4% (15.5, 17.2)	14.6% (14.0, 15.3)	**1.15 (1.06, 1.24)**	24.2% (23.2, 25.1)	24.4% (23.6, 25.2)	0.99 (0.93, 1.06)
Ages 12–19	17.6% (16.8, 18.4)	16.2% (15.5, 16.8)	**1.11 (1.03, 1.19)**	24.4% (23.5, 25.3)	25.1% (24.4, 25.9)	0.96 (0.90, 1.03)
Hispanic/Latino						
Ages 02–05	13.6% (12.8, 14.4)	11.9% (11.4, 12.4)	**1.17 (1.08, 1.27)**	16.7% (15.8, 17.5)	16.0% (15.4, 16.6)	1.05 (0.97, 1.13)
Ages 06–11	18.4% (17.6, 19.2)	15.4% (14.9, 15.9)	**1.24 (1.16, 1.32)**	28.1% (27.3, 29.0)	29.0% (28.4, 29.7)	0.95 (0.90, 1.01)
Ages 12–19	18.3% (17.5, 19.1)	17.0% (16.5, 17.5)	**1.10 (1.03, 1.17)**	25.5% (24.6, 26.4)	26.3% (25.7, 26.9)	0.95 (0.90, 1.01)
White						
Ages 02–05	10.8% (10.5, 11.2)	9.4% (9.1, 9.6)	**1.18 (1.12, 1.23)**	8.8% (8.5, 9.1)	7.7% (7.4, 7.9)	**1.16 (1.11, 1.22)**
Ages 06–11	15.2% (14.8, 15.6)	13.3% (13.0, 13.6)	**1.17 (1.12, 1.22)**	16.5% (16.1, 17.0)	14.9% (14.6, 15.2)	**1.13 (1.09, 1.18)**
Ages 12–19	15.4% (15.1, 15.8)	14.1% (13.8, 14.4)	**1.12 (1.08, 1.16)**	15.5% (15.2, 15.9)	15.8% (15.5, 16.1)	0.97 (0.94, 1.01)
Other						
Ages 02–05	12.1% (11.4, 12.7)	10.9% (10.4, 11.4)	**1.12 (1.04, 1.21)**	15.0% (14.4, 15.7)	14.1% (13.5, 14.6)	**1.08 (1.01, 1.16)**
Ages 06–11	17.1% (16.2, 18.1)	14.6% (14.0, 15.2)	**1.21 (1.12, 1.31)**	25.1% (23.0, 26.2)	25.0% (24.3, 25.7)	1.01 (0.94, 1.08)
Ages 12–19	18.3% (17.3, 19.4)	15.4% (14.7, 16.1)	**1.24 (1.14, 1.36)**	26.4% (25.2, 27.6)	26.2% (25.4, 27.1)	1.00 (0.93, 1.08)
Unknown						
Ages 02–05	11.0% (10.5, 11.5)	9.8% (9.4, 10.2)	**1.13 (1.06, 1.21)**	12.1% (11.6, 12.6)	10.1% (9.7, 10.5)	**1.23 (1.15, 1.31)**
Ages 06–11	15.7% (15.1, 16.2)	13.8% (13.4, 14.2)	**1.17 (1.10, 1.23)**	20.2% (19.6, 20.8)	18.8% (18.4, 19.3)	**1.10 (1.05, 1.15)**
Ages 12–19	16.4% (15.9, 17.0)	14.5% (14.1, 14.9)	**1.15 (1.09, 1.21)**	19.5% (18.9, 20.1)	19.6% (19.2, 20.1)	1.00 (0.95, 1.05)

[a]Values are shown as rate (95% CI).
Bold indicate statistically significant ($P < 0.05$) time effects.

using visit coded BMI category diagnosis. Outside of KPNC, BMI screening and counseling were provided much less frequently [24–26]. From 2004 to 2008, the KPNC office practice model was disseminated nationally to all of the other Kaiser Permanente regions as well as other health systems. The dissemination included practice tools as well as physician training.

From 2002 to 2006, KPNC tripled the number of facilities offering weight management programs for families. Self-care materials, web-based programs, and single-session weight

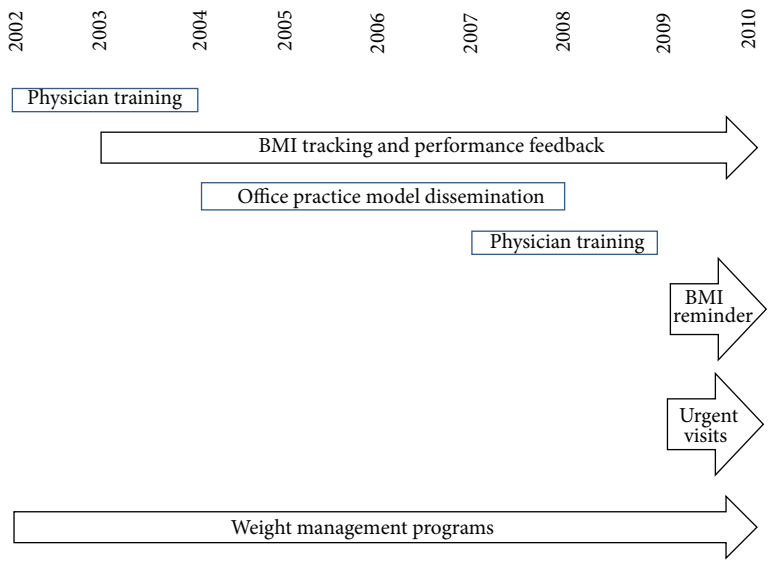

Figure 2: KPNC strategies to address childhood obesity.

Table 4: Overweight and obesity in children aged 2–19, in KPNC and NHANES.

	NHANES 2009-2010[a]	KPNC 2009-2010
Overweight and obese (BMI ≥ 85th percentile)	31.8%	29.2%
Obese (BMI ≥ 95th percentile)	16.9%	16.4%

[a]Data taken from reference [1].

Table 5: Comparison of obesity in children aged 2–19 years in the NHANES and KPNC populations in 2009-2010, stratified by race and gender.

	NHANES PEDIATRIC BMI ≥ 95th percentile %	KPNC PEDIATRIC BMI ≥ 95th percentile %
Both sexes		
White	14.0%	12.8%
Black	24.3%	21.0%
Hispanic/Latinos	21.2%	24.6%
Male		
White	16.1%	13.8%
Black	24.3%	19.4%
Hispanic/Latinos	23.4%	27.1%
Females		
White	11.7%	11.6%
Black	24.3%	22.7%
Hispanic/Latinos	18.9%	22.1%

management programs were offered in all service areas at no additional cost to members. Multisession weight management programs were also offered in the clinic setting and varied in intensity from 2 to 20 sessions. These programs were led by health educators and focused on family health behavior change. Many of these programs were evaluated, with most programs demonstrating improvements in health behaviors and multisession programs yielding modest improvements in weight. Many weight management programs for families have produced modest improvements in BMI, with more intensive programs yielding greater improvements [27]. Although the multisession weight management programs led to modest improvements in BMI among attendees, the number of families who attended these programs was relatively small compared to the number of obese children in the KPNC membership.

Table 6: KPNC counties versus KPNC for childhood and adolescent overweight and obesity in 2005 and 2010.

	Year	KPNC counties[a]	KPNC[b]
Overweight and obese	2005	36.2%	35.5%
	2010	36.5%	33.8%
Percent change[c]		+1%	−4.8%

[a]Overweight and obesity prevalence rates for KPNC counties were calculated amongst 5th, 7th, and 9th graders in 2005 and 2010 [12]. See the Methods section for the counties included.
[b]The KPNC sample consists of ages 6–19 years in 2003–2005 and 2009-2010.
[c]Percent change = percentage point difference/percent overweight and obese in 2005 or 2003–2005.

Pediatricians and family practitioners received training and tools to implement the "Expert Committee Recommendations Regarding the Prevention, Assessment, and Treatment of Child and Adolescent Overweight and Obesity" in 2007–2009 [28]. The training was provided by teleconference as well as at the clinic.

In 2009, an EHR was fully implemented and a reminder system was developed that provided all members and providers with an annual BMI screening reminder that members could view on the visit receipt at an office visit

and online. Personalized BMI information and education were developed for the After Visit Summary, a printed summary of the visit provided to patients. The use of the EHR to facilitate BMI screening and counseling was demonstrated in a study from Kaiser Permanente Southern California (KPSC) [29]. KPSC used an automated alert for overweight or obese patients to prompt providers to code an obesity diagnosis, provide counseling, and order appropriate lab tests. BMI measurement, coding for a diagnosis of obesity at an office visit, and counseling all significantly increased from 2007 to 2010. The prevalence of obesity over the study period was stable, but not improved, with 17% overweight, 14% moderately obese, and 7% to 9% extremely obese [29]. KPNC used a similar approach to improve BMI screening and counseling, but demonstrated a decrease in overweight and obesity prevalence. A longer study period and more intensive training for providers may have contributed to these differences. However, including only the BMI category, as opposed to the continuous BMI measurement, does reduce the precision of the inferences we can make.

Beginning in 2009, providers were encouraged to measure BMI and provide counseling annually at urgent care visits in addition to well-child visits. Clinics were provided quarterly feedback on BMI screening and counseling performance. The addition of BMI screening at urgent visits increased BMI data capture, provided counseling for patients who did not have a well-child care visit, and increased the likelihood that a patient would receive more than one counseling session during the calendar year. Since Medicaid-eligible children are less likely to be compliant with well-child care, more high risk children had BMI screening and received counseling [30]. Training combined with performance feedback can improve BMI screening by physicians [31]. In 2009, the Healthcare Effectiveness Data and Information Set (HEDIS) added annual BMI screening, nutrition counseling, and physical activity counseling for children aged 3–17 [32]. KPNC demonstrated improvement for all 3 HEDIS measures from 2009 to 2010.

Improvement in the prevalence of obesity among KPNC members 2–5 years is encouraging and mirrors improvements in obesity prevalence among low-income preschool-aged children [33]. Despite the overall improvements, several groups showed less improvement over the period examined. Obese adolescents and obese Hispanics/Latinos aged 6–19 in particular may need further intervention.

5. Conclusion

Findings from this observational study highlight the strides that KPNC has made in addressing obesity among children and adolescents in its member population. Although weight management programs and sociodemographic factors may have contributed to the overall improvements in BMI in the KPNC population, the contribution was likely to be small. Most of the improvements were likely attributable to physician counseling. Physician training, practice tools, automated BMI reminders, and performance feedback improved the frequency and quality of physician counseling. BMI screening and counseling at urgent visits, in addition to well-child care visits, increased the reach and dose of physician counseling.

These findings have also shed light on the varied response to the intervention. Understanding this variation will be key to quality improvement and will inform the development of strategies and interventions to effectively target groups at risk and to decrease obesity prevalence rates among KPNC's pediatric population. Two populations that will need further intervention and research are obese adolescents and obese Hispanics/Latinos aged 6–19.

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Research Article

Youth Understanding of Healthy Eating and Obesity: A Focus Group Study

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Introduction. Given the high prevalence of childhood obesity in the United States, we aimed to investigate youth's understanding of obesity and to investigate gaps between their nutritional knowledge, dietary habits, and perceived susceptibility to obesity and its co-morbidities. *Methods*. A marketing firm contracted by Children's Healthcare of Atlanta facilitated a series of focus group discussions (FGD) to test potential concepts and sample ads for the development of an obesity awareness campaign. Data were collected in August and September of 2010 with both overweight and healthy weight 4th-5th grade and 7th-8th grade students. We conducted a secondary analysis of the qualitative FGD transcripts using inductive thematic coding to identify key themes related to youth reports of family eating habits (including food preparation, meal frequency, and eating environment), perceived facilitators and barriers of healthy diet, and knowledge about obesity and its complications. *Results*. Across focus group discussions, mixed attitudes about healthy eating, low perceived risk of being or becoming obese, and limited knowledge about the health consequences of obesity may contribute to the rising prevalence of obesity among youth in Georgia. Most youth were aware that obesity was a problem; yet most overweight youth felt that their weight was healthy and attributed overweight to genetics or slow metabolism. *Conclusions*. Our analysis suggests that urban youth in Georgia commonly recognize obesity as a problem, but there is less understanding of the link to lifestyle choices or the connection to future morbidities, suggesting a need for education to connect lifestyle behaviors to development of obesity.

1. Introduction

The prevalence of childhood obesity in the United States has risen dramatically over the last three decades [1] and is the highest in the Southeastern region of the country [2]. Overweight youth are at risk of being obese during adulthood [3] and are likely to experience obesity-related chronic illness [4]. The increase in obesity and its comorbidities among youth is multifactorial in cause, including increased access to foods high in fats, added sugars and calories [5], increased eating outside the home [6], larger portion sizes [7], and a sedentary lifestyle [8]. The diversity of these contributors to childhood obesity has made it difficult to design simple, achievable, public health solutions.

Studies have been conducted to identify strategies to combat obesity among youth; yet much remains to be understood. A recent qualitative study found that barriers to a healthy family lifestyle included cost of healthy food, time and practicality, family preferences, and difficulty in changing habits [9]. In a recent focus group study evaluating lifestyle

perceptions among family members as young as 8 years of age, additional themes that emerged included making healthy activities fun, stage of youth development, and individual, family, and community involvement [10].

In order to understand why current obesity prevention strategies have largely failed and to inform the development of more successful future techniques to combat childhood obesity, it is imperative that the understanding of obesity among children be explored. While prior studies have assessed youths' perceptions of their own weight status and have explored their lifestyle behaviors, less emphasis has been placed on understanding youths' familiarity with the causes and consequences of obesity. The objective of this study was to explore youths' understanding of obesity as a problem and to investigate gaps between their nutritional knowledge, dietary habits, and perceived susceptibility to obesity and its comorbidities.

2. Materials and Methods

This study comprises secondary analysis of qualitative data collected by an Atlanta-based marketing company contracted by Children's Healthcare of Atlanta (Atlanta, GA, USA) as part of their efforts to develop a public health campaign to reduce obesity amongst youth in the state of Georgia (USA). These data were not collected with the intention of being used for scientific purposes and were not analyzed scientifically by the marketing agency which carried out the primary data collection. However, the questions asked and the dialogue that emerged yielded discussion about obesity-related topics that were of scientific interest. Although the data were originally collected for marketing purposes, the conversations provide a unique window to examine youths' knowledge and understanding of the relationship between behaviors and obesity.

Ten focus group discussions were conducted by the marketing company during August and September of 2010, in two regions of Georgia. As displayed in Table 1, participants were aged between 9 and 14 years and enrolled in either the 4th/5th grade (aged 9–11 years) or in the 7th/8th grade (aged 12–14 years). These age groups were selected because late childhood and early adolescence are key time periods where children begin to become independent from their parents and are able to evaluate and alter their dietary habits and attitudes [11]. Focus group discussions were limited to five children per group to enhance the children's comfort level and to account for the age and maturity level of the participants.

Discussion groups were stratified by age, gender, and weight status to construct homogenous groups of participants which encourages participants to feel comfortable in sharing their thoughts and in light of the potentially sensitive nature of discussing obesity. Both overweight and normal weight youth were included in the study in order to learn what all youth understood about obesity and the behaviors related to obesity and the potential marketing effectiveness of the proposed public health campaigns. The marketing company recruited youth through databases allowing for direct parent/caregiver contact and by networking with organizations serving children. Parents were randomly contacted and then screened for their child's eligibility. Participation was limited to one eligible child per household, and child weight status was determined by parent report of the child's height and weight. Of 52 youth recruited, 41 participated in the focus group discussions. The moderator was a slightly overweight female aged approximately 40 years old, with 15 years of experience moderating focus groups. Trained marketing company staff members obtained informed consent and assent from each parent/caregiver and each participant, respectively, before the focus group discussion began. Each focus group discussion was both audio- and video-taped with permission; only the audiorecordings were used in our secondary analysis.

Table 1: Distribution of participants ($n = 41$) in the focus groups ($n = 10$) separated by weight status, age, and gender.

	4th and 5th grades (Ages 9–11 years)	7th and 8th grades (Ages 12–14 years)
Weight status: normal		
Male	0	10
Female	0	4
Weight status: overweight		
Male	3	10
Female	6	8

Data Analysis. In the original analysis conducted by the marketing company, only text relating to youths' understanding and opinions of the marketing concepts and campaigns were analyzed. Thus, we did not analyze this information in our secondary analysis but instead focused on the understanding of the causes and consequences of obesity amongst youth. For the purpose of this analysis, the term "understanding" was defined as comprehending or having a mental grasp on the concept, such as understanding that obesity can be caused by eating too much, whereas "recognition" was defined as merely being able to identify obesity. We used the word "perception" to refer to interpretation of obesity in relation to the youths' daily lives.

We analyzed data from both overweight and normal weight youth in order to explore potential differences in understanding based on weight status, and because we were interested in learning what all youth knew about obesity and its causes and consequences. Although the marketing company asked similar research questions, their primary analysis was used to inform the development of a public health campaign to reduce obesity in the state of Georgia. Our secondary data analysis of the same focus group transcripts aimed to uncover themes in the transcripts and to gain an understanding of the context underlying the textual data. Our secondary analysis of the deidentified focus group transcripts was approved by the Institutional Review Board at Children's Healthcare of Atlanta. The research analyst (AS) analyzed the written transcripts and, when necessary, contacted the marketing company for clarification related to the study procedure.

Table 2: Example of coding scheme for theme[1] of food and healthy eating.

(1) Food and healthy eating
(1.1) Healthy versus unhealthy foods
(1.1.1) Easily identifies healthy food
(1.1.2) Difficulty in identifying healthy food
(1.1.3) Easily identifies unhealthy food
(1.1.4) Difficulty in identifying unhealthy food
(1.1.5) Enjoyment of healthy food
(1.1.6) Dislike of healthy food
(1.1.7) Enjoyment of healthy food
(1.1.8) Dislike of healthy food
(1.2) Consequences of eating healthy food
(1.2.1) Weight
(1.2.2) Risk of chronic disease
(1.2.3) Intellectual/school performance
(1.2.4) Other health benefits and risks (i.e., bone health)

[1] Food and healthy eating was the way that the theme was written in the codebook.

We used inductive thematic analysis to identify major themes in the textual data [12, 13] which emerged from the content of the focus group discussion transcripts. Two members of the research team (AS, an obesity researcher & DS, a behavioral science expert) read and reread the transcripts to familiarize themselves with the data and identify any patterns that emerged. Codes were developed to document patterns that emerged from the data which addressed the primary research question of whether youth demonstrated an understanding of obesity and its causes and consequences and if they perceived themselves as susceptible to the development of obesity. Codes were then compared to increase intercoder reliability and combined into overarching themes. Themes were then compared within and between the ten focus group discussions. For example, we noticed numerous comments that contrasted healthy and unhealthy foods (theme in codebook, 1.1) and found that youth could sometimes identify healthy foods such as broccoli (subtheme 1.1.1) while other foods were more ambiguous such granola bars and vitamin water (subtheme 1.1.2) and called these sub-themes "easily identifies healthy food (1.1.1), difficulty identifying healthy food (1.1.2)." An example of our coding scheme is further described in Table 2.

Participant's statements were often coded with multiple codes. The coding process was terminated when no new themes emerged from the transcripts during codebook development. We compared categories and codes between individuals to explore patterns that emerged in the data based on participant characteristics. Illustrative quotations demonstrating important themes which repeatedly emerged across focus groups and which enhanced our understanding of the data were extracted separately.

3. Results

Three themes emerged consistently across the ten focus groups that were related to youths' perceptions of their own lifestyle and the causes and consequences of obesity. The gender, age, and weight status of focus group participants are shown in Table 1.

Theme Number 1: My Mom Wants Me to Eat Healthy Foods Like Broccoli but It Looks Nasty and Tastes Gross. Youth did not have difficulty describing nutritious foods when asked "what does healthy eating make you think of?", although female participants expressed more positive attitudes toward actually consuming healthy foods. All youth described salads, vegetables, and fruit as nutritious, whereas fast food, fried food, and candy were described as unhealthy. One participant described healthy eating as *"you eat fruits and vegetables and you do not just sit around and eat chocolate bars all day" (7th/8th grade, overweight, female).*

Most youth reported learning what foods were healthy and unhealthy from their parents or from classes in their school. For example, when describing her mother's influence on her diet, one female youth stated *"When I ask her for snack foods she says no because you need to start eating healthier food" (7/8th grade, overweight, female)*, implying that the mother views snack foods as unhealthy and might offer healthier alternatives. In another discussion group, youth mentioned that the food pyramid was a resource that youth learned how to use in order to determine which foods are healthy. Youth said that they had learned about the food pyramid in 5th, 6th, and 7th grades in several classes, such as science class, family consumer sciences, health class, and home economics. In explaining the overlap between classes where the food pyramid was covered, one participant recalled that *"Health classes is talking about the food pyramid, but our home-economics is just teaching us about food and stuff, and what's nutritious and not" (7th/8th grade, normal weight, male).*

Youth attitudes towards consuming healthy and unhealthy foods were mixed. Female participants were more likely to report enjoying healthy foods and also expressed a greater desire to positively change their diet. A few females in particular stated that they had requested that their parents purchase healthy foods. In contrast, several male participants associated healthy food with tasting bad. One boy commented that *"They eat stuff that tastes nasty just to lose the weight" (7th/8th grade, overweight, male).* There were no differences in opinion based on weight status among males, while overweight females often expressed desire to improve their diet to include more healthy foods.

In addition to portraying more positive attitudes toward healthy diet than males, females expressed an understanding of the connection between food choices and body weight. One female participant explained that *"We used to do fast food and now my mom cooks more because it's like healthier" (4th/5th grade, overweight, female)* and also commented that *"I can get fat eating. I try to eat vegetables and stuff."* In contrast, when asked what healthy food makes him think of, one male stated that *"it looks nasty. . .you know how some foods just have a nasty look and it's good for you but it's like. . .uh, I do not know"* (7th/8th grade, normal weight, male).

Theme Number 2: Obesity Is a Problem but It Does not Apply to Me. Most youth were familiar with the term "obese" and

believed that obesity was a problem in Georgia. One person defined obese as a term *"for people who do not necessarily have a disease but that get too fat" (7th/8th grade, overweight, male).* When asked about the percentage of youth that were overweight or obese in Georgia, estimates varied greatly, ranging from 10% to 50%. However, many overweight or obese youth did not recognize that they were themselves overweight in the focus groups. For example, one overweight participant stated that "*I'm very aware of it because somebody in my school is overweight*," not appearing to recognize that he himself was also overweight. Overweight girls were more likely to recognize that they were overweight than overweight boys. Overweight females often reported feeling self-conscious or being scrutinized by their classmates while eating. One girl expressed *"...everyone looked at me like, I wonder what she's going to do...They're watching me. They're vultures." (7th/8th grade, overweight, female).*

About half of our participants believed that overweight and obese classmates recognized that they were overweight, but only some believed that they were trying to change. Normal weight youth more frequently commented that overweight classmates did not care or did not know how to change compared to overweight participants. Meanwhile, normal weight participants did not report practicing vigilance in their own eating habits to prevent weight gain. Across both normal weight and overweight youth, there was an overwhelming belief that their overweight peers would not recognize that they were overweight unless someone in their class had picked on them for being heavy. Only in response to being ridiculed, and not due to concerns about short- or long-term health, would their peers be motivated to change their body and to achieve a normal weight. When asked what health habits they would change, many overweight youth responded that they would focus on household chores or personal hygiene while lifestyle modifications and dietary improvements were rarely mentioned. In addition, when asked if overweight youth (in general) were doing anything to achieve a healthy weight, several participants responded that overweight youth do not care about their weight and "*will just eat whatever they want" and "not do anything about it*."

Theme Number 3: Everyone Is Made Differently and It Does not Matter If You Are Fat. Youth demonstrated a limited understanding of the causes and consequences of obesity yet most youth, regardless of weight status, recognized that you can gain weight from eating. One girl said *"I do not like that [the appearance of her stomach] because it makes me feel like I'm getting fatter, so I'm trying to stop eating all the time" (4th/5th grade, overweight, female).* However, many overweight youth attributed overweight to fate, genetics, or metabolism, whereas normal weight youth commonly associated overweight with poor lifestyle choices. One overweight girl stated that *"everybody's made differently and God made us that way" (4th/5th grade, overweight, female).* Another overweight female commented "*Sometimes people have strong metabolisms or weak ones...like you bite something and you gain five pounds" (7th/8th grade, overweight, female).* Overweight participants often said that they did not like the word fat or the word obese, most often because it was hurtful and because being obese does not make you a bad person. Meanwhile, participants in the normal weight focus groups were more likely to provide causal explanations of obesity. For example, one normal weight participant stated "*if you do not eat healthy or exercise, then you can become obese and all of that stuff*" (7th/8th grade, normal weight, female). Another normal weight female elaborated on this comment in saying "*and then you cannot function as well, as someone who is not overweight*" (7th/8th grade, normal weight, female).

Normal weight individuals felt that resolving obesity is a long-term, multifaceted approach, requiring time, commitment, and support, while many overweight individuals expressed frustration and helplessness. For example, while most youth connected weight loss with exercise, overweight youth often did not view increasing exercise as a reasonable treatment or prevention strategy. One boy said "*if you run like a mile it's really going to not seem like you would lose anything—I mean like it's really not going to change your life" (7th/8th grade, overweight, male).* In contrast, normal weight participants offered a different perspective in making statements such as, "*it is about committing to staying healthy and always being active. Because it's not really easy because you cannot just be active once, you have to be doing it every single day" (7th/8th grade, normal weight, female)*. Beyond the realization that staying healthy was a lifelong commitment, normal weight youth more often voiced the need for outside support, including having counselors and family members with whom they can talk.

One exception to the contrasting perspectives on long-term weight management when comparing overweight and normal weight participants were overweight youth who had witnessed the weight loss success of a close friend or family member. Youth who were familiar with someone who lost a substantial amount of weight and became healthy expressed views more similar to the normal weight children, in recognizing that weight loss was a slow and highly controlled process and not a quick fix solution. One overweight male commented "*My dad's like inspiring because he used to be like really fat and then he lost 150 pounds and now he's healthy*." When other participants in the conversation who were overweight asked whether the weight loss was shocking or sudden *("was it just like whoa?"),* he went on to describe that *"he gave up sweets for Lent and then a couple of weeks later he decided that it was really helping us so he gave up sweets for good."*

When discussing the consequences of being overweight or obese, overweight participants focused on current life events, such as not being able to fit on amusement park rides or holding back the team in gym class, rather than serious health conditions that might arise in the future. This was in contrast to normal weight participants who voiced a connection between lifestyle and quality of life. One normal weight male conveyed this clearly when he stated *"if you do not eat healthy and exercise you will die sooner than if you do eat healthy and exercise. If you eat healthy and exercise, you'll live a better life."*

Although limited understanding of lifestyle and weight change in the short term was demonstrated across focus group discussions, many overweight youth did not express familiarity with the long-term consequences of poor diet and

being overweight, nor did they view their lifelong health as a concern. Particularly among the 4th/5th grade children who were overweight, most stated that their health was "fine" or "good," and several participants also indicated that overweight youth would naturally become skinny without lifestyle change. For example, youth frequently referred to friends and family members who were fat and "*all of a sudden*" became "*pure skinny*" or "*pure muscle.*"

4. Discussion

We analyzed data from focus group transcripts to explore attitudes, beliefs, and knowledge of youth about healthy lifestyles and how such behaviors are related to the causes and consequences of obesity. Exploring youth's familiarity with obesity and its consequences will allow for more informed development of child targeted, community-wide obesity interventions. Most youth reported that they recognized obesity as a problem, in contrast to a study conducted in 2000, in which youth were indifferent to the topic [14]. However, even if they could recognize what it meant to be "overweight," youth who were themselves overweight did not consider themselves to be so, suggesting that youth do not see themselves as susceptible to becoming obese. This disconnect is consistent with previous research which found that body weight underestimation is greatest among youth with higher BMI [15, 16].

Youth who were overweight attributed being overweight to external causes such as slow metabolism and genetics, whereas most of the normal weight youth perceived being overweight as resulting from alterable lifestyle factors. This discrepancy in youth's understanding of the causes of obesity between weight status groups has to our knowledge not previously been shown. The belief in an external (and potentially nonmodifiable) locus of control is particularly concerning because this belief has previously been correlated with continued weight gain into adulthood [17]. Increases in youths' nutritional knowledge has often failed to produce behavior change [18], which may be explained by overweight youths' tendencies to attribute their weight to nonmodifiable attributes.

Difficulty in achieving behavior change among youth could also result from low familiarity with or perceived severity of the long-term health consequences of obesity. Our analyses demonstrate that although youth have knowledge about what healthy and unhealthy diets entail, they express that a healthy lifestyle has low appeal and do not connect their own lifestyle with the development of obesity. Overweight youth in particular often view long-term lifestyle modification as unrealistic and, thus, express frustration and helplessness that decreases their motivation to change their behavior. It is possible that obesity prevention education that includes the benefits of healthy diets, particularly attributes designed to have immediate appeal to youth (e.g., healthier skin, feeling stronger, feeling happier, etc.), would make these education efforts more successful.

There were some limitations of the composition of the focus group discussions that may influence the generalizability of our findings. There was an uneven distribution of weight status and age across groups (e.g., more groups with overweight than normal weight children), and none of the focus group discussions included 4th/5th grade children of normal weight. Additionally, because of the group-oriented setting, participants may have responded in a socially desirable manner, which may have introduced bias into the transcripts. Because the moderator was skilled at working with children in this type of setting, this was unlikely to affect our data. Furthermore, youth provided detailed accounts and challenged each other's opinion, which indicated a sense of openness among the focus group participants and demonstrates the generation of good quality data.

The results of these focus group discussions display the complex and evolving nature of youth attitudes towards obesity prevention efforts and their understanding of the causes and consequences of obesity. Obesity is now accepted and acknowledged as a problem amongst youth and by youth. However, attitudes towards prevention of obesity through employment of healthier habits remain mixed, with primarily negative connotations around healthy lifestyle choices.

5. Conclusions

We found that most youth in the state of Georgia (USA) recognized obesity as a problem yet failed to connect their behavior with the development of obesity. More overweight youth attributed being overweight to external causes, such as slow metabolism or genetics, rather than alterable lifestyle behaviors, such as diet and physical activity. They also did not tend to see sustained lifestyle change as desirable or achievable. It is well documented that excessive caloric intake and inadequate physical activity are important contributors to weight gain and obesity. Our study suggests that youth may benefit from education designed to increase the desirability of healthy habits, either from gaining benefit or from avoiding consequences, specifically linking lifestyle choices with weight-related outcomes. For overweight youth in particular, successful role models seem to be critical to their beliefs that change to a healthier state is achievable. Future research is needed to evaluate whether increasing youth understanding and awareness in these areas will lead to positive behavior change.

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Research Article

Participatory Action Research in the Implementing Process of Evidence-Based Intervention to Prevent Childhood Obesity: Project Design of the "Healthy Future" Study

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Objective. To describe the design of the developmental project Healthy Future that aims to implement a new evidence-based program for the prevention of childhood obesity and collaboration and sharing of work between specialist and community health care professionals in parts of a county in western Norway. *Methods*. Comprehensive participatory planning and evaluation (CPPE) process as an action-oriented research approach was chosen, using mixed data sources, mixed methods, and triangulation. *Discussion*. A bottom-up approach might decrease the barriers when new evidence-based childhood prevention interventions are going to be implemented. It is crucial not only to build partnership and shared understanding, motivation, and vision, but also to consider the frames of the organizations, such as competencies, and time to carry out the interventions at the right level of health care service and adapt to the overweight children and their families needs. *Conclusion*. The developmental process of new health care programs is complex and multileveled and requires a framework to guide the process. By CPPE approach evidence-based health care practice can be delivered based on research, user knowledge, and provider knowledge in the field of childhood overweight and obesity in a certain context.

1. Introduction

Health care professionals in Norway are increasingly worried about the negative trend they observe in the number of overweight and obese children and adolescents. The Norwegian Child Growth Study measuring 3rd graders from a national representative sample of 127 schools, in which nine of ten children took part, demonstrated a 3% increase in ISO-BMI from 2008 to 2010, and 22% of the girls and 17% of the boys were estimated to be overweight or obese in 2010 [1]. In a more detailed study of 1774 children from Finnmark, the northernmost county in Norway, born in 1999-2000, 19% of the children (22% of the girls; 16% of the boys) were classified as overweight when they had reached the age of six [2]. Overweight negatively affects children's physical and psychosocial health [3] and compromises their future health, particularly in terms of an increased risk of obesity [4]. Thus, the developmental trend in Norway is that more and more children become more and more overweight, at an earlier and earlier age, which accords with the developmental trend in most westernized countries [5]. Even though treatment of overweight might be considered to have an easy solution (increase energy expenditure and decrease energy intake) the rate of overweight children has been steadily increasing, suggesting that the prescribed solution is an aim rather than a method [6–9].

Up until 1998 the public health nurses measured all children's weight and height in order to estimate growth curves for all children as part of routine health examinations at the school health service in Norway. In 1998 the Norwegian health authorities revised their recommendations for the public health nurses to recommend that only school children judged to be ill or at risk for becoming ill should be weighed. The recent obesity pandemic in children worldwide has

recently led to a revision back to the original program for monitoring each child's weight and height in order to estimate ISO-BMI and growth curves, in an attempt to prevent children from becoming overweight. The Norwegian Health Directorate therefore published new guidelines for the school health service [10] where routine measurement of children's height and weight was reestablished, recommending measures to be taken at five years, 3rd and 8th grade with the goals to identify early growth aberrance, to reduce the individual negative consequences, and to make the basic for implementation and evaluation of interventions at a public health level. At the same time new national guidelines for prevention, mapping, and treatment of overweight and obesity in children and youth were published [11] to ensure proper professional service with regard to overweight problems in primary care, and to contribute to cooperation in all directions in the health care systems. The guidelines are structured by and are recommending interventions according to the level of ISO-BMI. These two sets of national guidelines are not widely implemented in the primary health care service yet.

As the monitoring of children's height and weight developments is important for identifying children at risk for obesity, it must be accompanied by effective interventions. Children or adolescents with obesity have traditionally been met by school nurse or general practitioners and told to reduce food intake and increase the physical activity. There has been no structured or systematically plan, and the responsibility for this care is experienced unclear [12]. Such a approach rely on a linear understanding that if energy intake is lower than expenditure, the weight will be reduced, but underestimate the importance of the persons feelings, thoughts, and environmental influences such as peers and parents. To help people change behavior, a psychological approach is needed. Competence in using these methods are mostly available in the mental health care, while obesity is tried solved in the field of somatic problems. Uncertainty where and by whom childhood obesity should be treated is a key question in Norway, and also if the competence exists where these children live [12].

There is limited access to evidence-based interventions for childhood overweight in Norway, and in rural areas there is also limited access to professionals with specialized training. Overweight individuals also often delay asking for help from health-care services. Many professionals in primary care are uncertain in meeting overweight children and need more knowledge of what works. The practitioners are faced with the challenge of implementing a program in their daily work and decide who in the community staff/hospital shall do what [12]. Due to limited resources and access to evidence-based programs, there is a great need for prioritizing the health care resources. This also calls for an increase in preventing efforts. It is much more demanding treating obese children than preventing overweight children from becoming obese. An increased effort on preventive measures is also called for by the fact that it is possible to identify specific risk factors for childhood obesity. One certain risk factor for becoming obese is having obese parents [13, 14], a second is when the ISO-BMI is increasing, the child starts becoming overweight [15], and parents are not aware of the situation [13].

The health care system seems to be faced with some challenging aspects regarding the treatment because obesity is understood with some discrepancy within the health care providers regarding treatment and preventions methods, and their differences in the understanding where and when treatment interventions should be initiated [12]. Therefore there is a great need for more research on the implementation of evidence-based treatment program for childhood obesity in primary care. From other countries it is pointed to the need for bringing pediatric weight management into practice [16], and that programs working in other countries are not always successfully implemented elsewhere [17]. Waters et al. [18] conclude that childhood obesity prevention research must move towards identifying how effective intervention components can be embedded within health, education, and care systems and achieve long-term sustainable impacts. According to Klesges et al. [19], enhanced reporting of relevant and pragmatic information in behavioral investigations of childhood obesity interventions is needed in order to improve the ability to evaluate the applicability of results to practice implementation and that such evidence would improve translation of research to practice, provide additional explanation for variability in intervention outcomes, and provide insights into successful adaptations of interventions to local conditions. The aim of this paper is to present the process of and theoretical consideration for implementing an evidence-based treatment program for overweight children in Norway, using a "bottom-up approach."

The increase in the number of obese children in Norway requires early interventions, particularly targeting children with overweight to prevent them from becoming obese. A multicase study from the childhood obesity field in Norway reported a great need for developing both preventive and treatment interventions that were evidence based. It was also recognized differences in the providers understanding with regard to the obesity situation as well as what kind of treatment should be chosen [12]. These findings have led us to take steps to coordinate a project with the aim to promote the implementing process of new national guidelines and based on the best evidence available achieve shared understanding among the providers in the field. After more than one year of preparations the project "Healthy Future-prevention of childhood obesity" (HF project) was established.

Evidence-based (EB) practice requires that the professionals make decisions based on the systematic gathering of evidence drawn from research, experience, and advice of clinicians working with the patients along with the patient's input, desires, and needs [12]. Unfortunately, it is not always the case that production of "evidence" means that practitioners integrate it into their everyday practice, and often practice lags behind what is known to be current best practice [20]. Steine [21] stated that important changes in the health services seldom occur solely from a top-down approach. During implementing health care interventions we have to consider both what kind of knowledge to be implemented and how knowledge is facilitated in the context where it will be used [22]. Successful implementation is the function of knowledge, context, and facilitation according to the framework "Promoting action on Research Implementation

in Health Care" (PARiHS) [23]. Research from implementing frameworks is published from a range of fields [24–31]. The Child System and Treatment Enhancement Projects (ChildSTEPs) were launched to help bridge the science-practice gap in children's mental health service [32, 33]. In this it was recognized that community mental health services were delivered through complex organizational systems, and that success of such systems is likely to be affected by several macrolevel factors that include official regulations, funding, and collaborative agreements among related service systems [34]. Translation of research findings and knowledge and making decision about its use in daily practice is challenging for health professionals [35–37]. As a response to this participatory action research (PAR) could be a methodological strategy to be used. According to research, PAR is a method that increases the possibilities for a better transformation to specific situations, facilitates the implementation of new knowledge, and in this way fills the gap between theory and practice [38–42]. Schultz et al. [43] underlines the need for a strong platform and more strategic systems approach in future obesity prevention research. Encouraging community engagement in formulating research agendas and promoting ownership of health solutions will be a key to improving obesity risk factors [44]. Community-based participatory research (C-BPR) approach is recommended in the field of obesity prevention [44–46], and others have found this to create the opportunity for partners to train together, build capacity, and increase cohesion, and develop relationships and trust [47].

2. The "Healthy Future" Study

2.1. Evidence for Changing Behavior in Childhood Overweight. During the last decades there has been an increased focus on and drive for quality improvement and demand to ensure that the delivery of health care is evidence-based and clinically effective, so also in interventions used for overweight children. Within the HF project the team needed to decide what and how they will use the current research evidence. In the latest Cochrane review of childhood obesity cognitive behavior therapy (CBT) is acknowledged as the treatment of choice. "While there is limited quality data to recommend one treatment program to be favoured over another, this review shows that combined behavioural lifestyle interventions compared to standard care or self-help can produce a significant and clinically meaningful reduction in overweight in children and adolescents" (Oude Luttikhuis et al., 2009:2) [48]. The behavioral economics model of obesity has been found to provide a particularly good framework for overcoming resistance to change in overweight children and adolescents [49] and was also associated with good long-term outcomes [50, 51]. In Iceland the Epstein model has been adapted and tested by Gunnarsdottir [52] and was found to be acceptable and effective in twenty children with overweight or obesity in a diverse sample. However, the Norwegian national guidelines did not recommend a special treatment program to be preferred and used but reported diverse evidence levels from A–D according to each initiative mentioned. In the list of recommendations we find that early onset and long-lasting treatment, multiprofessional cooperation, reducing sugar, salt, and fat are labeled evidence level B. Even in the guidelines it is stated that the health care professionals should know conventional recommendations for weight reduction in obesity treatment (page 54), and cognitive behavioral treatment (CBT) is discussed (page 55), CBT is not mentioned in the list of recommendations neither for overweight nor for obesity (page 10–12). Reading the guidelines the somatic side of obesity and its treatment are well described and emphasized, but research shows that psychological treatment methods added in the treatment plan are the most recommended and shows the best effect [48, 53].

Early onset and long-lasting treatment are highlighted and recommended [54], as well as the whole family is active in the treatment. According to Golley et al. [55] and Magarey et al. [56] parent skill training increases the efficacy of pediatric obesity interventions, and Kitzman-Ulrich et al. [57] concluded that parent training in general behavior management was associated with significantly better outcomes in family-based interventions.

The recommendations of expert panels (the US Center for Disease Control and Prevention, the American Medical Association, the American Academy of Pediatrics) and guidelines developed by the National Association of Pediatric Nurse Practitioners encourage a shift from a traditional model of counseling (by telling people what they should do) to a collaborative, family-centered model that includes the use of motivational interviewing (MI), in which the nurse and family jointly formulate a plan of care that is consistent with the family's values and priorities [58]. In the Norwegian guidelines for childhood obesity [11] MI is underlined as a tool to be used in encounters during prevention and treatment, as well as MI is described and recommended in most of the official guidelines with regard to public health initiatives in Norway. Motivational interviewing (MI) is a communicative technique that is highlighted as a method to help people change behavior with a large evidence base comprising more than 200 randomized clinical trials has emerged and is showing positive effects [59]. MI seems also to be a promising tool used in childhood obesity [60, 61]. The service to the overweight child and the effect of the treatment program will largely depend on the implementing quality. To facilitate the implementation process we used a bottom-up approach that could promote the institutionalization of our targeted interventions.

2.2. Aim and Objectives. The primary aim of this project is to prevent childhood obesity.

The project intends to

(1) map and define the need for initiatives aimed at families affected by obesity and risk for it,

(2) map resources and barriers within the health service (personnel, expertise, competency, attitudes, and treatment/management),

(3) establish a new comprehensive model for prevention, management, and followup and a model for

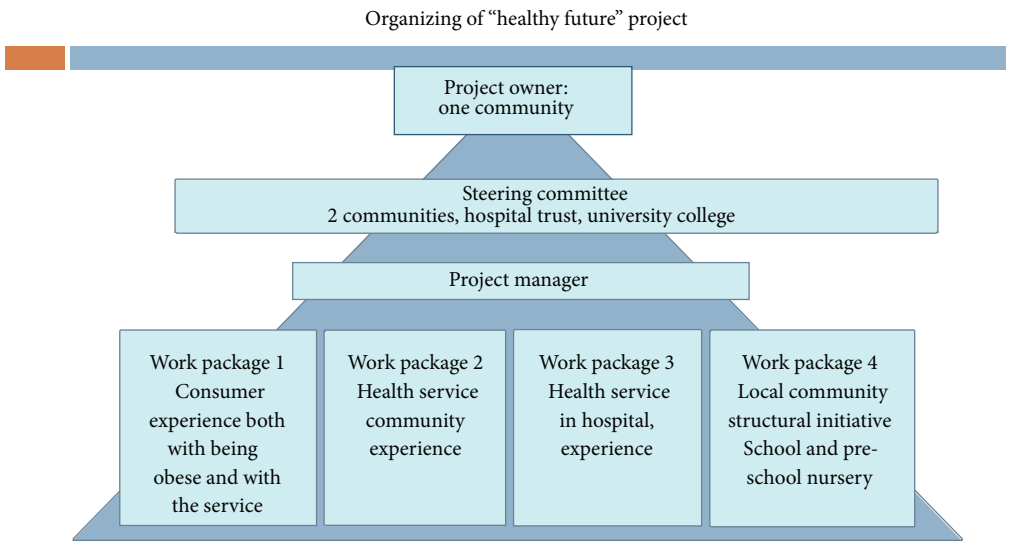

Figure 1

collaboration and sharing of work between specialist health-care services and the community,

(4) implement and evaluate the new model.

Secondary aims.

The project intends to

(1) understand what intervention children, adolescents, and their families with obesity/overweight problems want from health care personnel,

(2) achieve greater confidence from public health nurses and doctors in terms of raising the subject of/talking about obesity at an early stage in its development,

(3) develop evidence-based methods/materials for prevention, treatment, followup and health promotion for use in health care,

(4) improve provision of evidence-based practice in specialist's and community-based health care services to families with overweight and obesity,

(5) bridge the gap between the expectations from the target group and what the service can provide.

This paper describes the design of the project "Healthy Future-prevention of childhood obesity" (HF-project), process of establishing network and venue to build motivation to carry out new health care service to the group of overweight and obese children and their families in one region in Norway.

One example of research question for 1st phase:

What interventions do health care professionals offer to obese children and their family, which resources and barriers are pointed to, and what expectations with regard to childhood obesity interventions do health care providers recommend for the future?

2.3. Study Setting. The Healthy Future study is a comprehensive locally developed project, with diverse partners: two local hospitals within the same hospital trust, and two different municipalities, a university college and The User Association for Obesity. The query to the hospitals went to the pediatric- and the child psychiatric units and to the child- and adolescent health prevention service in the communities. The period of recruiting partners and strengthening motivation for the project lasted more than one year, mainly because there was no economical support for the project at that time. The prolonged process caused turnover in individuals and decreased the number of communities that participate in the project. The project is carried out in the southwestern part of Norway.

2.3.1. Participants. The Healthy Future study group comprises a total of 14 professionals who all are engaged in obesity prevention work. The professionals represent two municipalities in the county which are the core competence in helping overweight children and their families. The group comprises child physiotherapists and public health nurses (from the municipalities) and pediatricians, family therapists (from the hospital), nurses, and researchers (from the University College). In addition a social worker is a representative from the Local Association for Obesity in the group. (Figure 1, work package 2).

2.3.2. Organization of the Project. One municipality is defined as the project owner, which includes the administrative responsibility for running the project. One of us (GØ) acts as a manager, and the project was led by a steering committee from the Hospital Trust, both the municipalities, and the University College. The work to be done through each phase was divided into four work packages (WP): WP 1: consumer experience both with being obese and with the service, and recommendations for the future, WP 2: the experience and recommendations from the communities

health providers, WP 3: the experience and recommendations from the hospital obesity treatment providers, WP 4: the experiences and recommendations from providers working in the communities (Figure 1).

Within the HF-project's WP 1, WP 2, WP 3, and WP 4, respectively, 3, 3, 2, and 1 research studies are planned or ongoing as master- and ph-d-projects with diverse additional scientific partners but will not be described in this paper.

2.4. Design and Methods

2.4.1. Checkland's Soft System. The project was initiated by us as a result of the multicase-study [12] by inviting partners: two hospitals and six surrounding communities, and asking if their professionals could support the process of implementing EB interventions in the field of childhood obesity. All fourteen professionals attended the first meeting, where interventions for childhood obesity were raised and discussed guided by Checkland's "Soft System" theoretical framework [62]. This model, from a qualitative methodological perspective, is a framework for changing clinical practice, as a PAR design. The model consists of seven stages: (1) assessment of the situation or practical problem and description of this problem, (2) identification of the systems involved, (3) desirable modeling of the systems, (4) comparison of the desirable model and the problematic situation, (5) establishment of a concept of what is desirable and what is possible, (6) implementation of the proposed activities and observations, and (7) reflecting about the change. Two meetings discussing the situation and the review process of written proposal resulted in financial support from the Norwegian Health directorate. After fulfilling the phases from 1 to 6, to strengthen the structure of the implementation phase, the PARiHS framework acted as a theoretical framework for the project. Successful research implementation was described as a function of a dynamic, simultaneous relationship among evidence, context, and facilitation [63]. These three key elements are described in more detail, where evidence is characterized by research evidence, clinical experience, patient experience, and local data and information; context by culture, leadership, and evaluation; and facilitation by purpose, role, and attributes, derived from the research, practice development and quality improvement work by Rycroft-Malone [63] that other researches have supported [64].

2.4.2. Comprehensive Participatory Planning and Evaluation Process. Participatory action research (PAR) was chosen as a strategy in HF project because the aim was two-folded; to create both knowledge and new practice. According to Greenwood and Levin [65] Action Research (AR) is social research carried out by a team encompassing a professional action researcher and members of an organization or community seeking to improve their situations. AR promotes broad participation in the research process and supports action leading to a more just or satisfying situation for the stakeholders [65]. Many models and newly created frameworks are built on AR as a research practice with a social change agenda.

The comprehensive participatory planning and evaluation (CPPE) process is an action oriented approach designed to guide project planning and evaluation in communities during five steps including (1) problem assessments, (2) identification and selection of interventions, (3) planning, (4) intervention proposal development, and (5) monitoring and evaluation of the results [66], partly concurrent with the Checkland's Soft Systems, and provided for a context of complex systems as communities. A system approach underlies AR in all its manifestations. Social systems are not mere structures but are processes in continuous motion interlinked and intertwined in the individual's social structures and the larger ecology of systems into complex interacting macrosystems [65]. To build motivation for EBP it is crucial to involve each partner's participation during the process. Optimally, the practitioner has experience-based and well-considered knowledge about the practice field [67] and can offer input in important situations, whilst the researcher possesses theoretical knowledge and can offer input from these perspectives.

2.4.3. Mixed Research Methods. One way of using multiple research approaches to study the implementing process of childhood obesity interventions is through the application of mixed methods research that integrates the collection and analysis of both quantitative numeric data and qualitative narrative data. By combining these two approaches within mixed methods research designs, researches can maximize the strengths of each approach while making up for the weaknesses of the approaches, develop more complete and complementary understandings, increase validity of results, use one form to build on the results of the other, or examine contextualized understandings, multilevel perspectives, and cultural influences [68–71].

According to Creswell and Plano Clark [72] a definition of mixed methods is useful for differentiating the many perspectives people bring to defining mixed methods:

> *Mixed methods research is a research design with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis and mixture of qualitative and quantitative approaches in many phases of the research process. As a method, it focuses on collecting, analyzing, and mixing both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone. (p. 5)*

Mixing refers, according to Creswell and Plano Clark [68], to the researchers determining when and how to integrate or combine the data sets. Mixing might occur at any of the four major steps in a research process: during interpretation, data analyzes, data collection, and/or during the research design process. Of the six designs from Creswell and Plano Clark [68] we chose the multiphase design as fitting

the program development in HF project and its evaluation. The multiphase design occurs when the researcher combines both sequential and concurrent design elements over a period of time within a program of the study dealing with an overall programmatic objective. This design is useful when a complex approach is required to achieve multiple study objectives over time [68].

Action researchers accept a wide range of research techniques: surveys, statistical analysis, interview, focus groups, ethnographies, and life histories are all acceptable if the reason for deploying them has been agreed on by the AR collaborators and if they are used in a way that does not oppress the participants [65].

The number of research studies in the HF project has been growing through the working process during the first phase, and in WP1 we will use both qualitative methods as focus groups with adolescents and individual interviews with parents as well as quantitative studies using surveys to prescholars and their parents. In WP2 and 3 we will use focus groups along with survey targeting of participants from both the specialized and the community health services. In WP4 document analyses and interviews will be used. To evaluate the project we will use both process evaluation and a broad specter of methods to evaluate the effectiveness of the new interventions targeting both the providers and users. Pre- and postdata will inform the effectiveness, using different intervention groups and controls.

2.5. Data Collection. The project duration will be approximately 3 years after the protocol was accepted and became financially supported in December 2011. The project follows in line with the CPPE process [66].

Phase 1: problem assessments and phase 2: identification and selection of interventions lasted one year. In addition to the focus groups with providers, the data originated from discussions in the team meetings, knowledge transfer through two conferences and reviewing the summaries from each of these events, and evaluation of the conferences. The conferences were organized, and theme was chosen based on updated research findings in the field of childhood obesity and what providers expressed they need knowledge of to improve the health care service to this target group. One critical milestone is to agree on what interventions should be implemented.

Phase 3: planning and phase 4: intervention proposal development will last for eight months. In this phase the focus will be on the qualities of the context according to PARiHS framework. This involves negotiation and developing a shared understanding about the benefits, disadvantages, risks, and advantages of the new over the old during a dialectical process that requires careful management and choreography and one that is not done in isolation; in other words, it is a team effort [23].

Phase 5: monitoring and evaluation of the results will last for one year and four months. This phase, as the implementation stage by carrying out the interventions and the evaluation, represents one important empirical part of the HF project. In this phase useful data would be pre-post evaluation tests, both summary scores for evidence and context, narrative summary, and evaluation of facilitation approach, according to PARiHS [23].

2.6. Data Analysis. The data analysis varies depending on the method used in each study. Of the qualitative analyses, in the focus group discussions the content analysis is used [73]. Transcribed texts are analyzed in five steps. In the first step the interviews are read through and listened to several times. In the second step meaning units related to the aim are identified. In the third step the meaning units are condensed and labeled and finally coded on the basis of their content. Based on the codes, subcategories and categories are developed in the fourth step. In the fifth step the categories were carefully discussed until main categories are identified. The less-complex-content analysis method by Malterud is used in some of the studies [74] inspired by Giorgi [75]. This procedure consists of the following steps: (1) total impression—from chaos to themes; (2) identifying and sorting meaning units—from themes to codes; (3) condensation—from code to meaning; (4) synthesizing—from condensation to descriptions and concepts [76].

The quantitative data will be analyzed by appropriate statistical technique, according to the research questions and hypothesis.

To ensure the integration of mixed data, a triangulation process can be used in the meaning to describe a process of studying a problem using different methods to gain a more complete picture [77]. Triangulation techniques require researchers to list the findings from each component of a study on the same page and consider where findings from each method agree (convergence), offer complementary information on the same issue (complementary), or appear to contradict each order (discrepancy or dissonance) [78–80]. For example, interviews might be carried out with a sample of survey respondents, creating a subset of cases (individuals or groups) for which there is both a completed questionnaire and a transcript [81]. In the HF project a mixed method matrix could be used to study the relation between findings from research, interviews, and surveys according to the example of O'Cathain et al. [77, 82].

2.7. Ethical Considerations. The Declaration of Helsinki [83] provided the guidelines for the whole project. The multiple studies have been presented to the Regional Committee for Medical and Health Research Ethics (REC). No evaluation was necessary. The Norwegian Social Science Data Services (NSD) approved the project (number 29263).

3. Discussion

Attempts to promote change may fail if the innovator adopts an unstructured approach [84]. The HF is complex project and a process of different levels: both developing new interventions and developing new implementation strategies, both designed for community health care services, as well as strategies for collaboration and sharing of work between specialist and community health-care services. These developments are built on both qualitative and quantitative data,

and from the three kinds of sources: research findings, user information/data, expert information/data, and decision making and using the most suitable techniques in a mixed method design at each stage in the CB-PA process. The "Bottom-up perspective" is selected in HF project in order to decrease the barriers when new evidence-based interventions are going to be implemented. The initial phases of CB-PR, forming a partnership, assessing, and strengthening the community dynamics, are considered to be most critical [85, 86]. It is crucial not only to build shared understanding, motivation, and vision, but also to consider the frames of the organizations, such as competencies, and time to carry out the interventions at the right level of health care service and adapt to the obese child and their families needs, in a way comparison of the desirable model and the problematic situation [62]. The bottom-up perspective will hopefully be time consuming in the planning/developing process, but the intervention will be more sustainable and more easily institutionalized. As system support we offered conferences as part of the motivation process. This was evaluated to be useful and relevant for a wide range of professionals, and the conferences also acted as a meeting point for interested professionals to a wider region, which in turn will promote discussions in the field lacking health care services. In addition it is anticipated that the organizations must prioritize formal education in health care prevention and treatment for providers to be involved.

It is expected that "The Healthy Future" project will present knowledge about how to develop coordinated services for the obese child and his/her family and clarify the responsibilities and duties for hospital units and the communities, as well as the duties of the community as a whole, to promote health and that the study design and process will increase the ability to implement new practice both in hospital and community settings.

3.1. Limitations. The following are considered possible limitations for this project: (1) initiative of the project was taken of a researcher situated away from the daily concerns of the healthcare professionals. (2) The HF project took a long time to be established, and since its origin several enthusiastic providers that acted as door openers have changed work positions, which in turn require additional time and energy to build motivation in new personnel. (3) The design as a whole with the qualitative approach adapted to a special region area and results cannot be generalized but merely support knowledge to similar contexts and situations.

4. Conclusion

In conclusion, using a community-based participatory research approach in the Healthy Future Study shows an example of a method to be used in implementing childhood overweight and obesity preventive and treatment interventions in one certain region. The developmental process of new health care programs is complex and multileveled and requires a framework to guide the process. Mixed methods approach is demanding, but can be useful if the most appropriate triangulation technique is used during the different project steps. By this approach evidence-based practice can be delivered based on research, user knowledge, and provider knowledge in the field of childhood overweight and obesity in a certain context.

Conflict of Interests

The authors declare that they have no conflict of interests.

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Clinical Study

Eating Behaviors and Overweight among Adolescents: A Population-Based Survey in Japan

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Objectives. The aim of the present study was to investigate the relationship between eating behaviors and overweight among population-based adolescents in Japan. *Methods*. Study subjects comprised adolescents in the seventh grade (age range, 12–13 years) from Ina, a town in Saitama Prefecture, Japan, between 1999 and 2008. The height and weight of the subjects were measured, and information concerning eating behaviors (eating speed and eating until full) was obtained using a self-administered questionnaire. *Results*. Among boys ($n = 1586$), fast eating speed significantly increased the odds ratio (OR) for overweight when compared with medium eating speed, regardless of eating until full or not; moreover, a more marked increase in the OR was observed among boys eating until full (OR: 2.78, 95% confidence interval: 1.76–4.38) than among those not eating until full (2.43, 1.41–4.20). Among girls ($n = 1542$), fast eating speed led to a significant increase in the OR in those eating until full; however, no significant increases were observed in the OR in those eating quickly and not until full. *Conclusions*. Among adolescents, fast eating speed was associated with overweight; furthermore, the combination of both fast eating speed and eating until full may have a significant effect on overweight.

1. Introduction

Obesity is a major risk factor for chronic diseases, and it also plays a central role in both insulin resistance and metabolic syndrome, which includes hyperinsulinemia, hypertension, hyperlipidemia, and type 2 diabetes mellitus [1]. It was recently reported that the metabolic and physiologic abnormalities associated with obesity in adolescence (e.g., hypertension, dyslipidemia, and type 2 diabetes) tend to track into adulthood, along with the condition of obesity itself [2]. Moreover, independent of adult obesity status, adolescent obesity increases the long-term risk of adult mortality and morbidity [3]. Therefore, the importance of obesity prevention in adolescents is evident.

Overweight and obesity have also been reported to be associated with a variety of lifestyle factors [4–13], among which, eating behavior has long been identified as a factor. Several studies have reported an association between eating speed and overweight or obesity [9–11], and eating until full, which refers to consuming a large quantity of food in one meal and is unrelated to eating disorders [12], has been reported to be associated with overweight [12, 13]. However, the effect of eating speed on overweight could depend on the behavior of eating until full, because the total energy intake in those who eat quickly and until full is usually higher than that in those who eat quickly but not until full. In fact, Maruyama et al. reported that both eating quickly and eating until full are associated with overweight among adults, and the combination of the two may have a substantial impact on overweight [12]. For example, fast eating speed may not have a significant effect on overweight if the individual does not eat until full. Therefore, when eating speed is evaluated as a risk factor for overweight or obesity, it may be essential to consider eating until full behavior. However, to the best of our

knowledge, the combined effect of eating speed and eating until full behavior on overweight among adolescents has yet to be reported.

Accordingly, the aim of the present study was both to investigate the relationship between eating behaviors (eating speed or eating until full) and overweight and to examine the effect of the combined behaviors on overweight among population-based adolescents in Japan.

2. Methods

In addition to the annual national health checkups performed in accordance with the School Health Law of Japan, the town of Ina, located in Saitama Prefecture, has conducted a unique health-promotion program since 1994.

The program consists of a questionnaire survey, blood test, and physical examination for both fourth and seventh graders. Several studies concerning this program have been conducted [14–16].

2.1. Study Subjects. Study subjects comprised a total of 3256 seventh-grade school children (age range, 12-13 years) from Ina between 1999 and 2008 ($n = 306$ in 1999; 309 in 2000; 298 in 2001; 317 in 2002; 293 in 2003; 315 in 2004; 312 in 2005; 354 in 2006; 380 in 2007; and 372 in 2008). Informed consent was obtained from the parent or guardian of each subject prior to their participation in the study. The study protocol was approved by the Medical Ethics Committee of Showa University School of Medicine.

2.2. Questionnaire Survey. A self-administered questionnaire was distributed to each subject by a teacher in the junior high school. Each subject and a parent or guardian completed the questionnaire, which was composed of the following two sections: one (on the front of the questionnaire) to be completed by the subject; and the other (on the back) to be completed by the parent or guardian.

The questionnaire asked subjects about the following items: sex; age; exercise other than physical education class (daily, sometimes, or none); snacking after dinner (always, often, seldom, or none); eating speed; and eating until full behavior. Information concerning eating speed was based on three possible responses (fast, medium, or slow) [17] to the question "How fast is your eating speed compared to others?" With regard to eating until full behavior, possible responses were either yes or no [18].

The parent or guardian of each subject was asked to complete a self-administered questionnaire regarding the subject's birth weight, wake-up time, bedtime, frequency of eating breakfast (daily, sometimes, or none), and whether the child was an only child. The heights and weights of the parents or guardians were also self-reported in the questionnaire. Self-reported height and weight are commonly used in epidemiological studies and are generally reliable in Japanese men and women [19]. Sleep duration was calculated from wake-up time and bedtime, and frequency of eating breakfast was categorized into the following two groups: skipping breakfast (sometimes and none) and not skipping breakfast (daily).

2.3. Anthropometric Measurements. To protect the privacy of the subjects, height and weight were measured either in the school's infirmary or in a designated room. For the anthropometric measurements, the subjects wore light clothing and were barefoot. Height was measured to the nearest 0.1 cm using a stadiometer, and body weight was measured to the nearest 0.1 kg using a scale. Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared. These measurements were recorded annually from 1999 to 2008.

2.4. Definition of Overweight and Obesity. Childhood overweight (including obesity) was determined according to the age- and sex-specific cut-off points proposed by the International Obesity Task Force [20]. The criteria have been used in numerous epidemiological studies for both Japanese children and adolescents [8, 21–24]. Based on previous studies for Japanese adults [25, 26], parents who had a BMI $\geq 25\,\mathrm{kg/m^2}$ were defined as obese.

2.5. Data Analysis. Statistical analysis was performed separately for each sex. Either the chi-square test or the Wilcoxon rank-sum test was used to compare various characteristics between the overweight and nonoverweight groups. A logistic regression model was then employed to evaluate the relationship between eating behaviors and overweight, and both the crude odds ratio (OR) for overweight and the 95% confidence interval (95% CI) were estimated and subsequently adjusted for potential confounders. Variables that had been reported to be associated with overweight [4, 8, 27–30], and that were different between the overweight and the nonoverweight groups (P value less than 0.05) in this study, were considered as potential confounders. These included birth weight, obesity status of the parent, frequency of exercise, and skipping breakfast. A P value less than 0.05 was considered statistically significant. All statistical analyses were performed using Statistical Analysis System (SAS) software (version 9.2; SAS Institute Inc., Cary, NC, USA).

3. Results

Among all 3256 subjects, 28 refused to participate in the program (participation rate: 99.1%), and 100 were excluded due to incomplete data. Thus, data from a total of 3128 subjects were analyzed.

The characteristics of both the overweight and the nonoverweight boys ($n = 1586$) are shown in Table 1. Boys with one or more obese parents were more frequently found to be in the overweight group, and statistically significant differences were observed between the overweight and nonoverweight groups in both birth weight and frequency of exercise. A significantly higher proportion of those who eat quickly was found in the overweight group when compared

Table 1: Characteristics of the nonoverweight and the overweight boys among study participants.

Variables	Nonoverweight (n = 1355)	Overweight (n = 231)	P value[a]
Age (years)	12.0 (12.37)	12.0 (12.39)	0.594
Birthweight (g)			
<2500	6.0	8.9	<0.001
2500–2999	29.1	23.0	
3000–3499	45.7	38.1	
3500–3999	17.4	24.8	
4000+	1.8	5.3	
Only child (%)	7.8	9.3	0.438
Parent's obesity (%)			
None	69.5	41.2	<0.001
Father only	20.9	32.3	
Mother only	5.6	16.2	
Father and mother	4.1	10.4	
Exercise (%)			
None	9.5	16.1	0.005
Sometimes	8.4	10.3	
Daily	82.1	73.5	
Sleeping hours (%)			
9.0+	24.4	21.1	0.785
8.0–8.9	53.5	55.4	
7.0–7.9	19.8	21.1	
<7.0	2.3	2.5	
Skipping breakfast (%)	5.2	4.4	0.624
Snack after dinner (%)			
Seldom or none	39.9	42.6	0.441
Always or often	60.1	57.4	
Eating speed (%)			
Fast	21.8	47.2	<0.001
Medium	59.6	46.3	
Slow	18.6	6.5	
Eating until full (%)	54.7	58.9	0.237

Except where indicated percentage (%), values are median (mean).
[a]Chi-square test or Wilcoxon rank-sum test.

Table 2: Characteristics of the nonoverweight and the overweight girls among study participants.

Variables	Nonoverweight (n = 1363)	Overweight (n = 179)	P value[a]
Age (years)	12.0 (12.36)	12.0 (12.37)	0.757
Birthweight (g)			
<2500	7.3	1.7	<0.001
2500–2999	35.7	29.3	
3000–3499	44.0	47.1	
3500–3999	11.9	16.1	
4000+	1.1	5.8	
Only child (%)	8.2	11.2	0.175
Parent's obesity (%)			
None	67.4	41.8	<0.001
Father only	21.9	25.5	
Mother only	8.2	23.4	
Father and mother	2.5	9.2	
Exercise (%)			
None	26.4	38.5	<0.001
Sometimes	13.5	20.7	
Daily	60.1	40.8	
Sleeping hours (%)			
9.0+	15.5	12.5	0.610
8.0–8.9	50.7	50.7	
7.0–7.9	29.5	33.6	
<7.0	4.2	3.3	
Skipping breakfast (%)	7.2	11.8	0.033
Snack after dinner (%)			
Seldom or none	43.0	41.5	0.700
Always or often	57.0	58.5	
Eating speed (%)			
Fast	11.7	18.4	0.010
Medium	62.4	63.1	
Slow	25.3	18.4	
Eating until full (%)	53.3	50.8	0.541

Except where indicated percentage (%), values are median (mean).
[a]Chi-square test or Wilcoxon rank-sum test.

with the nonoverweight group. Furthermore, a higher proportion of subjects who reported eating until full was found in the overweight group; however, this difference was not statistically significant.

The characteristics of both the overweight and nonoverweight girls (n = 1542) are shown in Table 2. Similar to boys, girls with one or more obese parents were more frequently found to be in the overweight group, and statistically significant differences were also observed between the overweight and nonoverweight groups in both birth weight and frequency of exercise. A higher proportion of those who skip breakfast and a higher proportion of those who eat quickly were found in the overweight group.

The crude and adjusted ORs of eating speed or eating until full for overweight are shown in Table 3. When compared to adolescents who reported a medium eating speed, a significantly increased OR was found among both boys (OR: 2.65, 95% CI: 1.87–3.75, $P < 0.001$) and girls (1.73, 1.05–2.85, $P = 0.033$) in the fast eating speed group, whereas no increased OR was observed in the slow eating group, regardless of sex. The adjusted OR of eating until full was not statistically significant for either sex.

The adjusted ORs of eating speed for overweight were then calculated based on eating until full behavior (Table 4). In boys, a significant increase in the OR of a fast eating speed was observed compared with a medium eating speed, regardless of eating until full behavior. Furthermore, a more

Table 3: Crude and adjusted odds ratios of eating speed or eating until full for being overweight.

Variables	Total N	Overweight n (%)	Crude OR (95% CI)	Crude P value	Adjusted OR (95% CI)	Adjusted P value
Among boys						
Eating speed						
Fast	404	109 (27.0)	2.79 (2.07–3.76)	<0.001	2.65 (1.87–3.75)	<0.001
Medium	915	107 (11.7)	1.00		1.00	
Slow	267	15 (5.6)	0.45 (0.26–0.79)	0.005	0.51 (0.27–0.94)	0.031
Eating until full						
Yes	877	136 (15.5)	1.19 (0.89–1.57)	0.237	1.15 (0.83–1.60)	0.394
No	709	95 (13.4)	1.00		1.00	
Among girls						
Eating speed						
Fast	193	33 (17.1)	1.55 (1.02–2.37)	0.041	1.73 (1.05–2.85)	0.033
Medium	964	113 (11.7)	1.00		1.00	
Slow	385	33 (8.6)	0.71 (0.47–1.06)	0.094	0.74 (0.45–1.20)	0.218
Eating until full						
Yes	817	91 (11.1)	0.91 (0.66–1.24)	0.541	0.84 (0.58–1.22)	0.353
No	725	88 (12.1)	1.00		1.00	

OR: odds ratio; CI: confidence interval. Adjusted for birth weight, parents' obesity, exercise, and skipping breakfast.

marked increase was observed among those eating until full (OR: 2.78, 95% CI: 1.76–4.38, $P < 0.001$) than among those not eating until full (2.43, 1.41–4.20, $P = 0.001$) in the OR for overweight. In girls, fast eating speed resulted in a significantly increased OR among those eating until full, whereas no significant increase was observed in OR among those not eating until full. The ORs of eating slowly did not increase among either sex, regardless of eating until full behavior.

4. Discussion

In this study, some significantly different baseline characteristics were observed between the overweight and nonoverweight groups. For example, adolescents with one or more obese parents were more frequently found in the overweight group. Familial variables, especially parental obesity, have been reported to be the most important in relation to childhood obesity [31], and the association between parental overweight/obesity and childhood overweight/obesity has been reported in a number of studies [7, 8, 27, 30]. Moreover, a relationship has also been reported between overweight and birthweight, exercise, or skipping breakfast among children or adolescents [4, 8, 29, 30]. Therefore, our results were consistent with those from previous studies.

Furthermore, as shown in Table 3, fast eating speed significantly increased the OR for overweight, which is also consistent with results from previous studies [8, 11, 12]. Fast eating speed has been shown to be associated with adolescent overweight [8] and associated with overweight in children [11]. It has also been shown to be a risk factor for obesity among preschool children [10]. One possible mechanism underlying the relationship between fast eating speed and overweight is the increase in energy intake among fast eaters; this is because energy intake per day increases significantly with an increase in eating speed [9]. In addition, sex differences were observed in the effect of fast eating speed on overweight (Table 3). The adjusted OR of fast eating speed for overweight among boys was higher than that observed among girls. One of the reasons could be the difference between the sexes in eating speed. A previous study reported that men ate faster than women and women took more bites and longer to eat than men [32]. The second reason might be the result of differences between the sexes in food preferences. Boys have been shown to prefer meat, processed meat products, eggs, and fatty and sugary foods more than girls [33]. In addition, girls may be more likely to select low calorie foods when they snack due to girls' preferences in relation to body shape [8]. Accordingly, the differences observed between the sexes in the effect of eating speed on overweight may be the result of the differences in eating speed and/or food preferences; however, further study is needed to elucidate the biological mechanisms underlying these differences.

In this study, the effect of eating quickly on overweight varied by eating until full behavior (Table 4). The adjusted OR of fast eating speed for overweight was higher among those eating until full than that among those not eating until full. Eating quickly can lead to a reduced awareness of the quantity of food consumed, which in turn can lead to consumption of a quantity of food that exceeds the amount necessary for satiety [34]. It has recently been reported that fast eating speed may lead to overeating before the stomach senses fullness [9, 11]. Moreover, total energy intake has been shown to be higher among individuals who report eating until full than among those who do not [12]. Therefore, the amount of food consumed by those who eat quickly and until full could be

Table 4: Adjusted odds ratios of eating speed for being overweight by eating until full or not.

Variables	Eating until full				Not eating until full			
	Total *N*	Overweight *n* (%)	AOR (95% CI)	*P* value	Total *N*	Overweight *n* (%)	AOR (95% CI)	*P* value
Among boys								
Eating speed								
Fast	242	71 (29.3)	2.78 (1.76–4.38)	<0.001	162	38 (23.5)	2.43 (1.41–4.20)	0.001
Medium	503	56 (11.1)	1.00		412	51 (12.4)	1.00	
Slow	132	9 (6.8)	0.57 (0.25–1.28)	0.170	135	6 (4.4)	0.42 (0.16–1.11)	0.080
Among girls								
Eating speed								
Fast	106	22 (20.8)	2.97 (1.53–5.76)	0.001	87	11 (12.6)	0.90 (0.39–2.05)	0.793
Medium	503	50 (9.9)	1.00		461	63 (13.7)	1.00	
Slow	208	19 (9.1)	0.87 (0.43–1.75)	0.689	177	14 (7.9)	0.65 (0.33–1.30)	0.227

AOR: adjusted odds ratio; CI: confidence interval. Adjusted for birth weight, parents' obesity, exercise, and skipping breakfast.

larger than that consumed by those who eat quickly but do not eat until full. In girls, eating both quickly and until full was associated with an increase in the OR for overweight, whereas eating quickly and not until full did not. These results suggest that the combination of eating quickly and until full has a substantial effect on overweight, while not eating until full helps to prevent overweight in girls. However, further study is needed to verify these results because information on total energy intake was not collected in this study.

On the other hand, regardless of eating until full or not, no increase was observed in the OR of slow eating speed for overweight. Eating slowly may help to maximize satiation and thus reduce energy intake during meals [35]. In fact, it was recently reported that linear eaters—that is, people who eat at an approximately constant rate—ate less food when challenged to eat at a lower speed [36]. Furthermore, it has been shown that, by eating more slowly, an obese patient can improve his digestion, learn to savor the food, and may eventually achieve a normal state of satiation with less food intake [37]. Therefore, eating slowly could be effective for the prevention of overeating and childhood overweight.

The strengths of this study were that the outcome (overweight or nonoverweight) was defined by height and weight measurements, and that the effect of the combinations of eating speed and eating until full on overweight was evaluated in over 3000 population-based adolescents. However, this study has some potential limitations. First, information concerning eating speed and eating until full was self-reported and, thus, could be not objectively evaluated. However, a high level of concordance between self-reported and friend-reported rates of eating has been reported [38]. Additionally, a statistically positive association between the self-reported rate of eating and energy intake has been recently reported [9], and self-reported rapid eating has been shown to be associated with both overweight and weight gain [8, 11, 34]. Therefore, the findings from this study could be considered reasonable; however, further prospective or intervention studies are needed to verify our results. Second, the possibility of residual confounding in this study cannot be excluded. For instance, socioeconomic status (SES), which has been reported as being a risk factor for both overweight and obesity [39, 40], was not included as an item in the study questionnaire and therefore not evaluated. Third, the present study results were based on data from only one town in Japan. Therefore, due to cultural differences in eating behavior, applying our results to other populations may be difficult. Finally, the present study was a cross-sectional study, and, thus, determining a causal relationship of eating behaviors to overweight was not possible. Therefore, the possibility of reverse causality cannot be excluded.

5. Conclusion

Results of the present study indicated that fast eating speed was associated with overweight. Moreover, the combination of both fast eating speed and eating until full may have a significant effect on overweight among adolescents. Decreasing eating speed is therefore suggested to be an effective strategy for the prevention of overweight among adolescents.

Conflict of Interests

The authors declare that they have no conflict of interests.

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Research Article

Determinants of Fast Food Consumption among Iranian High School Students Based on Planned Behavior Theory

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Objective. This study was conducted to identify some factors (beliefs and norms) which are related to fast food consumption among high school students in Isfahan, Iran. We used the framework of the theory planned behavior (TPB) to predict this behavior. *Subjects & Methods*. Cross-sectional data were available from high school students ($n = 521$) who were recruited by cluster randomized sampling. All of the students completed a questionnaire assessing variables of standard TPB model including attitude, subjective norms, perceived behavior control (PBC), and the additional variables past behavior, actual behavior control (ABC). *Results*. The TPB variables explained 25.7% of the variance in intentions with positive attitude as the strongest ($\beta = 0.31$, $P < 0.001$) and subjective norms as the weakest ($\beta = 0.29$, $P < 0.001$) determinant. Concurrently, intentions accounted for 6% of the variance for fast food consumption. Past behavior and ABC accounted for an additional amount of 20.4% of the variance in fast food consumption. *Conclusion*. Overall, the present study suggests that the TPB model is useful in predicting related beliefs and norms to the fast food consumption among adolescents. Subjective norms in TPB model and past behavior in TPB model with additional variables (past behavior and actual behavior control) were the most powerful predictors of fast food consumption. Therefore, TPB model may be a useful framework for planning intervention programs to reduce fast food consumption by students.

1. Introduction

Fast food intake is still increasing specially among younger generation [1]. Fast food intake has been associated with poor dietary intake [2, 3] and weight gain [4] among young population. Fast food restaurants are becoming widespread worldwide, both in developed and even developing countries like Iran [5]. Based on reports, one-third of adolescents consume fast foods three or more times during a week [6]. Fast food contains higher levels of calorie and fat compared to the home-prepared meals [7]. Our previous studies in Isfahan, Iran, showed that the majority of students consume high servings of fast food per week [8, 9] which was related to higher dietary energy density and higher weight and waist circumference. Previous studies in Isfahan, Iran, showed that fast food consumption was associated with obesity and central adiposity [8, 9]. An important time for assessing and evaluating fast food intake and detecting the associated factors is from adolescents to younger adulthood, a high risk time for being overweight and obesity [10, 11]. Determining the factors influence on dietary intakes among adolescents, such as food preferences [4, 12], family eating patterns [13], and social norms [14, 15], could be a guide for conducting interventions aimed to adopt healthy eating behaviors. Theories and models could offer useful methods in promoting individual behavior. One of the well-known models is the

theory of planned behavior (TPB) [16]. This theory could successfully predict intention and behavior in eating and has recently received great attention in determining the norms and beliefs related to fast food and snacks consumption [17–21]. TPB model has been derived from the theory of reason action (TRA) [16] and explains health behaviors that are not completely under an individual's control. According to a report [16], intention to a behavior is controlled by three concepts: attitudes (favourable or unfavourable evaluations about the behavior), subjective norms (perceived social pressure to perform behavior), and perceived behavior control (PBC) (an individual's perceptions of the ease or difficulty of performing the behavior of interest) [22, 23]. This model has been examined in several studies on eating behavior [18, 24] and has been successfully applied, in a wide range of age groups, in the field of fast food consumption [25]. One of the important age groups that are usually interested in fast food intake is adolescents [25, 26]. Attitudes, PBC, and subjective norms are major parts of TPB, and further to these main parts, TPB could include additional variables if they constitute a large proportion of variance in behavior [17]. Two additional variables could be past behavior and actual behavior control (ABC) which have been mentioned in previous studies in the field of fast food consumption [18]. TPB model could increase the possibility of predicting intention and behavior [18, 27–30]. ABC referres to those factors and resources that could affect people's ability to do a behavior [31]. Dunn et al. found that intention, ABC, and PBC explained 50% of variance in the behavior related to fast food consumption [18]. To our knowledge, no study has examined the utility of a theoretical framework of fast food consumption in an Iranian population to date. As it was mentioned previously, fast food intake is a problem in Iran [9] and we are not aware of any research based on TPB in this population for determining the beliefs and norms related to fast food intake among Iranian adolescents. Although there is a large body of the literature on TPB, according to our knowledge, it is mostly conducted in developed countries and few studies have been conducted in developing countries. In developing countries, we are faced with the burden of diseases, so we have both malnutrition and over nourishment and chronic diseases due to high calorie intake. Therefore, it is not clear that if a model is suitable in predicting some factors related to fast food intake in developed countries, it may also be successful in developing countries. So, it seems that examining the usefulness of the models in each population is necessary. The present research examines some predictors of fast food consumption using TPB model and additional variables to increase the predictability of intention and behavior among high school students in Isfahan, Iran.

2. Method

2.1. Participants. In 2011, a sample of 521 high school students (244 boys and 277 girls) was recruited from 3 regions in Isfahan, Iran. We used a randomized stratified sampling to choose the participants of the present study. At the first stage, a systematic random-sampling procedure was used to select the schools. The schools were stratified into boys' and girls' high schools. The selection of the public high schools was proportional according to the population size. Six schools (three boys' and three girls' schools) were selected from each of the three regions in Isfahan. At the second stage, classes were selected from all grades (year of education in high school) by using a simple random-sampling design. In this way, one class was randomly selected in each of the three grades (first year, second year, and third year) in each high school. Thus, we had a total selection of at least 18 classes in each region (9 classes from the boys' schools and 9 from girls' schools). The explanations about the objectives of the present study were provided for principals of these schools. Participants completed a simple questionnaire during school hours. In total, 600 questionnaires were distributed, and 521 were returned (response rate, 86.83%). This study was approved by the Research Council and Ethics Committee of the Isfahan University of Medical Sciences.

3. Instrument

3.1. Measurement of the Constructs. First, participants completed questions related to demographic data and the TPB variables, which included attitudes, PBC, subjective norms, additional variable past behavior, and ABC. Most of the measures used within the study were developed in a previous study published by Blanchard et al. [32] based on the information obtained from initial interviews with 20 high school students.

A panel of experts, consisting of 5 experts in the fields of health behavior, education, nutrition, and a healthy eating provider with field experience in nutrition, reviewed and assessed the questions of commitment to a plan of action scale orally by evaluating the appropriateness and relevance of the items and response format. They confirmed them as being representative of the construct in order to confirm content validity of the instrument. The feedback from the panel of experts which was mostly regarding the wording and phrasing of questions was used to revise and modify the instrument.

A pilot study was conducted to examine the utility of the instruments and to identify the problems and benefits associated with the design. The questionnaire was pilot-tested with 30 students. The data were used to estimate the internal consistency of the scales, using Cronbach's coefficient alpha. The content validity of the scales was also established.

Attitude was defined as favorable or unfavorable evaluations about the behavior. Attitude to fast food consumption was assessed as the mean of twenty questions with 5-point items including ten items for behavior beliefs and ten for outcome expectancies. Beliefs such as "*fast food tastes good*" were measured on a 5-point scale between 1 (strongly disagree) and 5 (strongly agree). Expectancies, directly related to the previous beliefs, were also measured on a 5-point scale with participants responding to a sentence like "*eating fast food frequently is good for my health*" with a score between 1 (extremely unimportant) and 5 (extremely important). Participants rated on a scale of 1–5 with a higher score

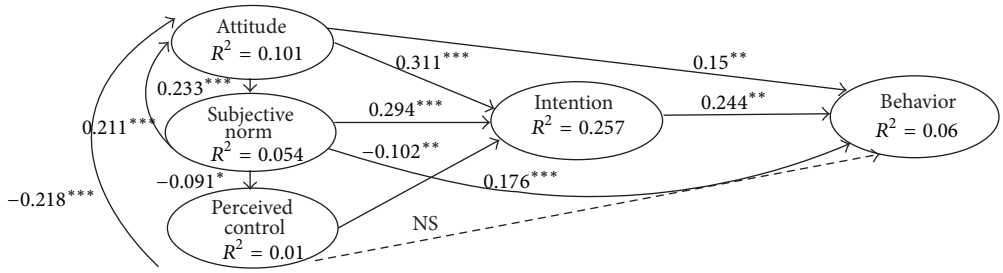

Figure 1: the results from the path analysis which was conducted to examine the direct and indirect effects of the TPB components on the behavior and intention.

indicating a more positive attitude. The reliability coefficient (alpha) for Attitude was 0.66.

Subjective norm was defined as perceived social pressure to perform behavior. Subjective norms were measured by four items. For example "*Most people who are important for me think that I should eat fast food regularly*" was typical of the items for this construct. Each item was presented on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree), with a higher score indicating higher normative pressure. Cronbach's α for the overall scale was 0.71.

PBC was measured by four items. For example "*It would be impossible for me not to eat fast food regularly during the next month*" was typical of the items for this construct. Each item was presented on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree), with a higher score indicating higher level of perceived control. Cronbach's α for the scale was 0.60.

ABC was assessed by two items. For example "*where I live, I have no access to fast-food outlets*." Two items were measured on a 5-point scale between 1 (strongly disagree) and 5 (strongly agree).

Past behavior was measured with two items, "*On average, how often do you eat fast food?*" and "*In the last week, how many times have you eaten fast food?*." Responses were rated on a 7-point scale, ranging from 0 (never) to 7 (more than once per day) for first item and the number for fast food intake in past week for second item.

Behavior intention was assessed using three items. For example "*given my lifestyle, it is likely that I will eat fast food regularly over the next four weeks*." Each item was presented on a 5-point scale from 1 (strongly disagree) and 5 (strongly agree), with a higher score indicating higher intention of fast food intake. Cronbach's α was 0.72.

Behavior (fast food consumption) was measured with a short self-report measure of fast food consumption during one week. Eight items (sandwich, Berger-piroshky, hot dog, snack, pizza, chicken nugget, and fried chicken) were used to assess consumption at each time point. Scores from the eight items were summed to create a composite score of the fast food consumption during one week.

4. Statistical Analysis

All data analyses were performed using SPSS version 14.0 with an alpha level of 0.05. To test normality of data, Kolmogorov-Smirnov test was conducted. TPB internal consistency was tested by Cronbach's alpha. Simple descriptive statistics were used to analyze the demographic data. Pearson correlation was used to examine the associations among the variables of the TPB model. We applied multiple regression analysis to predict intention and behavior with and without the additional variables. Finally, bivariate analysis and ANOVA were used to link the results of the TPB with individual characteristics of the respondents.

5. Results

Table 1 provides a summary of the demographic characteristics of the students in this study. There was a direct association between economic status and the amount of fast food intake in the present study ($r = 0.235$, $P < 0.001$). High levels of education of mother ($r = 0.154$, $P < 0.001$) and father ($r = 0.138$, $P < 0.001$) was positively correlated with fast food consumption. There was no significant association between parents' job and family size with fast food consumption.

Table 2 shows means, standard deviations, range, and bivariate correlations among attitude, subjective norm, PBC, intention, behavior, past behavior, and ABC regarding fast food intake among Iranian high school adolescents. All of the TPB variables with the exception of PBC ($r = -0.21$) and actual behavior control ($r = -0.09$) were found to have significant positive correlations with intention to consume fast food ($P < 0.01$). Higher positive attitude toward fast food consumption ($r = 0.40$), and subjective norms ($r = 0.38$) were significantly associated with a stronger intention to fast food consumption ($P < 0.001$). Furthermore, those who had a higher PBC towards eating fast food had a weaker intention to fast food intake. Male students had higher perceived subjective norms than female students (t (521) $= -2.89$, $P < 0.05$), but no gender differences were found for attitude or PBC ($P > 0.05$).

Figure 1 shows that Attitude, subjective norm, and PBC explained 25.7% of the variance in the intention to fast food consumption. Attitude ($\beta = 0.311$, $P < 0.001$), subjective norm ($\beta = 0.294$, $P < 0.001$), and PBC ($\beta = -0.102$, $P < 0.01$) had the greatest influence on intention, respectively. Regarding the association of PBC with attitude and intention to fast food consumption, less PBC toward fast food consumption was associated with a stronger positive attitude and intention. Furthermore, PBC was a nonsignificant predictor

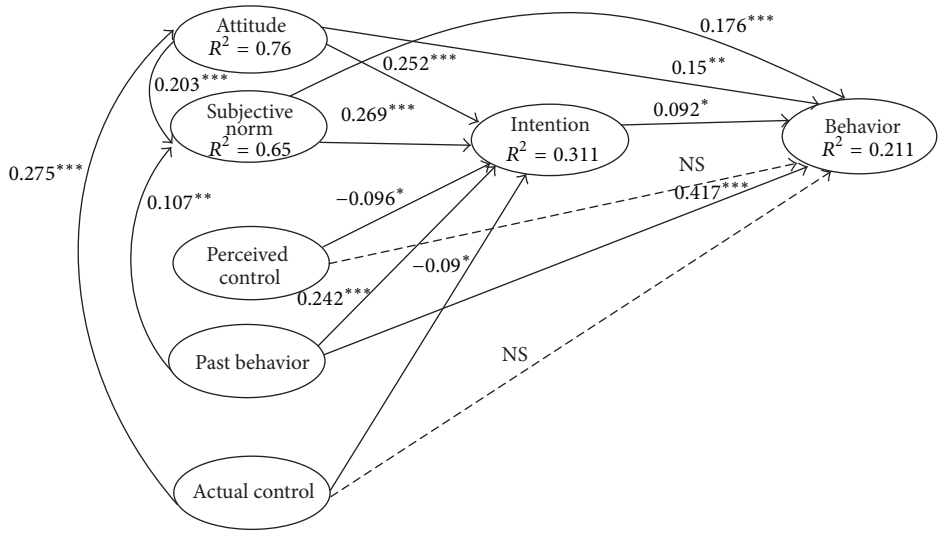

Figure 2: Path analysis based on the theory of planned behavior with additional variables (past behavior and ABC) to predict fast food consumption.

of high school students' behavior ($\beta = -0.01$, NS). The direct and indirect effects of both attitude and subjective norms on behavior were also significant ($P < 0.001$) and subjective norms were the strongest predictive of behavior. High school students' intention was positively related to their own behavior and accounted for 6% of its variance ($P < 0.001$). Figure 2 shows the TPB model with additional variables of past behavior and ABC as predictors of both intention and behavior. TPB model with additional variables explained 31.1% of the variance in the intention. Subjective norm ($\beta = 0.269$, $P < 0.001$), attitude ($\beta = 0.252$, $P < 0.001$), past behavior ($\beta = 0.242$, $P < 0.001$), PBC ($\beta = -0.096$, $P < 0.05$), and ABC ($\beta = -0.090$, $P < 0.05$) had the greatest influence on intention. Actual behavior control was found to be unrelated to behavior, and it was less effective than past behavior on intention ($P < 0.05$). Adding past behavior in this model significantly increased the variance in intention to 5.4% and the variance in behavior to 15.1%. Therefore, both directly and indirectly, past behavior was most predictive of behavior ($P < 0.001$). In total, 31% of the variance in intention and 21% of the variance in behavior could be predicted by the model presented in Figure 2.

6. Discussion

This study examined the applicability of TBP model and TPB model with additional variables of past behavior and ABC to determine predicting factors of fast food intake. So this study investigated the direct and indirect effects of TPB constructs on intention and behavior. The major finding was that TPB with additional past behavior and ABC had higher power compared to the classic TPB framework. In TPB model, the theory explained 25.7% of the intention. This was lower than the reported value from other study which showed that attitude, subjective norms, and PBC explained 50% of the variance in intention to fast food consumption in an Australian sample [18]. We found that intention to consume fast food was predicted by attitude (direct effect), subjective norm, and PBC (negative relationship), either directly or indirectly. Interestingly, while some studies suggest that subjective norms [17, 18] are better predictors of intention to consume fast food than attitude, in the present study, attitude was a stronger predictor of intention than subjective norms and PBC in the TPB model, but in the TPB with additional variable model subjective norms were the strongest predictor. Similar findings reported that attitude toward snacking was the strongest predictor of intentions, followed by subjective norm and PBC [27]. In this study, a strong subjective norm was related to decreased perception of controllability to consume fast food, thus, indicating the importance of social influence in fast food consumption. Our findings also indicated that intention was a proximal predictor of behavior. Consistent with the results of Collins and Mullan's study [27] intention was found to be a significant predictor of behavior, accounting for 28.8% of variance in snacking among undergraduate psychology students from an Australian University. This finding showed that the interventions to increase students' motivation for reducing the frequency of fast food consumption may need to focus on creating more positive attitudes regarding healthy eating, social norms, and increasing PBC to limit fast food consumption. Consequently, greater understanding of these determinants is likely to help in the development and implementation of future intervention for students, a group that consumes fast food more frequently than other age groups [19, 33, 34] emphasizing supporting peers to engage in healthy eating behaviors.

The TPB model with additional behavior in the present study showed that the model was more capable of explaining variation in behavior. Another noteworthy finding in the path analysis was the direct and indirect effect of past behavior. Past behavior had stronger direct and indirect effect on fast food consumption and significantly increased the amount

Table 1: Demographic characteristics of the students.

Total students	521
Mean age ± SD	16.28 ± 0.8
Age (years)	
15	115 (22.1)
16	184 (35.3)
17	180 (34.5)
18	42 (8.1)
Gender	
Male	277 (53.2)
Female	244 (46.8)
Year of education in high school	
First year	202 (38.8)
Second year	173 (33.2)
Third year	146 (28)
Father's education (%)	
Illiterate	16 (3.1)
Primary (1–9 years)	73 (14)
High school (10-11 years)	102 (19.6)
Diploma (12 years)	215 (41.3)
College/university education	106 (20.4)
Mother's education (%)	
Illiterate	13 (2.5)
Primary (1–9 years)	94 (18)
High school (10-11 years)	112 (21.5)
Diploma (12 years)	217 (41.7)
College/university education	81 (15.5)
Father's job (%)	
Worker	74 (14.2)
Employee	135 (25.9)
Teacher	13 (2.5)
Out of job	243 (46.6)
Retired	27 (5.2)
Others	18 (3.5)
Mother's job (%)	
Housewives	440 (84.5)
Employee	23 (4.4)
Teacher	26 (5)
Out of job	13 (2.5)
Others	9 (1.7)
Family size	
3 persons	46 (8.8)
4 persons	236 (45.3)
5 persons	144 (27.6)
6 persons	70 (13.4)
Household income	
<300000 Rial	105 (20.2)
300000–600000 Rial	183 (35.1)
600000–1000000 Rial	104 (20)
>1000000 Rial	52 (10)
Socioeconomic status	
Low	11 (2.1)
Low-middle	49 (9.4)
Middle	267 (50.7)
Upper-middle	167 (32.1)
High	26 (5)

of explained variance in both intention and behavior in our study. In the previous studies [27], past behavior improved the prediction of intention and behavior and it accounted for 13.6% of variance in intention and 21.5% of variance in snacking. The path model in the present study showed direct effect of ABC and indirect effect of behavior on students' intention to consume fast food. High school students in Isfahan were more likely to report positive attitude toward fast food intake and more likely to consume fast food with their friends and parents. Healthy eating for Iranian students should also aim at changing habitual behaviors. The results indicated that the older 15 to 18 year adolescents who reported the intention to consume fast food had a less PBC and actual control. Conversely, Collins and Mullan reported positive correlations between PBC and snaking intention [27]. All variables had a direct effect on behavior except for PBC and ABC that exert indirect effects on behavior in the present study. Although previous studies in Iran emphasized on the role of dietary intake on the risk of chronic diseases [35] as well as nutrients deficiency [36], we are not aware of studies mostly focus on the field of specific determinants such as norms and beliefs in Iran.

Seo and Lee examined fast food consumption status among middle school students and explored factors influencing fast food consumption using TPB. TPB effectively explained fast food consumption behaviors with relatively high R2 around 0.6. It has been suggested that higher intention, perceived behavior control, attitude, and subjective norm led to higher rates of fast food consumption behaviors among middle school students in Seoul [19]. The present study, however, focused on adolescents in Iran. There might be some differences between the results in the researches in Middle Eastern countries and other countries in other parts of the world. Thus, the discrepancy between our findings and other studies findings [17–19] may be due to differences in the age, cultural context, or health motivations. In this study, both models performed better in explaining the intentions than fast food consumption. It is suggested that future studies focus on TPB model with additional variables to reduce fast food consumption among children and adolescents in Iran.

7. Limitations

The strengths and limitations of this study should be noted. Strengths of the current study were a novel investigation regarding the predictors of fast food intake of high school students in Isfahan, Iran that identified possible avenues for interventions. Beaulieu and Godin emphasized on the

Table 2: Means, standard deviations, range, bivariate correlations among attitude, subjective norm, PBC, intention, behavior, past behavior, and ABC regarding fast food intake among Iranian high school adolescents.

Variable	Mean	SD	Range	2	3	4	5	6	7
(1) Attitude	26.35	12.18	(10–50)	0.23^{**}	-0.24^{**}	0.40^{**}	0.19^{**}	-0.06^{**}	0.27^{**}
(2) Subjective norm	9.86	3.21		(4–20)	-0.10^{*}	0.38^{**}	0.21^{**}	-0.08	0.16^{**}
(3) PBC	14.67	2.93			(4–20)	-0.21^{**}	-0.05	0.11^{*}	0.09^{*}
(4) Intention	7.51	2.24				(3–15)	0.24^{**}	-0.09^{*}	0.36^{**}
(5) Behavior	3.37	4.58					(0–31.1)	-0.05	0.45^{**}
(6) ABC	6.47	1.53						(2–10)	-0.02
(7) Past behavior									(0–11)

$^{*}P < 0.05$, $^{**}P < 0.01$.

importance of using TPB to develop nutrition-based interventions for encouraging high school students to stay in school for lunch instead of eating in fast food restaurants [37]. One limitation of the current study relates to the potentially biased sample of high school students aged 15–18 years. We had access to just this age group among adolescents and according to our hypothesis that that fast food consumption is a problem among adolescents, we just focused on adolescents in this study. However, researches have shown that this age group had higher intake of fast foods [38]. So, we should keep in our mind that the results of the present study could be specified for adolescents. Future research in Iran should involve another age group and obtain more detailed dietary information of various groups to better understand the relationship between beliefs and fast food consumption. In addition, self-report data and the cross-sectional design were used for this study. This study is limited due to its cross-sectional nature. The present study basically confirmed the applicability of the TPB to adolescent students in Isfahan, Iran, and the effect of past behavior and ABC on their intention to and behavior of fast food intake. Thus, further studies could examine the effectiveness of various strategies in altering the psychological determinant of fast food intake among Iranian students.

8. Conclusion

Findings indicate that TPB is useful for predicting factors directly and indirectly related to fast food consumption among high school students in Isfahan by comparing two models of TPB. The study was the first to use the TPB to predict fast food consumption in an adolescent population in a developing country, Iran. Subjective norms in TPB model and past behavior in TPB model with additional variables (past behavior and actual behavior control) were the most powerful predictors of fast food consumption. This study suggests that a higher social pressure from peers or family and higher past behavior had the strong influence of fast food consumption. This difference between studies in other countries may be attributed to sociocultural differences and differing behavioral patterns in adolescents towards fast food consumption. It is concluded that the TPB may be used in developing countries, like Iran, as a framework for planning intervention programs in order to predict and improve the healthy eating behavior of students. Among Iranian adolescents, eating fast food may be part of their lifestyles; thus, our results suggest that intervention programmers should focus on the beliefs, social norms, and past behavior based on PBT model to help adolescents in deciding how often to eat fast food, controlling their energy intakes and improving their overall diet quality.

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Review Article

Improving Prediction Algorithms for Cardiometabolic Risk in Children and Adolescents

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Clustering of abnormal metabolic traits, the Metabolic Syndrome (MetS), has been associated with an increased cardiovascular disease (CVD) risk. Several algorithms including the MetS and other risk factors exist for adults to predict the risk of CVD. We discuss the use of MetS scores and algorithms in an attempt to predict later cardiometabolic risk in children and adolescents and offer suggestions for developing clinically useful algorithms in this population. There is little consensus in how to define the MetS or to predict future CVD risk using the MetS and other risk factors in children and adolescents. The MetS scores and prediction algorithms we identified had usually not been tested against a clinical outcome, such as CVD, and they had not been validated in other populations. This makes comparisons of algorithms impossible. We suggest a simple two-step approach for predicting the risk of adult cardiometabolic disease in overweight children. It may have advantages in terms of cost-effectiveness since it uses simple measurements in the first step and more complex, costly measurements in the second step. It also takes advantage of the continuous distributions of the metabolic features. We suggest piloting and validating any new algorithms.

1. Introduction

Obesity is associated with a number of diseases, such as type 2 diabetes (T2D), cardiovascular disease (CVD), cancers, asthma, osteoarthritis, chronic back pain, and sleep apnoea [1]. As childhood obesity prevalence has risen markedly in recent decades [2], indicators of early development of some of these diseases are increasingly being seen in childhood and adolescence. For example, the lowest estimated prevalences of impaired glucose tolerance, hypertension, and raised total cholesterol in obese 5–18-year-old children in the European Union in 2006 were 8.4%, 21.8%, and 22.1%, respectively [3]. Obesity and its associated health risk factors track strongly from childhood into adulthood [4]. Therefore, identification of children at an increased risk of developing obesity-related diseases is critical for early prevention.

Various algorithms have been developed for adults to provide individual predictions of risk of obesity-related diseases, particularly of cardiometabolic risk leading to CVD [5–15]. These include the widely used Framingham Risk Score [6, 7], which uses information on age, sex, blood pressure, total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), diabetes, and current smoking behaviour to give an estimate of 10-year CVD risk in adults aged ≥20 years.

Attempts have also been made to develop similar algorithms to predict cardiometabolic risk in children [16–27], and most of them focus on identifying the Metabolic Syndrome (MetS, the clustering of abnormal metabolic traits associated with CVD risk) [28, 29]. However, these algorithms are not widely used. There is little consensus on the criteria for defining the MetS in children and adolescents, and most algorithms have not been validated. The existing childhood MetS definitions have been derived from adult definitions assuming that the conditions are related over the life course, while the utility and predictive value of MetS in children have not yet been fully established [30]. In this

review, we examine the benefits and limitations of MetS scores and algorithms that have been developed to predict later cardiometabolic risk in children and adolescents and offer suggestions for developing clinically useful algorithms in this population. Such algorithms could aid primary care professionals in the identification of children at high risk of obesity-related diseases and would be an important tool in childhood obesity management.

2. Using Metabolic Syndrome (MetS) Scores to Predict Cardiometabolic Risk

The MetS in adults is characterised by obesity (often assessed by large waist circumference (WC)), high triglycerides (TG), low HDL-C, high blood pressure, and high glucose levels [25]. The prevalence of the MetS increases with age. In children and adolescents, the thresholds for the individual variables to define these "high" and "low" levels depend on the age of the population and the MetS definition applied.

Notably, because there is no consensus about the definition of MetS in children, it can be difficult to make consistent and accurate diagnoses [27]. Due to the lack of universal MetS definition and for the sake of retaining statistical power, construction of continuous MetS scores (cMetS) has gained popularity [31]. Many algorithms which predict cardiometabolic risk in children are based on these MetS scores, with children who are classified as having MetS or children with a high value of cMetS being flagged as having an increased future cardiometabolic risk. Studies that have used either continuous [16] or binary [24, 26, 27] MetS definitions/scores to assess or predict future cardiometabolic risk have been reviewed previously. These studies do not always explicitly state the future disease that they are trying to predict (e.g., CVD); instead, terms such as cardiovascular or cardiometabolic risk are widely used. The association between MetS characteristics in childhood and increased adult risk of CVD may largely be due to tracking of obesity and other MetS characteristics from childhood into adulthood [4].

One recent example of a MetS definition is from the International Diabetes Federation (IDF), which modified a definition originally developed for adults. The IDF has age-specific definitions of MetS (6–<10, 10–<16, and ≥16 years) [25, 26] which is an improvement over earlier definitions that did not include age stratification [26, 27]. Except for the youngest age group (where MetS is not defined, but further measurements for obese children with a family history of CVD or related conditions are recommended), the IDF definition produces a binary outcome identifying children as having MetS if the child has high WC and exceeds threshold levels for at least two of the following four risk factors: high TG, low HDL-C, high SBP/DBP, and high glucose. In that sense, it is similar to earlier MetS definitions in paediatrics [16, 24, 26, 27]. However, the IDF definition has been regarded as the most appropriate binary MetS definition in children since it applies different criteria for each age group, acknowledging that blood pressure, lipid levels, and anthropometric variables change with age and pubertal development [27]. If the IDF definition in children becomes widely accepted, it could be used to aid in the identification of children at an elevated cardiometabolic risk. Alternatively, to maximise the use of information and statistical power, the underlying continuous risk factors that compose the IDF definition from age 10 years could be turned into a cMetS. The threshold indicating a high value of this score could then be defined for each age group or ever for each age (in years) to increase accuracy.

3. Algorithms for Cardiometabolic Risk Prediction Which Include Items in addition to MetS Components

Some algorithms for predicting cardiometabolic risk in children include additional characteristics to metabolic traits that are established risk factors of CVD. Examples include models which additionally use ethnicity, family history of disease, fitness level, or smoking status to compute a final risk score (Table 1) [18–23, 32–36]. In these algorithms, however, the choice of additional non-MetS components is rarely justified and in many cases appears to be based solely on availability of data or characteristics identified in studies restricted to adult populations.

Diagnostic test results for most of the algorithms developed in children have not been published, in most cases due to the lack of current or subsequent clinical outcomes (such as CVD) against which they could have been tested. We did, however, find two exceptions. One study—which predicted the probability of developing atherosclerotic lesions in the coronary artery and abdominal aorta based on age, sex, smoking, BMI, hypertension, hyperglycemia, HDL cholesterol, and non-HDL cholesterol—reported an area under the receiver-operating curve (AUC) of 0.78 for the risk of coronary artery lesions and of 0.84 for abdominal aorta lesions [21]. Another study tested a score based on the refined American Diabetes Association (ADA) criteria for glucose intolerance in a clinical high-risk population from Birmingham; this study reported sensitivity of 100%, specificity of 57%, and positive predictive value (PPV) of 36% [36].

We did not identify any validation studies of these risk algorithms in populations other than those in which they were first developed or applied. Without these two important steps of testing and validation, it is impossible to compare the performance of different algorithms to one other. Testing and validation are needed to develop consensus on what is the best method for predicting cardiometabolic risk in children.

4. Improving Cardiometabolic Risk Algorithm for Children

Using a summary score to predict cardiometabolic risk in children, like all the MetS scores reviewed here, is appealing because it reduces different metabolic dimensions into a single variable. However, certain assumptions have to be made when this approach is used [31]. Each item included in the score is assumed to be equally important (unless weighting is used) and exchangeable with any other item. For example, 1 SD increase in blood pressure is assumed to be

Table 1: Cardiometabolic risk scores developed for children and adolescents.

	Andersen and Haraldsdottir 1993 [32]	ADA 2000 [22, 36]	Rodríguez-Morán et al. 2004 [23]	McMahan et al. 2005 [21]	Andersen et al. 2006 [33]	Reed et al. 2007 [18]	Brambilla et al. 2007 [19] Bueno et al. 2007 [20]	Andersen et al. 2010 [35]
N	203	66	965	2,575	1,732	242	153	210
Age range (years)	15–19	5–17	10–18	15–34	9–15	9–11	9–13	9-10
Sex (% male)	43	29	N/A	N/A	47	50	52	54
Nationality or ethnicity	Danish	South Asian, British, and African Caribbean	Mexican		Danish, Estonian, and Portuguese	Canadian	Spanish	Danish
Stratification, adjustment, or standardisation	Sex	Age and sex (for BMI)	Age and sex (for BMI, BP, and TG)		Age, sex, and country	Age, sex	Sex (for obesity)	Sex
Exclusions							Nonobese	
Score name	Total risk score	T2D criteria	REGODCI	PDAY	Composite score	Healthy Heart Score	MIRACLE	Composite risk factor score
Risk factor included [Y = yes]								
Age				Y				
Sex				Y				
BMI		Y	Y	Y		Y	Y	
*WC**							*Y*	
Skinfolds	Y				Y			Y
*SBP**	*Y*		*Y*		*Y*	*Y*	*Y*	*Y*
*DBP**	*Y*		*Y*			*Y*	*Y*	
*Hypertension**		*Y*		*Y*				
TC	Y							
*HDL-C**	*Y*		*Y*	*Y*				
Non-HDL-C				Y				
TC:HDL-C					Y			Y
*TG**	*Y*		*Y*		*Y*			*Y*
*Glucose**			*Y*					
Dyslipidemia		Y						
Hyperglycemia				Y			Y	
Insulin resistance					Y			Y
T2D							Y	
PCOS		Y						
Smoking	Y			Y				
Fitness					Y	Y		Y
PA						Y		
Family history of CVD/ T2D/Hypertension/obesity		Y	Y				Y	
SGA							Y	
Birth weight			Y					
Ethnicity		Y					Y	
Acanthosis nigricans		Y					Y	

* MetS components are given in italics.

equivalent with 1 SD increase in TG or 1 SD decrease in HDL-C. These assumptions are unlikely to reflect reality, and they may be difficult to validate in real datasets.

Instead of using a binary MetS outcome, which is a common practice, a continuous MetS score (cMetS) may be preferable. This can be a sum of individual rankings, sum or mean of z-scores, principal components, or sum of standardised residuals [16]. This approach overcomes problems such as misclassification and low statistical power often related to binary scores. However, if the resulting cMetS is subsequently grouped using cutoffs, like the age-specific IDF MetS definition [26], misclassification may still occur. Researchers have been urged to create and validate population-specific cMetS for children [31]. Although this approach is justifiable, it complicates comparisons between populations.

There are also some general issues concerning screening tools that need to be taken into account when they are applied in clinical practice. If the sensitivity of the tool is not adequate, a considerable proportion of children at risk will not be detected. On the other hand, if specificity of the tool is limited, some children who are not at an increased risk will be captured and may have to go through unnecessary further testing which may cause anxiety to the children and their families. A test with reasonably good sensitivity and specificity may be useful for early identification of children with increased future risk, which in turn may create opportunities for early intervention. For example, in the study which predicted the probability of developing atherosclerotic lesions [21], AUC based on sensitivity and specificity was fairly good, but the results of this study were not replicated.

The applicability of an algorithm should always be piloted in the target population before implementing it, since an algorithm developed in one population may not be useful in another population without modification. For example, some algorithms have been developed in selecting clinical populations [36] or in ethnic groups of a higher risk. This is especially a concern when cMetS is used and when cut-off points for an increased risk are defined without a clinical basis [31].

We suggest development of an algorithm which fully utilises the continuous distributions of metabolic features (e.g., by calculating z-scores). For example, a two-step approach may have advantages in terms of cost-effectiveness. The first step would target a wider range of overweight/obese children, perhaps through primary care, and those who were flagged as overweight (using age, sex, and potentially ethnicity standardised BMI z-score) could be assessed for other easily measurable factors predictive of later cardiometabolic disease, for example, blood pressure. The small group of children that exceed a stringent threshold for a standardised summary score for estimated risk could then be taken forward to the next step. In this next step, more complex, costly, or time-consuming clinical measurements (e.g., lipids, insulin, and glucose) could be taken from referred children and an updated standardised risk score could be calculated. Children with a "high risk" score should be offered specialised weight management interventions if these are available or be monitored regularly and treated when necessary. This approach combines the benefits of the use of continuous metabolic features in the first step while retaining usability through the application of cutoffs for flagging children who are predicted to be at the highest risk.

The suggested algorithm could be based on a fitted prediction model in a large, longitudinal, population-based dataset that covers anthropometric and metabolic data and other relevant risk factors from childhood and adolescence as well as clinical outcomes (T2D, hypertension, and CVD) from adulthood. The algorithm should be validated and refined in other datasets. Once validated, it should be an improvement over existing algorithms because it uses complete information from the continuous distributions of the metabolic risk factors.

Our work using a large UK cohort [37] suggested that age, sex, and ethnicity standardised BMI z-score was the best predictor of having cardiovascular risk factors (elevated glucose, LDL-C, and/or SBP/DBP) present in childhood (submitted manuscript). Based on this work, we created a simple online tool that gives primary care providers guidance on how to treat and appropriately refer children who are overweight. This tool was piloted among future user groups in the UK. Validation against clinical cardiometabolic outcomes in adulthood was not possible using the same cohort due to its young age, but we hope to validate our models in larger, more diverse datasets in the future.

5. Conclusions

Several different MetS scores and algorithms which predict adult cardiometabolic risk in children have been developed, but diagnostic test results against a clinical outcome, such as CVD, have not been published for most of them, and they have not been validated in other populations. We suggest a simple two-step approach for predicting risk of adult cardiometabolic disease in overweight children and piloting and validating any new algorithms.

Acronyms

CVD:	Cardiovascular disease
CHD:	Coronary heart disease
MetS:	Metabolic Syndrome
cMetS:	Continuous metabolic syndrome score
T2D:	Type 2 diabetes
BMI:	Body mass index
WC:	Waist circumference
SBP:	Systolic blood pressure
DBP:	Systolic blood pressure
MAP:	Mean arterial pressure
TG:	Triglyceride
TC:	Total cholesterol
HDL-C:	High density lipoprotein cholesterol
TC : HDL-C:	TC/HDL-C ratio
LDL-C:	Low density lipoprotein cholesterol
IR:	Insulin resistance
HOMA:	Homeostasis model assessment
IDF:	International Diabetes Federation
IGT:	Impaired glucose tolerance
OGTT:	Oral glucose tolerance test
PCOS:	Polycystic ovarian syndrome

ROC: Receiver operating characteristic
PA: Physical activity
SGA: Smallness for gestational age
PPV: Positive predictive value.

Conflict of Interests

The authors declare that they have no conflict of interests.

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Clinical Study

Obesity and Preference-Weighted Quality of Life of Ethnically Diverse Middle School Children: The HEALTHY Study

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To date, studies examining the relation between body mass index percentile (BMI%) categories and health-related quality of life (QOL) measurements have not reported preference-weighted scores among ethnically diverse children. We report the associations between BMI% categories and preference-weighted scores among a large cohort of ethnically diverse sixth grade children who participated in the HEALTHY school-based type 2 diabetes risk factor prevention study. Health Utility Index 2 (HUI2) and Health Utility Index 3 (HUI3) and the feeling thermometer (FT) were the preference-weighted QOL instruments used to measure student's preference scores. Of 6358 consented students, 4979 (78.3%) had complete QOL, height, weight, and covariate data. Mean (SD) preference scores were 0.846 (0.160), 0.796 (0.237), and 0.806 (0.161) for the HUI2, HUI3, and FT, respectively. After adjusting for age, sex, blood glucose and insulin, Tanner stage, race/ethnicity, family history of diabetes, and educational attainment, children with severe obesity (>99%) had significantly lower preference scores compared to normal weight on all three instruments (HUI2 $P = 0.013$; HUI3 $P = 0.025$; and FT $P < 0.001$). Obese and severe obese categories were significantly associated with lower HUI2 functional ratings in the mobility domain and with lower HUI3 functional ratings in the speech domain.

1. Introduction

The growing literature on the effects of obesity on children's self-reported health-related quality of life (HRQOL) has shown negative associations between some body mass index percentile (BMI%) categories and HRQOL [1–9]. These studies, however, have mainly been clinic based, used small samples at the extreme ends of the BMI distribution, and included limited numbers of minority children, who suffer the greatest burden from obesity [10]. Although there were two community-based studies that analyzed the relationship between BMI and HRQOL among ethnically diverse children, the percentages of African American and Hispanic children were small and the HRQOL instrument used were health status and not preference weighted [3, 6].

Preference-weighted quality of life (QOL) measurements, also known as quality-adjusted life-years (QALYs), is the measurement recommended by the US Panel on Cost-Effectiveness in Health and Medicine for cost-effectiveness analysis (CEA) [11]. QALY measures are based on economic theories (utility and game theories) that quantify the way in which people make choices when faced with uncertainty [12]. Health status instruments ask people to describe the level of disability in several domains (e.g., vision, hearing, and mobility). QALY measures provide additional information, asking people to determine the risk of death they are willing to take to improve that level of disability. QALY combines length and quality of life into a single measure of health outcome. QALY scores usually range from 0 to 1, where 0 represents death and 1 represents perfect health. For example a score of 0.80 means that an individual is willing to give up 0.20 of their life to live in perfect health. There are states worse than death, which give negative preference-weighted scores [13]. The QALY classification system intention is to put a worth or "monetary term" to health outcomes. By measuring cost and health outcomes, economists can determine how much health an investment buys.

To date, studies examining the relation between BMI% categories and HRQOL have not reported preference-weighted scores among ethnically diverse children. We report

the associations between BMI% categories and preference-weighted scores among a large cohort of ethnically diverse sixth grade children who participated in the HEALTHY school-based type 2 diabetes risk factor prevention study [14]. Health Utility Index 2 (HUI2) and Health Utility Index 3 (HUI3) and the feeling thermometer (FT) were the preference-weighted QOL instruments used to measure student's preference scores. We hypothesized that BMI% categories are negatively associated with preference-weighted QOL scores in ethnically diverse middle school children.

2. Methods

2.1. The Trial. The HEALTHY intervention, which focused on environmental and individual changes in nutrition, physical activity, and behavior, was conducted in 42 middle schools recruited by 7 field centers across the USA. The goal of HEALTHY was to reduce or moderate 4 risk factors for type 2 diabetes: BMI%, waist circumference, and fasting blood glucose and insulin levels. HEALTHY was initiated among sixth grade students at the beginning of the 2006-2007 school year and continued through the eighth grade in the 2008-2009 school year. Data collected during the 2006-2007 school year was used for this analysis. Detailed methods and primary results of the HEALTHY trial have been published elsewhere [14].

2.2. Participants. Eligible students were in the sixth grade of the 42 middle schools. Eligible schools had at least 50% minority students, defined as African American, Hispanic, or American Indian, or at least 50% of the students eligible for free or reduced price meals from the National School Lunch Program (NSLP).

2.3. Measures. HEALTHY was approved by the Institutional Review Boards at all the seven study sites. Federalwide Assurance to conduct federally funded research was obtained for all schools in the study. Written parent/guardian consent and student assent were obtained for all participants.

Measures were collected at baseline from sixth grade students during the 2006-2007 school year. The HUI2 [15], HUI3 [16], and the FT from the EuroQOL [17] were the preference-weighted QOL instruments used. The HUI instrument asks respondents to rate their current level of health function across a number of domains. The HUI2 assesses seven health domains: sensation, mobility, emotion, cognition, self-care, pain, and fertility. The fertility domain questions are optional and were not used in this study [13]. The HUI3 assesses 8 domains: vision, hearing, speech, ambulation, dexterity, emotion, cognition, and pain. Preference scores are assigned to these ratings by use of utility scoring rules that have been developed by use of samples from the general public [15, 16]. The reading level of the questions used in HUI2 and HUI3 is grade six [18]. Reliability and validity of the instrument have been shown to be acceptable in children as young as 10 years [19]; several studies, proxy and self-reported, have used the instrument to assess preference-weighted scores among children younger than 11 [19–24].

The FT is another instrument that can be used to assess preference scores. We asked participants to rate how good or bad their current health is on a 0 to 100 scale, where 0 represented "worst imaginable health" and 100 represented "best imaginable health." FT ratings were divided by 100 in order to make them comparable to HUI scores. The FT has been shown to be reliable and valid in children as young as 8 year [25, 26]; Civita et al. have reported that the FT has been used with children as young as 7 years of age [23].

The HUI questionnaire was administered to the students under staff supervision by use of "Personal Digital Assistants." The FT was administered in a paper/pencil format. Both instruments were available in either English or Spanish.

Weight and height were measured once without shoes by trained and certified HEALTHY staff. Weight was measured by use of SECA Alpha 882 digital scales (SECA Corporation, Chino, CA, USA); height was measured by use of PE-AIM-101 stadiometers (Perspective Enterprises, Portage, MI, USA). BMI% was calculated from the Centers for Disease Control and Prevention BMI-for-age-and-sex growth charts and categorized as underweight (<5), normal weight (5 to <85), overweight (85 to <95), obesity (95 to ≤99), and severe obesity (>99) [27].

Fasting blood was drawn to determine glucose and insulin levels. We categorized fasting glucose as <100 mg/dL, 100 to <110 mg/dL, 110 to <126 mg/dL, and 126+ mg/dL [28], and fasting insulin as <30 μU/mL and 30+ μU/mL [29]. We collected self-report information on student age, gender, pubertal status (by use of the Tanner scale), and race/ethnicity. Parents provided information about family history of diabetes and, as a measure of socioeconomic status, the highest educational grade attained in the household. Age, gender, race/ethnicity, and parental education have been commonly controlled for in the literature that has studied the relationship between children's self-reported HRQOL and BMI% [1–3, 5–8].

2.4. Analyses. Exclusion criteria for this analysis were the following: children who were underweight, age 13 years or older, and had missing QOL scores and covariate data. Children who were underweight (<5 BMI%) were excluded because of the small proportion, the mean QOL scores for underweight and normal weight were nearly similar, and the study aim was to evaluate the relationship between QOL scores and greater BMI% ranges. Because the average age of a sixth grade student is 11 years, students age 13 years or more may have been retained in the sixth grade for reasons other than health and thus might have influenced QOL scores independent of BMI% categories.

All statistical analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, NC) by the George Washington University Biostatistics Center. We report means and proportions for descriptive statistics. Comparisons were performed using analysis of variance for self-ratings of preference-weighted QOL scores, and a P value <0.05 was considered significant with no adjustment for multiple comparisons.

We used linear mixed model analysis that accounts for the clustering of students within schools to assess the association between BMI% categories and QOL scores adjusted for

covariates. Covariates included were age, sex, blood glucose and insulin, Tanner stage, race/ethnicity, family history of diabetes, and educational attainment. For covariates that had only 2 categories, a single difference in QOL score and P value was reported compared to the reference group. For covariates that had more than 2 categories, an overall P value as well as differences and P values for the named categories versus the reference group was reported. Reference groups were normal weight, fasting glucose <100 mg/dL, fasting insulin <30 μU/mL, age of 11 years, female, Tanner stage 1, no family history of diabetes, non-Hispanic white children, and college graduate.

3. Results

3.1. Participant Response Rate. Of the approximately 11,158 sixth grade students at 42 schools, 6358 (57.0%) had written parent/guardian consent and student assent prior to baseline measurement. Ninety-nine children were underweight (1.6%), 279 were 13 years or older (4.4%), 389 had missing preference-weighted QOL data (6.1%), and 743 had missing covariate data (11.7%). After applying the exclusion criteria, 4979 students comprised the analytic sample (44.6% of the 11,158 sixth grade students enrolled or 78.3% of the 6,358 students with consent/assent). Of the analytical sample, 92.2% answered the questionnaire in English and 7.8% in Spanish. Students who were excluded from the analysis were more likely to be male (22.8% versus 20.7%; $P = 0.045$). No differences were seen for BMI% categories ($P = 0.13$) or for the other variables we collected.

3.2. Characteristics of Participants. Table 1 shows the characteristics of students. The rate of combined obesity and severe obesity was 30.5% (23.6% obesity and 6.9% severe obesity). African American and Hispanic children made up 78.8% of the participants, and 27.0% were from families with low educational attainment (as measured by no high school diploma). The average percent of students eligible for NSLP in the schools that participated in the HEALTHY study was 76.6%.

Table 1: Clinical and demographic characteristics of HEALTHY study participants.

	N	%
Age		
10 or younger	91	1.8
11	3535	71.0
12	1353	27.2
Male	2336	46.9
BMI percentile		
<85	2456	49.3
85–94	1003	20.1
95–98	1176	23.6
99+	344	6.9
Fasting glucose (mg/dL)		
<100	4172	83.8
100–110	745	15.0
110+	62	1.2
Fasting insulin ≥ 30 (μU/mL)	326	6.5
Tanner stage		
1	492	10.0
2	1280	26.1
3	1964	40.0
4 or 5	1170	23.9
Race/ethnicity		
Hispanic	2857	57.4
Black	1066	21.4
White	1056	21.2
Family history of diabetes	649	17.8
Highest educational grade attained in household		
No HS diploma	1308	27.0
Some college	2620	54.1
College degree or higher	912	18.8
	Mean	SD
Height (cm)	150.9	7.6
Weight (kg)	51.6	15.2
BMI	22.4	5.4
Fasting glucose (mg/dL)	93.5	6.6
Fasting insulin (μU/mL)	13.3	11.4

3.3. Preference-Weighted QOL Scores. The mean (SD) preference-weighted QOL scores were 0.846 (0.160) for the HUI2, 0.796 (0.237) for the HUI3, and 0.806 (0.161) for the FT. Table 2 shows the unadjusted scores stratified by clinical and demographic categories. BMI% categories were negatively associated with QOL scores on all three instruments (HUI2 $P < 0.001$, HUI3 $P = 0.004$, and FT $P < 0.001$). Scores for obese children (HUI2 $P = 0.007$, HUI3 $P = 0.026$, and FT $P < 0.001$) and severely obese (HUI2 $P < 0.001$, HUI3 $P < 0.001$, and FT $P < 0.001$) children were significantly lower than those for normal weight children. When overweight children were compared with normal weight, HUI2 and HUI3 scores showed no significant difference. Other clinical and demographic categories that showed significance after being stratified by QOL scores are shown in Table 2.

Table 3 shows the adjusted associations between clinical and demographic categories and the 3 QOL score differences derived from the mixed model analyses. Only children with severe obesity remained with significantly lower QOL scores, compared to normal weight, on all three instruments (HUI2 $P = 0.013$; HUI3 $P = 0.025$; and FT $P < 0.001$). Obese and overweight children did not have significantly lower scores than normal weight children on the HUI2 and HUI3. FT showed significance among all BMI% categories.

Hispanic and black children had significantly lower QOL scores than non-Hispanic white children on the HUI2 and HUI3 instruments but not on the FT. Other characteristics that were significantly associated with one or some of the QOL scores were age, gender, and Tanner stage.

Table 2: Unadjusted preference-weighted QOL scores stratified by clinical and demographic characteristics.

	N	Health Utility Index 2		Health Utility Index 3		Feeling thermometer	
		Mean	(SD)	Mean	(SD)	Mean	(SD)
BMI%							
<85	2456	0.853	(0.157)	0.805	(0.233)	0.826	(0.156)
85–94	1003	0.848	(0.157)	0.795	(0.236)	0.803	(0.155)
95–99	1176	0.838	(0.163)	0.786	(0.242)	0.784	(0.159)
99+	344	0.814	(0.175)	0.759	(0.245)	0.740	(0.189)
		<0.001		0.004		<0.001	
Fasting glucose (mg/dL)							
<100	4172	0.845	(0.160)	0.794	(0.238)	0.807	(0.161)
100–110	745	0.852	(0.160)	0.803	(0.230)	0.798	(0.161)
100+	62	0.815	(0.173)	0.779	(0.262)	0.790	(0.179)
		0.135		0.438		0.346	
Fasting insulin (μU/mL)							
<30	4653	0.847	(0.159)	0.797	(0.237)	0.809	(0.159)
30+	326	0.830	(0.168)	0.781	(0.237)	0.761	(0.181)
		0.088		0.272		<0.001	
Age							
10 or younger	91	0.849	(0.174)	0.790	(0.250)	0.808	(0.187)
11	3535	0.852	(0.153)	0.806	(0.225)	0.810	(0.158)
12	1353	0.829	(0.174)	0.768	(0.262)	0.795	(0.166)
		<0.001		<0.001		0.112	
Sex							
Male	2336	0.847	(0.160)	0.799	(0.238)	0.811	(0.154)
Female	2643	0.845	(0.160)	0.793	(0.236)	0.800	(0.167)
		0.697		0.331		0.006	
Tanner stage							
1	492	0.872	(0.147)	0.821	(0.220)	0.802	(0.162)
2	1280	0.851	(0.149)	0.803	(0.221)	0.811	(0.155)
3	1964	0.845	(0.161)	0.798	(0.238)	0.808	(0.160)
4 or 5	1170	0.830	(0.174)	0.773	(0.256)	0.798	(0.168)
		<0.001		<0.001		0.150	
Family history of diabetes							
Yes	649	0.832	(0.168)	0.773	(0.256)	0.786	(0.167)
No	3004	0.850	(0.157)	0.802	(0.232)	0.810	(0.159)
		0.014		0.007		0.002	
Race/ethnicity							
Hispanic	2857	0.836	(0.163)	0.779	(0.244)	0.791	(0.164)
Black	1066	0.849	(0.159)	0.802	(0.235)	0.825	(0.159)
White	1056	0.870	(0.149)	0.834	(0.214)	0.826	(0.152)
		<0.001		<0.001		0.019	
Highest educational grade attained in household							
No HS diploma	1308	0.833	(0.167)	0.773	(0.251)	0.789	(0.166)
Some college	2620	0.849	(0.161)	0.799	(0.234)	0.807	(0.162)
College grade or higher	912	0.859	(0.144)	0.825	(0.214)	0.827	(0.153)
		0.015		<0.001		0.009	

Table 3: Adjusted* differences of preference-weighted QOL scores by clinical and demographic characteristics compared with reference categories**.

	Health Utility Index 2		Health Utility Index 3		Feeling thermometer	
	Difference	(*P*-value)	Difference	(*P*-value)	Difference	(*P*-value)
BMI%						
85–94	−0.007	(0.330)	−0.018	(0.084)	−0.025	(<0.001)
95–99	−0.009	(0.178)	−0.015	(0.128)	−0.040	(<0.001)
99+	−0.030	(0.013)	−0.039	(0.025)	−0.087	(<0.001)
	(0.078)		(0.068)		(<0.001)	
Fasting glucose (mg/dL)						
100–110	0.005	(0.551)	0.010	(0.396)	0.003	(0.697)
100+	−0.030	(0.205)	−0.026	(0.475)	−0.019	(0.431)
	(0.357)		(0.520)		(0.666)	
Fasting insulin (μU/mL)						
30+	0.004	(0.720)	0.014	(0.426)	−0.009	(0.419)
Age						
10 or younger	0.002	(0.909)	−0.006	(0.824)	−0.030	(0.121)
12	−0.022	(<0.001)	−0.032	(<0.001)	−0.013	(0.041)
	(0.003)		(0.003)		(0.044)	
Sex						
Male	0.000	(0.992)	0.006	(0.491)	0.014	(0.023)
Tanner stage						
2	−0.027	(0.006)	−0.023	(0.124)	0.013	(0.200)
3	−0.032	(<0.001)	0.024	(0.088)	0.006	(0.552)
4 or 5	−0.042	(<0.001)	−0.039	(0.017)	0.014	(0.190)
	(0.002)		(0.128)		(0.381)	
Family history of diabetes						
Yes	−0.011	(0.109)	−0.019	(0.065)	−0.011	(0.104)
	(0.109)		(0.065)		(0.104)	
Race/ethnicity						
Hispanic	−0.029	(<0.001)	−0.041	(<0.001)	−0.008	(0.213)
Black	−0.020	(0.017)	−0.034	(0.006)	0.005	(0.533)
	(<0.001)		(<0.001)		(0.156)	
Highest educational grade attained in household						
No HS diploma	−0.006	(0.524)	−0.020	(0.127)	−0.008	(0.383)
Some college	0.004	(0.588)	−0.006	(0.623)	−0.006	(0.421)
	(0.368)		(0.250)		(0.651)	

*Linear mixed models adjusted for age, sex, blood glucose and insulin, Tanner stage, race/ethnicity, family history of diabetes, and educational attainment.
**Reference groups were normal weight, fasting glucose < 100 mg/dL, fasting insulin < 30 μU/mL, age of 11 years, female, Tanner stage 1, no family history of diabetes, non-Hispanic white children, and college graduate.

3.4. Domains Associated with Lower Preference-Weighted QOL Scores. BMI% categories were significantly associated with lower HUI2 functional ratings in the mobility domain and with lower HUI3 functional ratings in the speech domain (see Figure 1). The other domains showed no significance between BMI% categories and lowered functioning scores. Obese and severely obese children were 1.5 and 2.9 times more likely, respectively, to present lower levels of HUI2 mobility. Both obese and severely obese children were 1.3 times more likely to show lower levels of HUI3 speech, although findings were not statistically significant in severely obese children.

4. Discussion

This is the first school-based study to measure preference-weighted QOL scores in a large, ethnically diverse population of sixth grade students. The purpose was to determine the association between preference-weighted scores using three instruments (HUI2, HUI3, and FT) and BMI% among mostly minority children. This is important because minority children suffer the greatest burden of obesity. Students who were severely obese rated their preference-weighted QOL in all three instruments significantly lower than those who

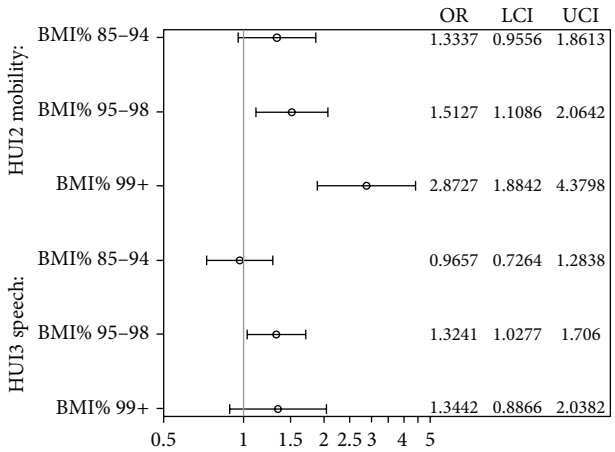

Figure 1: Odds ratios by level of Health Utility Index functioning for BMI category compared with normal weight, adjusted for gender, race/ethnicity, tanner stage, household education, and insulin.

were normal weight, before and after the adjustment for demographic factors and glucose and insulin levels. Scores based on the FT instrument were significantly lower among overweight, obese, and severely obese students than their normal weight counterparts.

A number of studies have found that children with combined obesity and severe obesity report significantly lower QOL scores than do normal weight children [1–8], but none to our knowledge have studied a range of BMI categories and preference-weighted QOL instruments among a large population of minority children. The current paper is the first to suggest that preference-weighted QOL function ratings decrease clinical at severe obesity level (>99%).

Although there are no studies of children to determine the clinical significance of differences in QOL scores, reports from adult populations have identified differences of 0.03 as being clinically significant and differences of as little as 0.01 as being meaningful [30–33]. By this measure, severely obese children in the current study had clinically and meaningful differences in all from the three instruments (range −0.03 to −0.09).

There is only one other study in the USA that used the HUI3 to compare scores between normal weight and overweight/obese children [34]. This study used a convenience sample of 76 predominantly African American and Hispanic children, age of 5–18, drawn from hospital clinics. The overall HUI3 score for the entire sample was 0.79 (0.17) which is close to the HUI3 score in our population (0.80 (0.24)). Also similar to the HEALTHY study, their study did not show significant differences in HUI3 scores between the normal weight and overweight/obese groups (0.81 versus 0.78, resp.). The HEALTHY study extends these findings into a larger group of minority children and a wider range of BMI%.

The significantly lower QOL scores in the HEALTHY study were due, in part, to lower levels of functioning reported by children in the mobility domain (bend, lift, jump, walk, and run) for the HUI2 and the speech domain (being able to be understood when speaking and being able to speak at all) for the HUI3. The low mobility score in obese and severely obese children is well documented in the literature [5, 7, 35].

The second domain affected among obese, but not severely obese children, was speech. An extensive review of the literature was conducted, and no other study was found showing this relationship. HUI3 was also analyzed in our study by English and Spanish responders, and there was no difference in the speech domain between groups. Because we have no explanation for this finding, further studies are needed to fully understand this association.

After adjusting for covariates, being older, male, Hispanic, African American, and advanced Tanner stage were associated with lower QOL scores. Blood glucose and insulin, on the other hand, were not. The rate of severe obesity for children 10 or younger, 11, and 12 years of age was 5.5%, 6.2%, and 8.9%, respectively; for males and females, it was 7.7% and 6.2%, respectively; and for Hispanics, African Americans, non-Hispanic white, it was 7.3%, 8.0%, and 4.9%, respectively. QOL scores were lower in older, male, and minority children because of their higher severe obesity rates. For Tanner stage, longitudinal studies have shown that obese children have more advanced Tanner stage than their lean counterparts [36–38].

The strength of this study is in the use of preference-weighted QOL instruments in a large school-based cohort of ethnically diverse children. This study is unique because it involves minority children who have the highest rates of obesity, and it is important to understand the role that BMI% categories may have on these children's physical and mental function. There are only two community-based studies involving small number of minority children and none used preference-weighted QOL instruments; and the only study to use a preference-weighted QOL instrument included a small number of minority children who were enrolled in hospital clinics.

Despite these strengths, there were three limitations we must note. First, there was a low response rate (57.0%). When we analyzed the BMI, age, ethnicity, and sex between consented and nonconsented children, however, we found no significant differences [14]. Drawing three tubes of blood to measure lipids, insulin, and glucose may have dampened response rates, but in return we collected valuable biochemistries to include as covariates. Second, children in the current study are not representative of US school children. The present study had 73% African American and Hispanic children, whereas nationally 39% of children enrolled in public schools are African American and Hispanic [39]. Nonetheless, minority and disadvantaged children were oversampled because of their higher risk for obesity and type 2 diabetes.

Third, the algorithms for estimating HUI preference-weighted scores were not derived from children or U.S. populations. They were derived from white middle-class Canadian adults [13, 15, 16]. Health care cost and preference-weighted scores used for CEA are usually considered from a societal perspective. It is the society that usually pays health care bills, and as the budget holder, it insists on economic evaluations to inform decisions of resource allocations. To develop HUI

preference scores for children, adults were asked to take risk on their children's health outcomes given several fictitious health states. They were asked, for example, if their child had a physical or mental disability, would they prefer a treatment that would decrease the child's lifespan to give him/her a better quality of life or leave the disability unchanged to preserve the longer lifespan. It is likely that parents anywhere would make decisions on what is best for their child given a medical condition similar to those made by the middle-class Canadian adults who were involved in developing the HUI preference-weighted scores. Nonetheless, preference-weighted QOL measure in children is still an incomplete science, and more research is needed to determine their discriminative and evaluative roles.

In conclusion, we found that severely obese children of ethnically diverse backgrounds had significantly lower preference-weighted QOL scores than did normal weight children in all three instruments. Being overweight and obese was related to lower preference scores in one of the three instruments. The specific domains affected were mobility and speech. Lastly, although this is the first study to evaluate the relationship between preference-weighted scores and BMI% categories in a large cohort of mostly minority children, more research is needed to validate preference-weighted QOL instruments in children.

Conflict of Interests

The authors have no conflict of interests including relevant financial interests, activities, relationships, and affiliations.

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Clinical Study

Individual-, Family-, Community-, and Policy-Level Impact of a School-Based Cardiovascular Risk Detection Screening Program for Children in Underserved, Rural Areas: The CARDIAC Project

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The Coronary Artery Risk Detection In Appalachian Communities (CARDIAC) Project has screened more than 80,000 children (10–12 years) for cardiovascular and diabetes risk factors over the past 15 years. Simultaneous referral and intervention efforts have also contributed to the overall program impact. In this study, we examined evidence of programmatic impact in the past decade at the individual, family, community, and policy levels from child screening outcomes, referral rates, participation in subsequent services, and policies that embed the activities of the project as a significant element. Within this period of time, fifth-grade overweight and obesity rates were maintained at a time when rates elsewhere increased. 107 children were referred for additional screening and treatment for probable familial hypercholesterolemia (FH); 82 family members were subsequently screened in family-based screening efforts. 58 grants were distributed throughout the state for community-appropriate obesity intervention. A state wellness policy embedded CARDIAC as the method of assessment and national child cholesterol screening guidelines were impacted by CARDIAC findings. The sustainability and successful impact of this school-based program within a largely underserved, rural Appalachian state are also discussed.

1. Introduction

The prevalence of childhood obesity and health concerns associated with it including insulin resistance, hypertension, and dyslipidemia has steadily increased over the past three decades in the United States and internationally [1–3]. Increased prevalence of these health conditions and attendant media coverage has contributed to increased public awareness and demand for effective detection and treatment [4]. Universal obesity detection, particularly programs that are school based, has received mixed reactions from health care providers, school personnel, parents, and communities [5, 6].

Screening guidelines for comorbidities such as hypercholesterolemia traditionally target only select groups of children based on family history [7] in an effort to limit cost and deter overuse of cholesterol-lowering medication. Current guidelines recommend blood cholesterol screening for all children [8].

Comparison of the impact and efficiency of universal versus targeted screening programs has been rare given the limited number of universal screening programs throughout the United States for children [9, 10]. Comprehensive cardiovascular and metabolic risk detection programs designed to assess comorbidities are also rare.

The Coronary Artery Risk Detection In Appalachian Communities (CARDIAC) Project began in 1998 and has screened more than 80,000 fifth-grade students throughout rural, Appalachian West Virginia (WV). Quality improvements related to the program as well as priorities, procedures, and public response have contributed to the success of the program over the past 15 years. Through its surveillance, intervention, research, and educational efforts, The CARDIAC Project has had an impact at the individual, family, community, and policy level. We will review evidence of its programmatic impact at each level and discuss factors that will likely lead to sustainability of programs of this nature.

2. Materials and Methods

2.1. Program Purpose. The primary aim of the CARDIAC Project is to determine the prevalence of children who are obese or overweight and assess associated co-morbidities. The secondary aims of the program include referral of children at risk for developing chronic disease for further evaluation and testing as per guidelines established by the American Academy of Pediatrics and to establish a sustainable statewide health educational program to improve children's health-related knowledge and behaviors.

2.2. Setting. The CARDIAC Project was first implemented in 1998 for 5th-grade students enrolled in elementary schools throughout three rural counties in West Virginia (WV). Since that time, the program has expanded to include 53 of the 55 counties in the state. The remaining two counties conducted their own school-based screening programs. The program is conducted within public, and some private, schools throughout the academic year at the beginning of the school day.

2.3. Patient Population. All fifth-grade students are eligible to participate in the CARDIAC Project. Parents of children who participate in CARDIAC are also eligible to receive a free cholesterol screening in their local community.

2.4. Measures. Children participating in the CARDIAC Project receive the following screening services during one assessment period. A health report based on the findings in these areas is sent home to the participant's family between 4 to 6 weeks after screening.

2.4.1. Body Composition. Children's height and weight are assessed using SECA Road Rod stadiometers and the SECA 840 digital scales (Seca Corp, Hanover, MD, USA) after their shoes, extra clothing, and hats are removed. Body Mass Index (BMI) is then calculated by *EpiInfo* using the following equation: BMI (kg/m^2) = weight (kg)/height (m)^2. Age- and gender-specific growth charts are then compared to each child's BMI values to calculate a BMI percentile value [11]. BMI percentiles are then often recoded into four categories for interpretation: underweight (0–4.9th%), healthy weight (5–84.9th%), overweight (85–94.9th%), and obese (≥95th%).

2.4.2. Blood Pressure. Two assessments of blood pressure are completed using the Welch Allyn Cuff (NY, USA), and if significantly different from one another, a third measurement is conducted. Pressures are adjusted for height, age, and gender to calculate blood pressure percentiles. Percentiles ≥95th percentile are considered abnormal.

2.4.3. Prediabetes. The acanthosis nigricans (AN) marker is characterized as a pigmented rash on the neck or axilla. CARDIAC screening incorporates an exam of the back and base of each child's neck for the marker. Screening personnel are trained on ways to detect the marker during summer training sessions and report either the presence or absence on a screening form.

2.4.4. Lipid Analyses. Trained volunteer phlebotomists from local communities collect the fasting blood sample from each participating child. All samples are forwarded and analyzed by a commercial reference laboratory or local hospitals. Results include total cholesterol (TC), low-density lipoprotein (LDL), very low-density lipoprotein (VLDL), high-density lipoprotein (HDL), and triglycerides (TRIG). Children who also have the AN marker receive additional testing for insulin and glucose. Universal blood cholesterol screening of children identifies children likely to have serious inherited familial hyperlipidemias, such as familial hypercholesterolemia (FH). Children who are at probable risk of FH have LDL values at, or greater than, 190 mg/dL and a positive family history.

2.5. Program Procedures. Regional coordinators visit participating classrooms to provide educational sessions on cardiovascular disease, diabetes, and risk factors for other chronic conditions related to lifestyle and inherited conditions. Once complete, CARDIAC consent forms and a descriptive booklet are left with the teachers to distribute to all children and their families. Shortly before the scheduled screening date, regional coordinators collect all returned forms and send them to the main CARDIAC office where they are processed to develop a database, labels, and other support items on screening day. Screening day begins early before classes in a large room—typically the cafeteria or gymnasium. Upon completion of the screening, children receive a token incentive (e.g., bookbag tag, stickers) and additional educational materials. Between 4 to 6 weeks after screening, families receive a health report including screening values, information on how to interpret their findings, and recommendations. Results are also shared with the primary care physician if parent consent is obtained as well as school nurses for followup as appropriate. A toll-free hotline is available for families for questions after they have received screening results. All procedures require at least one parent or legal guardian consent and have been approved by the Institutional Review Board at West Virginia University. Children are not obligated to participate in all screening portions.

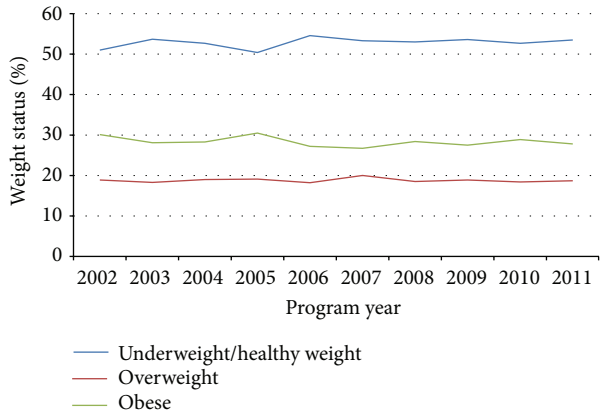

Figure 1: Body composition results in past decade.

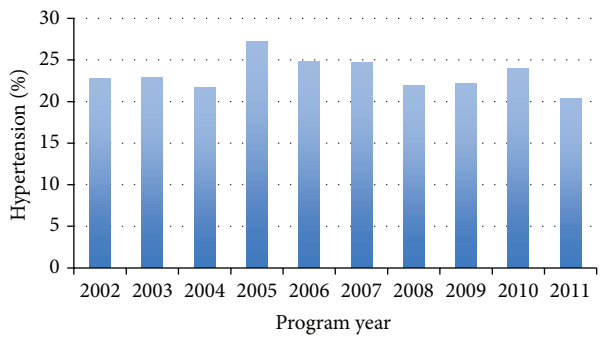

Figure 2: Percentage of sample with hypertension in past decade.

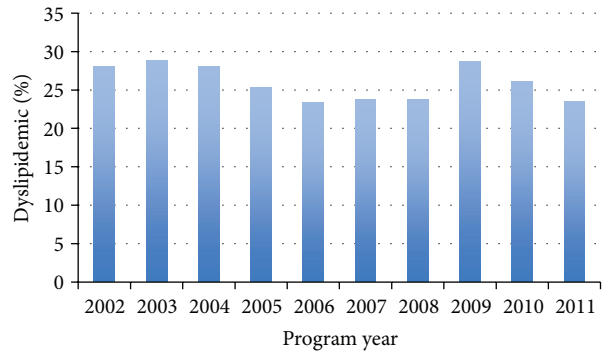

Figure 3: Percentage of sample with abnormal lipid results in past decade.

3. Results

3.1. Participant Characteristics. Since the project's inception, The CARDIAC Project team has screened 81,156 fifth-grade children. Slightly more than half of these children were female (53.0%). The majority of children were Caucasian (93.2%), 2.9% of the sample was African-American, and 2.3% of children described themselves as biracial. The remaining sample slightly represented Asian (0.4%), Hispanic (0.7%), or "other" (0.5%).

Slightly more than half of fifth grade children throughout the state participate in the CARDIAC Project. A sample of 342 parents provided their views of the screening opportunity and identified factors that influenced their decisions to consent (or not consent) their children to participate [12]. Only two differences were found between children who participate in the CARDIAC Project and those who do not. First, the parents of the participating children were more likely to have health insurance than parents of children who did not participate. Participants were also more likely to have a health care provider. Participants did not differ from nonparticipants on any health outcomes (e.g., BMI) or demographic variables (e.g., age, financial status, and gender).

3.2. Individual-Level Impact. Children's screening results since the project's inception are provided in Table 1. A closer examination of children's body compositions over the past decade (Figure 1) illustrates a steady prevalence of overweight and obese among screened children. Similar patterns are illustrated in Figures 2 and 3 for children's hypertension and abnormal lipids. When we examine these outcomes across various body compositions, we notice increased risks for those children who are overweight or obese. Comparisons of CARDIAC screening outcomes based on children's body composition illustrate the role of obesity as a hub for other health issues (Table 2). Presence of the AN marker increases from 0.6% of children in the under- or normal weight categories to 2.2% of overweight, 10.2% of obese, and 32.3% of those in the morbidly obese category. Likewise, increases in triglycerides and blood pressure parallel the presence of the AN marker. As expected, HDL cholesterol is inversely related to BMI. Notably there is only a modest increase in LDL from normal weight to overweight, which does not increase in prevalence further as weight status worsens. Only 10–12% of obese youth have hypercholesterolemia and rarely it is severe enough to fulfill criteria for cholesterol-lowering medication. In contrast, there is evidence of progressive insulin resistance as the severity of obesity worsens.

3.3. Family-Level Impact

3.3.1. Screening Impact on Parents' Intention to Change Health Behaviors. Parent telephone interviews conducted between four and six weeks after screening revealed that a portion of parents of children who were identified as having at least one risk factor from the CARDIAC Project would follow up on the screening results. Particularly, 40% of 342 parents of at-risk children had made changes to their children's diets in that short-term period; 34% had modified their children's physical activity opportunities. Twelve percent of the parents of at risk children had made other changes to their children's health care after receiving the health reports from the screening project [12].

3.3.2. Use of an Individualized Approach for Children at Risk and Their Families. The CARDIAC Project encourages healthcare providers throughout WV to monitor at-risk CARDIAC participants' BMI and other health indicators and to prescribe healthy practices to their patients, both children

Table 1: 5th-grade screening results, 1998–2012.

	Year 1 1998-1999	Year 2 1999-2000	Year 3 2000-2001	Year 4 2001-2002	Year 5 2002-2003	Year 6 2003-2004	Year 7 2004-2005	Year 8 2005-2006	Year 9 2006-2007	Year 10 2007-2008	Year 11 2008-2009	Year 12 2009-2010	Year 13 2010-2011	Year 14 2011-2012	Total
Number of participating counties	3	7	14	27	40	53	55	54	53	55	55	53	50	51	—
Eligible 5th-grade population	781	1.487	3.549	8.495	13.168	18.274	20.854	19.220	17.720	19.778	18.169	18.642	17.845	14.628	192.610
Children screened number (%)	349 (44.7)	709 (47.7)	1.247 (35.1)	3.917 (46.1)	5.973 (45.4)	8.984 (49.2)	9.008 (43.2)	9.257 (48.2)	7.599 (42.9)	7.794 (39.4)	7.816 (43.0)	7.547 (40.5)	6.176 (34.6)	4.780 (32.7)	81.156 (42.1)
Underweight-normal <85th percentile number (% of screened)	188 (55.8)	360 (52.1)	647 (53.3)	2.039 (54.6)	2.948 (51.0)	4.633 (53.7)	4.603 (52.7)	4606 (50.4)	3.878 (54.6)	4.109 (53.3)	4.139 (53.0)	4.039 (53.6)	3.253 (52.7)	2.555 (53.5)	41.999 (52.9)
Overweight BMI ≥ 85th–94th% number (% of screened)	59 (17.5)	141 (20.4)	213 (17.5)	684 (18.3)	1.089 (18.9)	1.576 (18.3)	1.664 (19.0)	1.741 (19.1)	1.293 (18.2)	1.538 (20.0)	1.447 (18.5)	1.422 (18.9)	1.136 (18.4)	892 (18.7)	14.895 (18.8)
Obese BMI ≥ 95th% number (% of screened)	90 (26.7)	190 (27.5)	355 (29.2)	1.017 (27.2)	1.736 (30.1)	2.426 (28.1)	2.469 (28.3)	2.785 (30.5)	1.935 (27.2)	2.060 (26.7)	2.218 (28.4)	2.075 (27.5)	1.781 (28.9)	1.325 (27.8)	22.461 (28.3)
Blood pressure ≥ 95th percentile number (% screened)	69 (24.8)	133 (20.7)	174 (29.7)	823 (23.9)	1.210 (22.8)	1.824 (22.9)	1.757 (21.7)	2.034 (27.2)	1.405 (24.8)	1.565 (24.7)	1.627 (21.9)	1.587 (22.2)	1.470 (23.9)	962 (20.3)	16.640 (23.4)
Child abnormal lipid value (% of FLP sample)	25 (73.5)	21 (77.8)	18 (72.0)	109 (58.0)	214 (28.0)	757 (28.8)	1.173 (28.0)	1.375 (25.3)	1.392 (23.4)	1.451 (23.8)	1.465 (23.7)	1.697 (28.7)	1.458 (26.1)	1.050 (23.5)	12.204 (25.7)
Acanthosis nigricans (AN) number with present marker (%)	—	—	—	111 (3.1)	347 (5.9)	430 (5.0)	378 (4.4)	522 (7.0)	442 (6.9)	498 (7.7)	252 (3.8)	301 (4.1)	248 (4.1)	187 (3.9)	3.716 (5.2)
Child abnormal insulin level (% of AN positive + ordered insulin sample)	—	—	—	19 (11.1)	20 (23.0)	57 (23.9)	56 (30.8)	106 (42.6)	99 (35.4)	126 (40.8)	72 (43.6)	118 (41.0)	162 (42.4)	72 (62.1)	907 (36.8)

Table 2: Mean (SD) screening results based on weight status.

	Underweight and normal weight N = 24,818	Overweight N = 8,958	Obese N = 10,375	Morbidly obese N = 3,082	ANOVA P value
Total cholesterol (mg/dL)	158.18 (26.58)	162.38 (29.29)	166.54[A] (31.1)	165.81[A] (31.75)	<0.001
HDL cholesterol (mg/dL)	54.4 (11.97)	49.28 (11.06)	45.05 (10.19)	41.73 (9.28)	<0.001
LDL cholesterol (mg/dL)	89.38 (23.85)	94.84 (26.03)	98.56[A] (26.96)	98.39[A] (27.71)	<0.001
Non-HDL cholesterol (mg/dL)	104.1 (25.54)	113.6 (29.04)	122.01 (30.79)	124.68 (31.71)	<0.001
Triglycerides (mg/dL)	73.67 (37.08)	94.13 (53.29)	118.36 (67.96)	133.2 (72.79)	<0.001
Systolic blood pressure (mmHg)	104.43 (10.64)	108.93 (10.68)	112.44 (11.02)	118.82 (12.11)	<0.001
Diastolic blood pressure (mmHg)	66.02 (8.88)	68.63 (8.83)	70.84 (8.99)	74.53 (9.26)	<0.001

[A]indicates no difference in pairwise comparison within weight category; analysis conducted on log-transformed triglycerides.

and their families. CARDIAC participants who are at a particularly high risk are referred to a specialized children's lipid clinic for regular intervention and followup. The CARDIAC Intervention Team, along with other experts, developed and led a statewide intervention for overweight/obese children between the ages of 11 and 14 and their caretakers. Three cohorts of the year-long program, Camp NEW (Nutrition, Exercise, and Weight Management), were enrolled and participated in the program between 2008 and 2011. CARDIAC screening participants whose BMI was above the 85th percentile were invited to enroll in the program, where children participated in a two-week summer residential camp and three follow-up family weekends throughout the year. The program included parent educational sessions and one-on-one family counseling throughout the program.

3.3.3. Additional Family Screenings. Approximately 107 of children participating in the project were found to have probable FH. The criteria for diagnosing FH are a total cholesterol value greater than 6.7 mmol/L or LDL-C greater than 4.0 mmol/L in a child who is 16 years old or younger plus DNA-based evidence of an LDL receptor mutation in a first- or second-degree relative. Parents of these children are strongly encouraged to bring their child to one of five children's lipid clinics strategically located around the state; it is recommended that all first-degree relatives likewise have blood cholesterol levels measured and undergo treatment as indicated. Currently, a family-based program focusing on cascade screening of affected probands has been initiated, since it would be expected that half of the child's close relatives would be affected by the same genetic dyslipidemia. To date, 82 family members have been screened to elucidate the family history pathways. Many of these children fulfill national recommendations for consideration of cholesterol lowering medication, if LDL levels remain above acceptable levels following a period of lifestyle modification [13].

3.4. Community-Level Impact

3.4.1. Use of Aggregate Data to Inform Actionable Strategies for Change. Aggregate data from the CARDIAC Project is used at the school, county, and state levels to inform decision makers (e.g., educators, administrators, funders, and policy leaders) of the need for targeted interventional strategies. Schools and counties are provided aggregate data on all students screened each year and are encouraged to use the CARDIAC data specific to their children to seek funding and support for increased physical activity opportunities and improved dietary intake in the schools and communities where their children and their families live, learn, work, and play.

3.4.2. Project Development Stimulation. CARDIAC data for specific counties may also be used in project proposals from school systems to increase local efforts that fuel healthy lifestyles. West Virginia On the Move (WVOM) is a statewide, nonprofit organization that promotes a physically active lifestyle throughout the state in three areas: schools, seniors, and communities. Since 2005, their *Schools on the Move* program has awarded 58 grants to schools in 30 WV counties. The *Schools on the Move* program is a collaborative project with the CARDIAC Project. Both programs contribute to the support through the minigrants provided to school personnel for projects including (but not limited to) new walking trails, biking resources, heart rate monitors, and active living programming.

3.5. Policy-Level Impact.

The breadth and sustainability of the CARDIAC Project have significantly impacted policy and practice within the state and beyond. The unique comprehensive focus on cardiovascular disease and diabetes risk factor screening of more than 10,000 children annually throughout the state contribute to the project's influence.

3.5.1. West Virginia's Healthy Lifestyle Act of 2005 (HB2816). This legislation mandated BMI measurement in schools, as well as an amount of time required for physical education in all grades and a restriction of available sweetened beverages. The CARDIAC Project was named as the mechanism by which the state would meet mandated BMI measurement among school-age children. Members of the CARDIAC team

also contributed to other aspects of House Bill 2816, including contributions to writing the bill and expert recommendation.

3.5.2. Influencing National Youth Screening Guidelines. CARDIAC's goal of offering comprehensive risk factor screening, including a fasting blood draw to all fifth-grade students for whom there is parental consent, provided an opportunity to retrospectively apply targeted National Cholesterol Education Program (NCEP) criteria for screening based on family history of premature heart disease. The purpose of the comparison between targeted versus universal screening among over 20,000 youth was to validate the use of family history in identifying children with severe or genetic hyperlipidemias [14]. The findings demonstrated that targeted (selective) criteria for screening would have missed over one-third (37%) of children with moderate dyslipidemia who warranted consideration of pharmacologic treatment following a trial of lifestyle modification. Subsequent guidelines recommend screening all children at least once during childhood.

3.6. Factors Contributing to Program Sustainability

3.6.1. Institutional Review Board (IRB) Packaging for Community Programs. The required components of institutional review form documents can become a barrier to community-based studies especially if unaccompanied by less intimidating informational materials. Communicating the appropriate consent and assent elements in a way that improves health and study literacy should be an essential goal of any community-based program. In an effort to clearly present study elements, a modified consent/assent document was developed for the CARDIAC Project in 1999. Particularly, the approved IRB consent and assent documents consisted of an eight-page booklet. The booklet includes information about what to expect on screening day, the risk factors assessed in the program, and followup after the screening. All required consent elements (e.g., risks, benefits, voluntary participation, and confidentiality) were embedded within a personal letter from the Director and Principal Investigator of the CARDIAC Project.

3.6.2. Joint Agreements with Hospitals, Laboratories, and Schools. The success of the CARDIAC Project required a growing volunteer workforce and central staff to effectively process children's screening results. Expansion also imposed another goal that CARDIAC team members move beyond detection of risk factors to referral and treatment of documented risks. To effectively meet these expanding aims, the project began to establish joint agreements with local hospitals, laboratories, and schools throughout the state. Over time, agreements have become more formalized. Signed permission by school superintendents is required prior to a screening within the district. School boards are not solicited as that is, at the discretion of the superintendent. Hospitals and laboratory agreements describe the type of documentation and response time following receipt of the blood specimen. Discussions have incorporated elements of participant confidentiality, new online communication including electronic transmission of laboratory results, and better ways to link children's and parents' screening results.

3.6.3. Enhanced Recruitment Efforts. Multiple modifications were made to the recruitment procedures in response to findings from an NHLBI-funded grant examining ways to enhance CARDIAC Project participation [12]. First, an educational session for students was created and implemented prior to the screening date. This session complimented the health content areas of instruction that the fifth-grade teachers are required to provide. The session provides an opportunity to discuss the elements of a healthy lifestyle in order to prevent chronic illness such as diabetes and heart disease.

A second modification was made to the health report to children and their families after screening. Initial health reports provided the raw screening values for height, weight, BMI, blood pressure, and the lipids. A modified version of the report provided new sections on how to interpret one's screening results (including a visual scale for parents to interpret their children's BMI results), recommendations, and educational facts for physical activity and nutrition. Participants were also asked if they wanted to share their screening results with their primary care provider. This new component was added to help facilitate the followup process between the participant and provider.

4. Discussion

The CARDIAC Project has grown from a school-based program in three counties of a rural state to a statewide evidence-based leader in children's chronic disease risk factor screening. Since its inception, more than 80,000 children have received comprehensive cardiovascular risk screening, interventions tailored to their immediate community and/or family, and health education they may apply throughout their lives. Program impact is evident at the individual and family levels based on the number of children screened, the number of children referred for additional services, and the additional services provided for those families who may be affected by a genetic predisposition.

While select screening outcomes were maintained over time, others like children's insulin levels rose sharply in the same period. Before we can best interpret these findings, we must understand that only children who presented with the AN marker were screened additionally for insulin and glucose. This limits the generalizability of these findings. With this in mind, we may be witnessing a rise in diabetic risks. These findings may also be the result of advanced screening and analyses methods in corporate laboratories.

The CARDIAC Project has contributed to the larger community through its collaborative efforts and the number of small grants funded to change the built environment or add to the course offerings for healthy lifestyle skills building. Community representatives also utilize the screening results as pilot information and leverage for additional grants and other resources coming into their areas. Finally, the policy impact of the project is noticeable at the state and national

levels. Very few surveillance programs are able to contribute to the discussion of new cholesterol screening guidelines at the national level. Furthermore, the ability of the program staff to respond to community and state needs has helped position the program as one means of obtaining valuable health assessments for the state.

The project has also witnessed an unusual sustainability record over the past 15 years in a state that is underserved and at great risk for many chronic health conditions such as diabetes and heart disease. The CARDIAC Project's growth and success have resulted from an effective balance between being responsive to the needs of rural communities and implementing a national model of innovation in health surveillance and intervention. As needs and evidence changed over the years, so have the procedures, measures, and reporting for the project. The project has also expanded to meet the additional, yet related, needs of the state policy makers and school administration. Together, these individuals have effectively impacted children's health, access to diagnosis and treatment services, and the overall climate and discussions related to childhood obesity and lifestyle behaviors.

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Research Article

The Associations of Parenting Factors with Adolescent Body Mass Index in an Underserved Population

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Background. The current study examined parental factors related to risk of adolescent obesity within the context of a family systems framework. *Methods*. Seventy predominantly African American, low-income caregiver-adolescent dyads participated in the study. Validated measures of parental perceived child risk for development of type 2 diabetes mellitus, parental limit setting for sedentary behavior, and parental nurturance were evaluated as predictors of adolescent body mass index. *Results*. In this cross-sectional study, multiple linear regression demonstrated that parents of adolescents with higher zBMI reported worrying more about their child's risk of developing type 2 diabetes mellitus. Parent limit setting was also a significant predictor of adolescent zBMI. Contrary to expectations, higher levels of nurturance were associated with higher adolescent zBMI. Post hoc analyses revealed a trend towards a significant interaction between nurturance and limit setting, such that high levels of both parental nurturance and limit setting were associated with lower adolescent zBMI. *Conclusions*. Current findings suggest the importance of authoritative parenting and monitoring of adolescent health behaviors in the treatment of obesity.

1. Introduction

Obesity has long been a major health concern among adults but more recently has become a public health priority among children and adolescents due to the increasing prevalence rates and associated health risks over the last three decades. Over 32% of children and adolescents in the United States are classified as overweight or obese, with the highest rates among ethnic minorities [1, 2]. Obesity places children at greater risk for a number of physical and mental health conditions including type II diabetes mellitus (T2DM) [3]. However, the factors that determine childhood body weight are still not completely understood. Though it is clear that energy intake and energy expenditure are under genetic influence, it is also clear that genetic factors do not fully explain the current increases in the prevalence of overweight and obesity [4, 5].

Recent reviews indicate that parental involvement and parental monitoring of child health behaviors are important factors to consider in preventing and treating childhood obesity [6]. Some investigators have argued that the home environment is an important setting for shaping children's eating and physical activity (PA) behaviors and that parents are powerful change agents [7]. As such, primary and secondary prevention efforts are needed to focus on the treatment of obesity by altering the perceptions, attitudes, and behaviors of parents who influence their children's diet and energy expenditure [8, 9]. The purpose of the present study was to evaluate parent factors that may contribute to adolescent overweight. Parent factors including parental nurturance, parental limit setting of sedentary behavior, and parental perceived risk for development of T2DM were evaluated as predictors of adolescent zBMI. Understanding parenting-related factors of childhood

obesity will help in directing future interventions for preventing overweight.

Family systems theory (FST) provides a framework for understanding how families and parents may influence youth health behaviors. According to FST, functional families are more able to manage daily life in the context of warm and supportive family interactions [10]. Parenting styles that are authoritative having moderate levels of control and high levels of support result in more positive family function including better communication, problem solving, and conflict resolution and have been associated with a range of positive adolescent outcomes [11, 12]. Locke and Prinz [13] consider the dimensions and measurement of parental nurturance and discipline as key parent-related factors in youth development. Parental nurturance has been shown to be associated with a variety of health-related behaviors, including higher levels of fruit and vegetable intake [14], positive body satisfaction, and self-esteem [15], and with more frequently eating breakfast [14]. Taken together the above studies suggest that parental nurturance may serve as an important dimension of the familial context and has an important role in family and child health practices.

Screen time is also considered a substantial contributor to overweight in youth. The American Academy of Pediatrics recommends that screen time for youth be limited to 1-2 hours per day [16]. Nonetheless, youth aged 12–17 years watch over 24 hours of television per week [17]. In a study by Andersen et al. [18] youth who watched four or more hours of television per day were found to have greater body fat and higher BMI than those who watched less than two hours per day. In addition, ethnic minorities exhibited significantly higher levels of television viewing and lower rates of vigorous physical activity (PA). Parental limit setting of screen time may be one important intervention avenue. The current study seeks to examine limit setting in the context of other parent-related variables—such as nurturance—thought to be important in the context of pediatric obesity.

A hallmark clinical trial—the Diabetes Prevention Program (DPP)—found that high-risk individuals (such as those who are overweight) can implement lifestyle changes to avoid the development of T2DM [19]. Unfortunately, research has shown that parents often do not perceive their child as overweight (the most significant risk factor for T2DM) or at risk for health problems such as T2DM, despite the contrary [20], and thus may fail to implement those critical changes. Recently, however, the concept of risk perceptions has begun to be explored more thoroughly and recognized as influential in both preventing and treating overweight in youth [21]. The literature supports the idea that parents often underestimate their child as obese; low parental recognition of overweight status has been replicated across studies [8, 22, 23]. This suggests that those at greatest risk for obesity are also at greatest risk for failing to seek treatment or engaging in active health promotion effort for their youth [24]. In addition to parental nurturance and limit setting, in order to initiate and maintain family behavior change parents must likely also perceive their child to be at risk for negative health consequences. No known study to date has examined the association of parental risk perceptions with other parent related variables (limit setting, nurturance) thought to be related to pediatric obesity.

The goal of this study was to expand on past research by evaluating whether parental nurturance, limit setting, and perceptions of adolescent risk are associated with adolescent zBMI. Specifically, this study examined the associations of parental risk perceptions for their adolescent's development of T2DM, parental limit setting of sedentary behavior, and parental nurturance with adolescent zBMI in a primarily African American population. It was hypothesized that higher levels of parental risk perceptions, limit setting, and nurturance would be associated with lower adolescent zBMI.

2. Methods

2.1. Participants. This research project was undertaken as part of two studies examining family health (see [25–27] for related studies) with the goal of obtaining a sample with variation in adolescent weight status and sex, as well as ethnic minorities given the increased risk observed among underserved populations for obesity. Families were recruited from two small southeastern communities in South Carolina through community partners, radio, and newspaper advertisements. Families were eligible to participate if they had (1) an adolescent aged 11 to 15 years, (2) at least one parent living in the same household as the adolescent willing to participate, and (3) no physical or dietary restrictions. A total of approximately 350 families were contacted, resulting in seventy parent-adolescent dyads (see Table 1).

2.2. Procedures. The Institutional Review Board at the University of South Carolina approved the study prior to enrolling participants. Parents signed an informed consent and adolescents signed an assent form to participate. Demographic information was obtained from parents, and both the parents and adolescents completed psychosocial surveys and anthropometric measures of height and weight.

2.3. Measures. A Shorr Height measuring board was used to obtain height measurements, and weight was measured with a SECA 880 digital scale. Two measures of height and weight were taken by certified study staff members for both adolescents and their parents. The average was then computed and utilized in BMI calculations. Indices of the anthropometric status of adolescents (z-score for body mass index-for-age, BMI values, and BMI-for-age percentiles) were calculated based on the 2000 CDC growth charts and a Statistical Analysis System (SAS) program made available by the CDC [28]. Parent BMI was also calculated based on the standard formula of weight (kg)/height (m)^2.

Parental risk perceptions of T2DM were assessed through a modified version of the Risk Perception Survey for Developing Diabetes (mRPS-DD; [29]). For the current study, the RPS-DD was modified to reflect parent responses to the items based on the risk perceptions for their child. Parents were asked to respond to these items reflecting on their attitudes and behaviors towards the child participating in the current study. A 4-point Likert response format, ranging from strongly disagree to strongly agree, was used to measure

Table 1: Sample demographic characteristics (N = 70 parent-adolescent dyads).

Variable	Statistic
Adolescent mean age (SD)	12.6 (1.34)
Adolescent gender (%): female	58.6
Adolescent weight status (%)	
Normal	30.0
Overweight	18.6
Obese	51.4
Ethnicity (%): African American	90
Parental marital status (%): married	45.7
Parent mean BMI (SD)	35.2 (7.61)
Parent weight status (%)	
Normal weight	7.1
Overweight	18.6
Obese	74.3
Family history of diabetes (%): yes	37.1
Family history of hypertension (%): yes	77.1
Highest level of education completed (%) by parent	
Grades 9–11 (some high school)	7.1
High school graduate	21.4
College 1 year to 3 years	38.6
College graduate	20
Graduate training or professional degree	12.9
Gross household yearly income (%)	
Less than $10,000	14.3
$10,000–24,000	28.6
$25,000–39,000	17.1
$40,000–54,000	17.1
$55,000–69,000	4.3
$70,000–84,000	7.1
$85,000 or more	7.1
Other	4.3

parent's level of agreement with each statement. The Worry subscale of the mRPS-DD was used for the purpose of the present study. During the survey development phase of the original RPS-DD, items were reviewed by a panel of clinical experts, including health psychologists, for face and content validity. Internal consistency reliability, as reflected by coefficient alpha, has ranged from 0.65 to 0.80 [29, 30]. The instrument has been used in previous studies [29–32], including the DPP trial [19] to examine risk perceptions of T2DM.

The Limiting-Activity subscale of the previously validated Parenting Strategies for Eating and Activity Scale (PEAS) [33–35] was used to assess parents' use of appropriate boundaries for sedentary behavior. The reliability of the Limiting subscale has been shown to be adequate, with an internal consistency of 0.81–0.87 [36, 37]. For the current study, the coefficient alpha value for this subscale was 0.76. A 4-point Likert response format was used to assess parent's responses to the Limiting-Activity subscale of the PEAS. Parents were instructed to indicate how often they engage in the particular parenting practice specified in each item. Each item response ranged from 1: "Strongly Disagree" to 4: "Strongly Agree."

The Parenting Dimensions Inventory-Short Version (PDI-S) [38], a 27-item self-report instrument, was administered to parents. The PDI-S measures several dimensions of parenting, including parental support, parental control, and parental structure. For the purposes of this study, only the parental nurturance subscale was utilized as a primary construct of interest. The nurturance subscale of the PDI-S has a total of 6 items which measure emotional nurturance, focusing on emotional expressions of warmth and support, such as verbal statements of love, communication of acceptance, and physical affection and warmth [13]. The reliability of the nurturance subscale has been shown to be adequate with an internal consistency of 0.80 [36] in the original sample. The reliability of this subscale for the current sample was 0.76. Moreover, the subscale has shown high stability over a four-year period ($r = 0.46$, $P < 0.0001$; [38]). A 6-point Likert format was used and parents were asked to choose the response that mostly closely applied to them and their child, with responses choices ranging from 1: "Not at all like me" to 6: "Exactly like me."

2.4. Data Analyses. Data were reduced and analyzed using SPSS Statistics software, version 17.0, and SAS software, version 9.0. The data were analyzed for outliers, normality, missing values, and linearity. Sex (male/female) was recoded as a dummy variable. Variables, excluding variables that were dummy coded or already standardized (i.e., zBMI), were centered to enhance beta weight interpretability. An inverse square root transformation was conducted on the outcome variable due to concerns regarding normality of the distribution [37, 39]. This transformation resulted in an improvement in the skewness (−0.306) but increased the flatness of the distribution (kurtosis = −1.050). The Kolmogrov-Smirnoff test of normality was nonsignificant when considering this transformed distribution, $P > 0.05$, indicating improvement in the normality of the distribution.

Pearson product moment correlations were used to analyze the associations among variables. A multiple linear regression model was conducted to determine if adolescent zBMI could be predicted from parental factors (including risk perceptions, limit setting, and parental nurturance) while controlling for adolescent sex, age, and parent weight status (variables which have been highlighted as risk factors for pediatric obesity). An additional, post-hoc analysis was conducted to explore whether parental limit setting moderates the relationship between adolescent zBMI and parental nurturance. A simple moderated regression was conducted to ascertain whether or not this relationship was significant; simple slopes analysis was not conducted due to the lack of significance. Significance level for this study was defined as $P \leq 0.05$.

Table 2: Multiple regression analysis of parental variables predicting adolescent zBMI.

Variable	B	SE	β	P	F	R^2
					4.378	0.227
Adolescent sex	0.250	0.198	0.138	0.211		
Adolescent age	−0.010	0.006	−0.176	0.117		
Parent weight status	0.364	0.161	0.245	0.027*		
Parental nurturance	0.363	0.133	0.301	0.008**		
Parental limit setting	−0.255	0.120	−0.239	0.037*		
Parental risk perceptions	−0.263	0.130	−0.225	0.047*		

*$P \leq 0.05$, **$P \leq 0.01$.

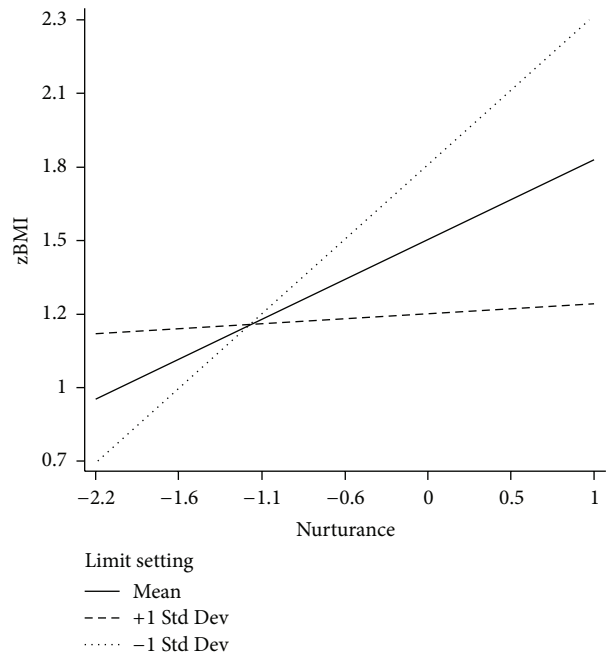

Figure 1: Model of the moderational role of parental limit setting in the relationship between parental nurturance and adolescent zBMI.

3. Results

3.1. Demographic and Descriptive Variables. Table 1 provides a summary of the study sample demographics, including pertinent adolescent, parent, and family characteristics. Additionally, the means, standard deviations, and range of scores for parent variables were calculated. The mean parental nurturance score ($M = 4.99$, SD $= 0.85$) suggested that parents self-reported exhibiting moderate levels of warmth and support. The average limit-setting score ($M = 3.31$, SD $= 0.75$) revealed that parents reported moderate-to-high levels of engagement in parenting practices related to limit setting. Finally, the mean parental risk perceptions score ($M = 2.87$, SD $= 0.77$) was slightly lower, indicating that on average parents reported not often worrying about the risks of T2DM for their youth.

3.2. Correlational Analyses. Pearson product moment correlations (r) among adolescent zBMI, adolescent age, parent BMI, parent risk perceptions, parent limit setting, and parental nurturance revealed a significant positive correlation between adolescent zBMI and parental risk perceptions ($r = 0.327$, $P < 0.01$), indicating that as adolescent zBMI increased, parental perceptions of diabetes risk also increased. In addition, a significant positive correlation between adolescent zBMI and parent BMI was found ($r = 0.301$, $P \leq 0.05$), showing that the more overweight the parent, the higher the adolescent zBMI. No other significant correlations were reflected.

3.3. Multiple Regression Analyses. Multiple linear regression analysis (see Table 2) was conducted to evaluate whether parent factors significantly predicted adolescent zBMI while controlling for adolescent age, gender, and parent BMI. No multivariate outliers were detected using Cook's Distance. Tolerance, as a measure of collinearity, was acceptable with values ranging from 0.81 to 0.99, and the Variance Inflation Factor (VIF) did not exceed 1.2, well below the standard criteria for violation value of 10. The linear combination of predictor variables was significantly related to adolescent zBMI, $(6, 63) = 4.38$, $P = 0.001$. Approximately 23% of the variance (adjusted $R^2 = 0.23$) in adolescent zBMI in the sample was accounted for by the overall model. In addition, a significant beta coefficient was demonstrated for parental nurturance ($\beta = 0.30$, $P < 0.01$) reflecting a positive relationship with adolescent zBMI, such that higher levels of reported nurturance were associated with higher zBMI values. Parental limit setting was also a significant predictor ($\beta = -0.24$, $P < 0.05$), with lower levels of limit setting associated with higher zBMI values. Lastly, parental risk perceptions was positively related to adolescent zBMI, such that higher levels of parental perceptions of risk for T2DM associated with higher zBMI values ($\beta = -0.25$, $P < 0.05$).

As the relationship between parental nurturance and adolescent zBMI was in the direction opposite of what was hypothesized, a post-hoc analysis was conducted to explore the potential relationship between parent nurturance and parent limit setting. Specifically, the idea that the influence of family nurturance on adolescent zBMI varies as a function of parental limit setting was explored. Parental nurturance, limit-setting, and the interaction term were entered into the regression equation and the interaction term approached significance ($P = 0.079$). At higher levels of parental limit-setting and higher levels of nurturance, adolescent zBMI values were lower; however, at lower levels of parental limit setting but higher levels of nurturance, adolescent zBMI values were higher (Figure 1).

4. Discussion

This study investigated parent factors associated with adolescent overweight, conceptualizing the family as central to the etiology and maintenance of pediatric obesity [40]. Parental risk perceptions, limit setting, and nurturance were

all significantly related to adolescent zBMI in the present study when controlling for adolescent age, gender, and parent weight status. The results of the current study provide some insight into important parental variables that are related to adolescent overweight and may be important to incorporate for future intervention treatment programs for overweight adolescents.

In the present study parental limit setting of sedentary behavior was a significant predictor of adolescent zBMI. Setting limits on sedentary behavior has been cited as an important area of opportunity for intervention efforts [41]. Limit setting may operate both directly and indirectly as it may increase PA and has also been shown to improve self-regulation [42], which plays an important role in preventing overweight [43]. Israel et al. [44] found that interventions targeted at enhancing self-regulation were directly related to decreased body fatness. As such, parental limit setting will be an important factor for future interventions with both direct and indirect benefits to adolescent weight-status.

Interestingly, parental nurturance was a significant predictor of adolescent zBMI in the current study but in the direction contrary to proposed hypotheses. Though much of the literature has focused on the benefits of parents who exhibit warmth and nurturance, [18, 45], the observed effect in the present study was not in the hypothesized direction as higher levels of nurturance were associated with higher adolescent zBMI values. A post-hoc analysis was conducted to determine whether the influence of parental nurturance on adolescent zBMI varied as a function of parental limit setting. This interaction effect did not reach statistical significance; however, this trend is of interest given the small sample size of the current study. This trend suggests that as the level of parental limit setting increased, the positive relationship between nurturance and zBMI weakened. More specifically, high levels of nurturance and high levels of parental limit-setting were associated with lower zBMI values. This may be interpreted in light of a line of research from previous studies that have examined indulgent parenting and feeding styles characterized by high nurturance and low structure, which have been linked to increased body mass in children [46–48]. This suggests the possibility of an optimal combination of parental nurturance and parental limit-setting in which parents are sensitive and caring but also provide their children with guidelines that provide structure, particularly around sedentary behavior. Further research should be conducted in this area to establish whether parental limit-setting moderates the effect of parental nurturance on adolescent zBMI and to, more generally, continue to clarify the links between parenting style and children's health behaviors.

There are several strengths of this study including a primarily ethnic minority sample of participants and an examination of a set of modifiable parent-related variables. Few studies focusing on adolescent and overweight have considered ethnic minorities, and fewer ones still have incorporated an array of key familial variables [49, 50] however, future work should seek to determine whether the current results hold across other populations. The current study took a family systems perspective, acknowledging the multifactorial nature of pediatric obesity. Several limitations of the current study should also be noted. A limitation of the current study was the small sample size and cross-sectional nature of the study design. Future studies should incorporate larger sample sizes and a longitudinal approach. For instance, it may be informative for future longitudinal studies to examine the development of parental risk perceptions across time to better understand the critical points at which prevention efforts may be most effective. In addition, the study targeted overrecruiting an underserved ethnic minority population, and thus, the sampling method was not completely at random.

In summary, this study supports the notion that parental perceptions of risk, limit setting, and nurturance may be important in understanding pediatric obesity and should be considered for future interventions. In forecasting the future burden of current adolescent overweight in the United States, Lightwood et al. [51] predict that overweight in our society will have dramatic implications both in humanistic terms, considering the impact on quality of life and premature death, and in fiscal terms, considering the heavy economic burdens. The current study presents a set of key parent-related variables that had yet to be examined in combination, particularly in a predominantly African American sample. The examination of parental risk perceptions for T2DM risk is especially noteworthy, as there is a gap in the research in this area. As research has continued to show the importance of taking a family systems approach to the obesity epidemic, studies should persist in investigating the complex condition of obesity, taking a family systems approach, and considering combinations of variables to inform primary T2DM and secondary obesity prevention practices. Approaches that incorporate a family systems approach will serve to lead the field in providing a more comprehensive analysis of the obesity epidemic, thereby informing clinical practice.

Authors' Contribution

E. M. Schneider (1st author) participated in all aspects of the project including conducting the study, analyzing the data, and drafting the paper. D. K. Wilson (2nd author) assisted with the overall concept of the study, study design, and hypothesis development, as well as assisting with interpretation of the data and writing of the paper. H. Kitzman-Ulrich (3rd author), S. M. St. George (4th author), and K. A. Alia (5th author) all assisted with the study design, conducting the research, and the interpretation of the data and writing of the paper.

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Research Article

Policy Challenges in the Fight against Childhood Obesity: Low Adherence in San Diego Area Schools to the California Education Code Regulating Physical Education

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Objective. Assess the adherence to the Physical Education (PE) requirements per California Education Code in San Diego area schools. *Methods*. Surveys were administered anonymously to children and adolescents capable of physical activity, visiting a specialty clinic at Rady Children's Hospital San Diego. The main questions asked were their gender, grade, PE classes per week, and time spent doing PE. *Results*. 324 surveys were filled, with 36 charter-school students not having to abide by state code excluded. We report on 288 students (59% females), mostly Hispanic (43%) or Caucasian (34%). In grades 1–6, 66.7% reported under the 200 min per 10 school days required by the PE code. Only 20.7% had daily PE. Average PE days/week was 2.6. In grades 7–12, 42.2% had reported under the 400 min per 10 school days required. Daily PE was noted in 47.8%. Average PE days/week was 3.4. Almost 17% had no PE, more so in the final two grades of high school (45.7%). *Conclusions*. There is low adherence to the California Physical Education mandate in the San Diego area, contributing to poor fitness and obesity. Lack of adequate PE is most evident in grades 1–6 and grades 11-12. Better resources, awareness, and enforcement are crucial.

1. Introduction

The World Health Organization declared obesity a global epidemic associated with negative health outcomes in 1997 [1]. In over three decades of national surveys in the USA, from 1971 until 2000, the prevalence of children and adolescents who are obese has tripled [2, 3]. Recently though, the prevalence has stabilized except for those with a BMI ≥97 percentile [4], such that in 6–19-year olds in the 2007-2008 survey more than 1 in 6 were obese (18.7% with BMI ≥95%), and over 1 in 3 were overweight or obese (34.7% with BMI ≥ 85%) [4]. One of the most effective ways of battling obesity is through legislation or policies that enable changes in lifestyle, whether it impacts diet or exercise. For such policies to be effective, their implementation ought to be monitored and enforced. Promotion of routine physical activity in children from preschool age on may help prevent the development of overweight and obesity and associated comorbidities, and the role of schools in achieving that has been recognized and emphasized in guidelines to help battle obesity [5, 6]. As not all children live in safe neighborhoods or are allowed to play outside, schools offer a safe place to accomplish physical activity, delivered with guidance. Schools have historically promoted physical activity and healthy eating, and since over the past 2 decades more than 99% of 7–13-year olds and over 95% of 14–17-year-old youths are enrolled in schools [7] and spend 5 days a week in school, the school environment can play an important role in preventing obesity [5, 6].

When we routinely asked overweight or obese children and adolescents that visited the pediatric endocrine clinic about the amount of PE they have, we were struck by how many have little or no PE time. Thus, we conducted a Physical Activity Survey given to all comers: children and adolescents from first through twelve grades who are able to participate in sports attending specialty clinics at Rady Children's Hospital San Diego (RCHSD). The survey assessed minutes

of physical education per day and number of sessions per week in the school setting. This modest size, anonymous, self-reported survey supports prior data as in the 2007 California Health Interview Survey [8], which is not well recognized in the medical literature, showing inadequate PE time in California and should prompt stricter enforcement of the existing statutes. The current Physical Education requirement in California is as follows: Education Code Section 51210 that requires 200 minutes of physical education every ten school days for students in grades one through six. Education Code Section 51222 provides for 400 minutes of physical education every ten school days for students in grades seven through twelve. The requirement for physical activity does not include time spent during recess or lunch break. We describe in this paper the rate at which the Physical Education requirements of the state of California are met in San Diego County.

2. Methods

One-page surveys were handed to children and adolescents who maintained they were fit to practice PE. Surveys were filled together with their parent or guardian, while waiting to be seen for their clinic visit in a specialty clinic at RCHSD, located in southern California. The vast majority attended endocrinology and diabetes, or gastroenterology clinics, at that location. Patients reside mostly in San Diego County, with a small minority from adjacent Imperial and Riverside counties, representing both urban and rural communities. The samples are representative of San Diego County schools, as RCHSD is the only children's hospital in the metropolitan area of San Diego, serving all children in San Diego County. The surveys were anonymous, with no name, date of birth, or address requested. We did include their gender, ethnicity, their age in years, grade level, and whether they attended a charter school. They were asked how many times per week they have PE (not including physical activity at recess or lunch break, which is not included in the PE code either). This allowed us to arrive at the number of minutes per 10 days of school (double their 5-day week in school). We also asked about walking to/from school, and participation in a walking club at their school. The surveys were administered in two rounds, in Autumn 2011 and Spring 2012 semesters, to account for any seasonal variation. The sample size calculated to detect a difference in compliance rates with PE code between grades 1–6 and 7–12 with a $P < 0.05$, and a power of 80%, was 91 in each group. A lower sample size of 62 in each group was needed to detect a difference of 1 day in mean PE days per week among groups, assuming a rather wide SD of 2 days. We used a chi square analysis to compare the rates of participation among groups with the same PE requirements, and the rates of students participating in walking club or walking to/from school. We used the t-test to compare mean days of PE per week among groups.

3. Results

We collected 324 surveys that were completed properly, containing the key data elements. We present data only from 288 surveys, since 36 were from charter schools that are not mandated to comply with California PE code. However, PE participation rates in charter schools were very similar to the data we present in noncharter schools. Out of 288 surveys filled, 59% were females. Most were of Hispanic descent (43%), or Caucasian (34%), with smaller numbers of Asian (7%), or African American descent (6%), and 10% were of other or mixed ethnicity. There were 135 subjects from grades 1 through 6 and 153 from grades 7–12, that is, from middle school (64) and high school (89).

Time spent in PE per 10 days of school and weekly frequencies of PE are presented in Table 1. For grades 1–6, 90 (66.7%) had reported less than 200 min per 10 school days as required. None of those having PE only once weekly and only 2 out of 29 having PE twice weekly had ≥200 min of PE per 10 days, so, in general, having PE twice weekly is insufficient. Even with three times per week, 55% were under the 200 minutes mark. For grades 7–12, 65 (42.2%) had reported less than 400 min per 10 school days as required. A higher percentage of those in grades 1–6 did not meet the California PE mandate ($P < 0.001$), though the time required in grades 1–6 is lower. Although it appears that more adolescents in high school do not meet the required 400 min (47.2%) versus middle school (32.8%), this did not reach significance. Even if one would apply the 200-minute standard of lower grades, almost 1 in 4 (22.9%) students in grades 7–12 fails to receive that either, fewer in grades 7-8 (9.4%) versus in high school (30.3%). In contrast to grades 1–6, few in grades 7–12 had PE once or twice weekly (Table 1). Unlike in lower grades, all but one of the 12 who had PE twice weekly had less than 200 minutes of PE per 10 days, but only one met the 400-minute cutoff. Again, though the numbers are small, twice weekly PE fails to meet the required time for most students in middle and high schools. Even with three times per week, 54% were under the 400 minutes mark. Almost 17% had no PE, more so in high school and its final 2 grades; in grades 9-10, 7/54 (13%) had no PE, and in grades 11-12 as much as 16/35 (45.7%) had no PE. Daily PE was more common in grades 9-10 (46.3%) compared with grades 11-12 (34.3%), and a bit lower than in grades 7-8 (56.3%).

While we cannot compare the times spent in PE, as the mandate is different between grades 1–6 and grades 7–12, one can compare the frequency of PE per week (Table 1). More students in grades 7–12 had PE five times a week compared with grades 1–6 ($P < 0.001$), and less had PE once or twice weekly, respectively ($P < 0.001$); for no PE, the sample size was too small. Those results remain significant when examining those in grades 7-8 and 9–12 compared separately to those in Grades 1–6; an analysis was not performed on those with PE once a week or none due to the small numbers. As in Table 1, the average days of PE per week were lower in grades 1–6 versus grades 7–12 ($P < 0.0001$), due to the higher rate in grades 7-8, which was higher than in grades 9–12 (4.0 versus 3.0 days per week, $P < 0.001$); there was no statistical difference comparing PE days per week in grades 9–12 versus grades 1–6. There were no statistically significant differences in the number of PE days per week or the total time spent per 10 days in PE between females and males.

Table 1: Rates of PE, and average time in PE.

	Grades 1–6 (n = 135)		Grades 7–12 (n = 153)		Grades 7-8 (n = 64)		Grades 9–12 (n = 89)	
<200 PE min/10 d	**66.7%***							
<400 PE min/10 d			**42.2%**		**32.8%**		**47.2%**	
Rate and time in PE	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)
No PE	1.5	0	16.9	0	4.7	0	25.8	0
PE × 1 per week	33.3*	77 (31)	2.6	100 (70)	1.5	60	3.4	120
PE × 2 per week	21.5*	136 (53)	7.8	265 (90)	7.8^{+}	228 (114)	7.9^{++}	291 (64)
PE × 3 per week	14.8	223 (89)	16.4	448 (208)	18.8	393 (196)	14.6	494 (214)
PE × 4 per week	8.2	335 (138)	8.5	458 (53)	10.9	480 (46)	6.7	433 (53)
PE × 5 per week	20.7*	343 (123)	47.8	533 (182)	56.3§	490 (130)	41.6§	575 (215)
PE days/week		2.57** (1.56)		3.4 (1.89)		3.98§§,† (1.41)		2.98 (2.08)

Rates are in %, and average time is in minutes per 10 days (2 weeks of school). No SD presented if <3 observations. Comparing grades 1–6 to 7–12: $^{*}P < 0.001$, $^{**}P < 0.0001$. Comparing upper grades to grades 1–6: $^{+}P < 0.05$, $^{++}P < 0.01$, $^{\S}P < 0.001$, and $^{\S\S}P < 0.0001$. Comparing grades 7-8 to 9–12: $^{\dagger}P < 0.001$.

Table 2: Rates of walking to or back from school.

Walking %	Grades 1–6	Grades 7–12	Grades 7-8	Grades 9–12
To school	18.5	19	28.1	12.4
From school	23.7	28.8	34.4	24.7
To and/or from	26.7	33.3	40.6*	28.1

Rates are in %. $^{*}P < 0.05$ comparing grades 7-8 to grades 1–6.

The rates of walking to school, from school, and to and/or from school are presented in Table 2. In grades 1–6, more children reported walking back from school rather than to school, and slightly more than a quarter had either walked to and/or from school. Most children who walked had done it both ways. In grades 7–12, the data shows more adolescents walking back from school, rather than to school. Walking rates to and/or from school was highest in grades 7-8 (40.6%), significantly higher than in grades 1–6 ($P < 0.05$), whereas the rates at high school were quite similar to those in grades 1 through 6. The numbers were too small to look at females versus males. Walking club participation was reported in 33.3% of children in grades 1–6, significantly higher ($P < 0.01$) than 15.6% in grades 7-8 and 13.5% of high school students.

4. Discussion

Based on the results of this moderate size study, it appears that there is currently low adherence to the PE requirements as stated in the California Education Code in San Diego schools. This is in agreement with prior reports in adolescents in California [8], and across the nation [9, 10], though there is wide variation among states [9]. The low adherence is more pronounced in this survey in grades 1–6, where only one in three children met the state requirement of at least 200 minutes per 10 days of school, whereas in grades 7–12, almost 58% met the guidelines of 400 minutes or more. Significantly fewer subjects in grades 1–6 had daily PE (5 times weekly) versus those in grades 7–12 ($P < 0.001$). Fewer high school students in grades 11-12 had daily PE (34.3%) than in grades 9-10 (46.3%), but a large number had no PE at all, 45.7% and 13%, respectively. To contrast, very few subjects in grades 7–12 had PE once weekly versus 33.3% of those from grades 1–6 in our survey ($P < 0.001$). Less than 10% of students who have PE twice a week meet the minimum requirements of PE, and only about a half of all students who have PE three times a week meet the state requirements. It is important to point out that the California PE requirements are lower than the National Association for Sports and Physical Education (NASPE), which recommends 150 minutes per week for elementary schools and 225 minutes for middle and high school (equivalent to 300 minutes and 450 minutes, resp., per 10 days of school standards in California). To meet the California PE code, we suggest that PE should be delivered 4-5 times per week or alternatively 3 times a week with longer periods than what is presently practiced. We did not ask about activity during recess or lunch break, as this is excluded from the PE code. We did inquire about other activities related to school that are meaningful in terms of total daily activity. Currently, due to our urban planning and parental concerns for their children's safety, less students walk to school. We found that for students in grades 1–6 and in grades 7–12, 26.7% and 33.3% either walked to and/or from school, respectively. This type of activity should be encouraged for all students. If more parents would walk with their children to/from elementary school, it would send a powerful signal to the children of the importance of physical activity while offering them safety and benefitting the parents as well. Participation in a walking club at school was reported in 33.3% of students in grades 1–6, which is significantly higher ($P < 0.01$) than the 15.6% in grades 7-8 and 13.5% in grades 9–12. This may be more appropriate for elementary schools due to peer perception. As mentioned previously, the data obtained from this study supports prior data that shows inadequate PE times [8–10]. This is particularly worrisome in the light of the increase of obesity rates since 1970 [2, 3]. In an observational study consisting of 814 third grade students in four states (including California), only 5.9% had PE five times per week [10]. Students had an average of 68.7 min/week in PE (i.e., 137.4 min per 10 day) and an average of 2.1 lessons per week [10]. Our study shows similar findings, with 6.5% of 3rd graders having had PE daily, with an average of

70.7 min/week, and 1.9 lessons per week. Additionally, a result of a nationwide study conducted in 2006 with 988 schools showed that only 3.8% of elementary schools, 7.9% of middle schools, and 2.1% of high schools provided PE daily [11]; this does not mean that all students in schools offering daily PE actually had PE daily. It is encouraging to see that the percent of students having daily PE in our survey is much higher than that (Table 1). However, there is still much more room for improvement, especially in grades 1–6, where the academic pressures should be less than grades 7–12, yet they have less PE on a daily basis. The average days/week of PE reported in this survey in San Diego area schools at grades 7–12 is 3.4 days/week, and it is higher than 2.7 days/week reported in a study from 2007, in 12–17-year olds in California [8]. In a national study from 2011 in high school students [9], only 52% of students attended PE per week. They reported no PE more often in 12th grade (62%) versus 9th grade (32%). The trend was similar in our cohort, but we are glad to report that the rates were lower, at 38.9% and 11.5%, respectively. The CDC also reported [9] higher daily PE in 9th grade (41%) versus 12th grade (24%). We found a similar trend comparing daily PE in grades 9-10 versus 11-12. This reflects the reality by which students usually do PE only for 2 years in high school to satisfy their academic credits but do not comply with the PE code. Nationally [9], the percentage of high school students who attended PE classes daily decreased from 42% in 1991 to 25% in 1995 and has recently remained stable at the level noted in 2011 (31%). The rates of daily PE reported by high school students in our survey (41.6%) are higher than the national rates, which is another piece of positive data in this cohort. According to the U.S. Surgeon General, regular physical activity is one of the most important ways to maintain and improve one's physical health, mental health, and overall wellbeing [12]. Physical activity scores of children in the 5th, 7th, and 9th grades that measured aerobic capacity, body composition, strength, and flexibility were strongly and positively correlated with language arts and mathematics proficiency [13]. It is unfortunate and short-sighted of schools that are increasing the time afforded to academics at the expense of physical activity classes. It goes against the extensive evidence that demonstrates better academic achievement in students who are more fit [13, 14].

Though there are some limitations to this study, they do not detract from the main message of low adherence to the PE code. We did not specifically ask if subjects had exemptions from PE due to religious or other causes, though we asked the surveys to be filled by students capable of doing PE. Nationally, the number of students' exempt from PE is relatively high, with 40% of elementary schools, 52% of middle schools, and 60% of high schools allowing an exemption from PE classes, particularly for students with permanent physical disabilities and those having religious reasons [15]. Since we used one-page surveys and gave them to randomly selected children and adolescents waiting for their clinical appointments, we did not ask in-depth questions about their physical education. We asked general questions used to analyze how much physical activity was done but did not track the types of activity and the intensity of activity among other factors. However, the data from this study and others offer important data that can benefit schools by giving guidance on how to best meet the California PE code.

Legislation for PE itself will not be sufficient. There needs to be proper enforcement of the legislation in order for students to meet the PE mandate and be more fit, if we want to have a healthier society with less of our youth becoming overweight and obese at an early age. It is the clinical impression of the author (RSN) that most parents are unaware of the California PE code or they assume that lunch and recess activity times actually count. Perhaps we can see a real change in adherence if the California PE code would require that parents should be notified in writing of the PE requirements or that schools that do not meet the mandate will get financially penalized. To make a meaningful change, PE should be mandated academically in high school in a way that is, compatible with the Education code that governs PE.

The results offered by this study demonstrate the need to address the issues of low adherence to physical education required in schools and to raise awareness of the importance of physical activity. The two biggest deficiencies in PE participation we found are in grades 1–6 and in grades 11-12. Pediatricians and other health care professionals should educate families on the PE code mandate, so parents can demand what is right for their children. If school administrators would know that the public is aware of the low adherence to the PE requirements and is concerned about the possible consequences to their children's weight and academic performance, it may prompt schools to increase PE time and offer better physical activity programs in schools. Schools are in a unique position to help decrease obesity prevalence in children and adolescents, and all measures must be taken to optimize that potential, beginning with enforcing current PE state mandates.

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Review Article

Expanding the Role of Primary Care in the Prevention and Treatment of Childhood Obesity: A Review of Clinic- and Community-Based Recommendations and Interventions

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Although pediatric providers have traditionally assessed and treated childhood obesity and associated health-related conditions in the clinic setting, there is a recognized need to expand the provider role. We reviewed the literature published from 2005 to 2012 to (1) provide examples of the spectrum of roles that primary care providers can play in the successful treatment and prevention of childhood obesity in both clinic and community settings and (2) synthesize the evidence of important characteristics, factors, or strategies in successful community-based models. The review identified 96 articles that provide evidence of how primary care providers can successfully prevent and treat childhood obesity by coordinating efforts within the primary care setting and through linkages to obesity prevention and treatment resources within the community. By aligning the most promising interventions with recommendations published over the past decade by the Institute of Medicine, the American Academy of Pediatrics, and other health organizations, we present nine areas in which providers can promote the prevention and treatment of childhood obesity through efforts in clinical and community settings: weight status assessment and monitoring, healthy lifestyle promotion, treatment, clinician skill development, clinic infrastructure development, community program referrals, community health education, multisector community initiatives, and policy advocacy.

1. Introduction

The identification of effective strategies to address the prevention and treatment of childhood obesity is critical to improving the health of the US population. National data from 2009 and 2010 show that nearly one in three children in America is either overweight or obese, and the numbers are even higher among certain demographic groups [1]. In the short term, obesity poses significant risks for children's physical health and psychosocial well-being [2, 3]. In the long term, many of today's children will age into adulthood with obesity that began in childhood and will experience the negative health consequences associated with obesity as adults, such as type II diabetes [4]. Addressing the high prevalence of childhood obesity will require coordinated and collective efforts in multiple sectors and settings—government, health care, school, workplace, and community—that influence the food and physical activity environments in which children live [2, 5].

Primary care providers (PCPs), defined for purposes of this paper as physicians, physician's assistants, nurse practitioners, registered nurses working in a primary care setting (e.g., community health center), or clinicians working in a school-based health center setting, have important roles in meeting obesity prevention goals. Primary care providers have traditionally measured patients' heights and weights to assess growth, development, and body mass index (BMI) and treated obesity and health-related conditions, but there is a recognized need to expand these roles to include advocacy, modeling healthful behaviors in the community, and counseling individuals and families about obesity prevention [5, 6].

A number of scientific organizations have published recommendations or guidelines for primary care providers to address childhood obesity prevention and treatment (see Table 1). The most recent, by the Institute of Medicine (IOM) in its 2012 report "Accelerating Progress in Obesity Prevention," includes the goal to "expand the role of health care providers, insurers, and employers in obesity prevention." Health care providers have a role in each of the four strategies recommended by the IOM to achieve this goal:

(1) Strategy 4-1: provide standardized care and advocate for healthy community environments;

(2) Strategy 4-2: ensure coverage of, access to, and incentives for routine obesity prevention, screening, diagnosis, and treatment;

(3) Strategy 4-3: encourage active living and healthy eating at work; and

(4) Strategy 4-4: encourage healthy weight gain during pregnancy and breastfeeding and promote breastfeeding-friendly environments.

Recommendations by the White House Task Force on Childhood Obesity [7], the American Academy of Pediatrics [8, 9], the American Heart Association [10], and other health organizations have focused primarily on the health care provider's role of assessment and monitoring of BMI, encouraging and supporting recommendations for physical activity and healthy eating, and serving as positive role models for obesity prevention [11]. The Guide to Community Preventive Services recommended behavioral interventions to reduce screen time but noted insufficient evidence for provider-oriented interventions (e.g., provider education, feedback, or reminders) for obesity prevention and treatment [12].

1.1. Motivation for the Study. Despite these recommendations, PCPs are not doing as much as they should to prevent and treat childhood obesity. Data from a 2008 national survey of PCPs found that fewer than half of all PCPs assessed BMI percentiles regularly in children, and only 18% reported referring children for further evaluation or management [11]. Most (58%) reported never, rarely, or only sometimes tracking patients over time concerning weight or weight-related behaviors [11]. National survey data from 2007 found that 12% of physician office visits of all child or adult patients included counseling about nutrition or diet [13]. Obstacles limit the ability and activity of PCPs to meet these recommendations. Several studies identified a lack of office time to gather background information from families as a major impediment to addressing healthy weight [14–17]. Other obstacles include lack of awareness of the issue, lack of comfort or skill counseling families on the issue, need for organizational prompts, and lack of familiarity with available community resources for lifestyle counseling or obesity prevention programs [5, 11, 18–21].

Evidence suggests that with the right interventions and activities, PCPs can effectively play an expanded role in preventing and treating obesity among children and adolescents [20]. Obstetricians and gynecologists also play an important role in prenatal care, monitoring maternal weight gain, and encouraging and supporting breastfeeding [22]. The purpose of this review is to identify effective or promising practices in the expanded roles that are now recommended for PCPs (see Table 1). These roles include the following:

(1) *weight status assessment and monitoring:* assessment and monitoring of BMI, nutritional intake, physical activity level, and other indicators of weight status in children and adolescents;

(2) *healthy lifestyle promotion:* dissemination of healthy lifestyle recommendations and materials as part of primary prevention efforts in the primary care setting, excluding healthy lifestyle promotion that is part of patient treatment (item no. 3);

(3) *patient treatment:* use of evidence-based techniques, such as behavioral and motivational counseling, within the primary care setting to treat patients identified as overweight or obese (treatment may include healthy lifestyle promotion);

(4) *clinician skill development:* education and training on evidence-based assessment and counseling techniques;

(5) *clinical infrastructure development:* implementation of capacity building within the primary care setting, such as improvements to organizational systems or care models used by providers;

(6) *community program referrals:* referral of patients to community-based obesity treatment programs outside of the primary care setting;

(7) *community health education:* dissemination of healthy lifestyle recommendations and materials as part of prevention efforts in the community setting;

(8) *multisector community initiatives:* participation in multisector obesity prevention and treatment initiatives to achieve policy and systems goals; and

(9) *policy advocacy.* support of and advocacy for policy changes in the broader community setting.

This review, guided by a socioecological framework and a systems approach [5, 23], focuses on the intersection between PCPs (including community health centers) and public health in the community. Studies of child or family interventions in primary care settings or community interventions with a direct link to primary care (e.g., a community intervention with active referral to PCPs) were the focus of the review. Although other reviews on childhood obesity and health care have been published since IOM's 2005 report on "Preventing Childhood Obesity," the extent to which they summarize the specific roles of primary care providers in implementing the intervention varies [24–26]. This review updates the most recent reviews of literature on the primary care role in obesity prevention and treatment published from 2005 to 2012, addresses 2012 IOM recommendations that emphasize both a clinical and community advocacy role for PCPs [5], and incorporates multisector interventions and community advocacy-specific interventions involving PCPs.

Table 1: Recommendations for primary care providers for the prevention and treatment of obesity and selected citations.

Recommendation types (source)	Desired outcome					Citations for promising evidence-based interventions
	Active living	Healthy eating	Other health behaviors	Clinical practice	Community policy	
Weight status assessment and monitoring						
Primary care providers (PCPs) should screen children aged 6 and older for obesity (USPSTF 2010) [28].				×		Ewing et al., 2009[1] [33] Kopp and Hornberger, 2008 [30] Kubik et al., 2008 [15] Mckee et al., 2010 [17] Perrin et al., 2007[2] [20] Perrin et al., 2008 [31] Polacsek et al., 2009 [32] Savinon et al., 2012 [29] Van Gerwen et al., 2009[2] [19]
PCPs should inquire about nutritional intake, calculate and plot BMI, and identify obesity-related comorbidities (AAP 2003) [9].		×		×		
PCPs should routinely track BMI and offer relevant evidence-based counseling and guidance about obesity prevention (IOM 2005) [2].				×		
PCPs should encourage parents to discuss weight status with their child's health care provider and monitor age- and gender-specific body mass index (BMI) percentiles (IOM 2005) [2].				×		
PCPs should calculate and plot BMI once a year in all children and adolescents and use change in BMI to identify rate of excessive weight gain relative to linear growth (AAP 2003) [9].				×		
PCPs should identify and track patients at risk by virtue of family history; birth weight; or socioeconomic, ethnic, cultural, or environmental factors. Recognize and monitor changes in obesity-associated risk factors for adult chronic disease, such as hypertension, dyslipidemia, hyperinsulinemia, impaired glucose tolerance, and symptoms of obstructive sleep apnea syndrome (AAP 2003) [9].				×		
Healthy lifestyle promotion						
PCPs should make AAP guidelines on screen time more available to parents, and young children should be encouraged to spend less time using digital media and more time being physically active (WH 2010) [7].	×					Kubik et al., 2008 [15] Perrin et al., 2007[2] [20] Plourde, 2006 [39] Pomietto et al., 2009 [38] Waldrop and Ferguson, 2008 [21]
PCPs should inform pregnant women and women planning a pregnancy of the importance of conceiving at a healthy weight and having a healthy weight gain during pregnancy, based on the relevant recommendations of IOM (WH 2010) [7].				×		
PCPs should provide information to pregnant women and new mothers on breastfeeding, including the availability of educational classes, and connect pregnant women and new mothers to breastfeeding support programs to help them make an informed infant feeding decision (WH 2010) [7].			×			
PCPs should use behavioral interventions aimed at reducing screen time based on sufficient evidence of effectiveness for reducing measured screen time and improving weight-related outcomes. Interventions can be single component or multicomponent and focus on changing screen time through classes aimed at improving children's or parents' knowledge, attitudes, or skills (Community Guide 2011) [12].	×					
PCPs should promote healthy eating (AAP 2006) [8].		×				
PCPs should encourage parents to limit sedentary activity and make physical activity and sport recommendations to parents and caregivers that are consistent with the developmental level of the child (AAP 2006) [8].	×					
PCPs should recommend parent, guardian, and caregiver responsibilities for children's nutrition: (1) control when food is available, (2) provide social context for eating, (3) teach about food and nutrition when cooking and at the grocery store, (4) counteract inaccurate information from the media and other influences, (5) teach other caregivers what parents want their child to eat, (6) serve as role models and lead by example, and (7) promote and participate in regular daily physical activity (AHA 2006) [36].	×	×	×			

Table 1: Continued.

Recommendation types (source)	Desired outcome					Citations for promising evidence-based interventions
	Active living	Healthy eating	Other health behaviors	Clinical practice	Community policy	
PCPs should promote guidelines for improving nutrition in young children: (1) parents choose mealtimes, not children; (2) provide a wide variety of foods; (3) pay attention to portion sizes; (4) use nonfat or low-fat dairy products; (5) limit snacking; (6) limit sedentary behaviors; (7) allow self-regulation of total caloric intake in the presence of normal BMI; and (8) have regular family mealtimes (AHA 2006) [36].		×				
PCPs should promote guidelines for nutritional quality after weaning: (1) delay the introduction of juice until at least 6 months of age, (2) respond to satiety cues and do not overfeed, and (3) include healthy foods and continue offering if initially refused (AHA 2006) [36].		×				
PCPs should promote breastfeeding for first nutrition and try to maintain it for 12 months (AHA 2006) [36].			×			
PCPs should support and promote healthful dietary patterns among diverse ethnic groups, taking into consideration regional and cultural differences (ADA 2004) [34].		×				
PCPs should support and promote (1) Dietary Guidelines for Americans for healthy children after the age of 2 years; (2) use of the US Department of Agriculture's Food Guide Pyramid as a guide for meeting dietary recommendations with use of the Food Guide Pyramid for Young Children aged 2 to 6; and (3) use of the Fitness Pyramid for Kids to encourage physical activity among children (ADA 2004) [34].	×	×				
PCPs should encourage parents and caregivers to promote healthy eating patterns by offering nutritious snacks, such as vegetables and fruits, low-fat dairy foods, and whole grains; encouraging children's autonomy in self-regulation of food intake and setting appropriate limits on choices; and modeling healthy food choices (AAP 2003) [9].		×				
PCPs should encourage, support, and protect breastfeeding (AAP 2003) [9].			×			
Patient treatment						
PCPs should offer or refer children aged 6 and older to intensive counseling and behavioral interventions to promote improvements in weight status (USPSTF 2010) [28].				×		Dalton et al., 2011 [48] Henes et al., 2010[1] [44] Jacobson and Melnyk, 2011[1] [90] Jacobson and Gance-Cleveland, 2011[2] [24] Kubik et al., 2008 [15] Kwapiszewski and Lee Wallace, 2011[1] [43] Mcclaskey, 2010[1] [49] Siegel et al., 2009[1] [45] Stahl et al., 2011 [40] Taveras et al., 2011 [41]
PCPs should use technology-supported multicomponent coaching or counseling interventions intended to reduce weight on the basis of sufficient evidence that they are effective in improving weight-related behaviors or weight-related outcomes. The Task Force on Community Preventive Services recommends technology-supported multicomponent weight coaching or counseling interventions intended to maintain weight loss on the basis of sufficient evidence that they are effective in maintaining weight-related behaviors or weight-related outcomes. These interventions often also include other components, which can be technological or nontechnological (e.g., computers; videoconferencing; in-person counseling; written feedback; or computerized telephone system interventions that target physical activity, nutrition, or weight) (Community Guide 2011) [12].			×			
PCPs should offer pregnant women counseling, such as guidance on dietary intake and physical activity that is tailored to their life circumstances (IOM 2009) [22].	×	×		×		
PCPs should routinely offer relevant evidence-based counseling and guidance about obesity prevention (IOM 2005) [2].				×		

Table 1: Continued.

Recommendation types (source)	Desired outcome					Citations for promising evidence-based interventions
	Active living	Healthy eating	Other health behaviors	Clinical practice	Community policy	
Clinician skill development						
PCPs should provide education and training in breastfeeding for all health professionals who care for women and children (SG 2011) [91].			×			Cluss et al., 2010 [56] Cronk et al., 2011[1] [54] Haemer et al., 2011 [50] Holt et al., 2011 [51] Jacobson and Melnyk, 2011[1] [90] Maher et al., 2010 [57] McGaffey et al., 2011 [52] Perrin et al., 2008 [31] Polacsek et al., 2009 [32] Pomietto et al., 2009 [38] Stahl et al., 2011 [40] Schwartz et al., 2007[1] [53] Savoye et al., 2011 [55]
Medical and other health professional schools, health professional associations, and health care systems should ensure that health care providers have the necessary training and education to effectively prevent, diagnose, and treat obese and overweight children (WH 2010) [7].				×	×	
Medical student, resident, and continuing medical education programs should consider and periodically review basic community pediatric competencies to be included in training and maintenance of certification efforts for pediatricians (AAP 2005) [35].					×	
Training programs and certifying entities should require obesity prevention knowledge and skills in their curricula and examinations (IOM 2005) [2].					×	
PCPs should foster communication by building partnerships across health-related disciplines and professional organizations and conduct effective nutrition education training programs for physicians, child nutrition personnel, and other health care providers on strategies that can be used with children to promote healthier eating habits (ADA 2004) [34].		×			×	
Clinical infrastructure development						
Hospitals and PCPs should use maternity care practices that empower new mothers to breastfeed, such as baby-friendly hospital standards (WH 2010) [7].			×		×	Anand et al., 2010 [58] Ariza et al., 2009 [59] Ariza et al., 2012 [60] Pomietto et al., 2009 [38] Polacsek et al., 2009 [32] Whitlock et al., 2008 [92]
PCPs should use interventions during pregnancy and after birth to promote and support breastfeeding (USPSTF 2010) [28].				×		
Insurers and accrediting organizations should provide incentives for maintaining healthy body weight and include screening and obesity prevention services in routine clinical practice and quality assessment measures (IOM 2005) [2].					×	
Referrals to community programs						
PCPs should educate themselves concerning the availability of community resources that affect the health and well-being of the children they serve (AAP 2005) [35].					×	Dreimane et al., 2007[1] [62] Estabrooks et al., 2009[1] [67] Foster et al., 2012[1] [68] Heinberg et al., 2010[1] [63] Paul et al., 2011[1] [64] Pinard et al., 2012[1] [65] Quattrin et al., 2012[1] [69] Stark et al., 2011[1] [70] Taylor et al., 2005[1] [71]
PCPs and insurance companies should provide information to pregnant women and new mothers on breastfeeding, including the availability of educational classes, and connect pregnant women and new mothers to breastfeeding support programs to help them make informed infant feeding decisions (WH 2010) [7].			×			

Table 1: Continued.

Recommendation types (source)	Desired outcome					Citations for promising evidence-based interventions
	Active living	Healthy eating	Other health behaviors	Clinical practice	Community policy	
Community health education						
PCPs should make AAP guidelines on screen time more available to parents, and young children should be encouraged to spend less time using digital media and more time being physically active (WH 2010) [7].	×					
Education and outreach efforts about prenatal care should be enhanced through creative approaches that take into account the latest in technology and communications (WH 2010) [7].				×		Agrawal et al., 2012 [77] Eisenmann et al., 2008 [74] Gombosi et al., 2007 [75] Moore et al., 2009 [76]
PCPs should become involved in the education of residents and medical students in community settings. Pediatricians have the unique opportunity to model roles outside the traditional clinical roles that students and residents encounter. Pediatric academicians should use resources from the AAP and the Ambulatory Pediatric Association to engage community pediatrician as educators, both in the care of individual patients in community-based practice and in roles related to promotion of the well-being of all children in the community. Community-based resources outside the bounds of the traditional hospital and outpatient office setting should be used to instruct residents on the effect of the community on child health status and the positive effect of interdependent collaboration of community agencies with health professionals on child health (AAP 2005) [35].					×	
Multisector community initiatives						
Local health departments and community-based organizations, working with health care providers, insurance companies, and others should develop peer support programs that empower pregnant women and mothers to get help and support from other mothers who breastfeed (WH 2010) [7].			×		×	Multi-sector: Chang et al., 2010 [78] Chomitz et al., 2010[1] [83] Cousins et al., 2011 [80] Economos et al., 2007[1] [82] Karanja et al., 2010[1] [79] Samuels et al., 2010 [81] School-PCP: Edwards, 2005 [87] Stephens et al., 2011 [85] Tyler and Horner, 2008 [86] Whaley et al., 2010 [14]
PCPs should ensure that maternity care practices throughout the United States are fully supportive of breastfeeding and develop systems to guarantee continuity of skilled support for lactation between hospitals and health care settings in the community (SG 2011) [91].			×			
PCPs and other members of the community should interact and advocate to improve all settings and organizations where children spend time (e.g., child care facilities, schools, and youth programs). School and community resources should be considered as assets in developing strategies for the problems that children will face now and throughout their lives (AAP 2005) [35].					×	
PCPs should become comfortable with an interdisciplinary collaborative approach and advocacy effort to child health. Pediatricians can play an important role in coordinating and focusing new and existing services to realize maximum benefit for all children (AAP 2005) [35].					×	
PCPs should work collaboratively with public health departments and colleagues in related professions to identify and decrease barriers to the health and well-being of children in the communities they serve (AAP 2005) [35].					×	
PCPs should foster communication by building partnerships across health-related disciplines and professional organizations. Conduct effective nutrition education training programs for physicians, child nutrition personnel, and other health care providers on strategies that can be used with children that promote healthier eating habits (ADA 2004) [34].		×			×	

Table 1: Continued.

Recommendation types (source)	Desired outcome					Citations for promising evidence-based interventions
	Active living	Healthy eating	Other health behaviors	Clinical practice	Community policy	
Policy advocacy						
PCPs should use community data (epidemiologic, demographic, and economic) to increase their understanding of the health and social risks on child outcomes and of the opportunities for successful collaboration with other child advocates (AAP 2005) [35].					×	
Include basic support for breastfeeding as a standard of care for midwives, obstetricians, family physicians, nurse practitioners, and pediatricians, and ensure access to services provided by International Board Certified Lactation Consultants (SG 2011) [91].			×			
PCPs should advocate for the appropriate allocation of funding for quality research in the prevention of childhood obesity (AAP 2006) [8].					×	
PCPs should advocate for (1) a school curriculum that teaches children and youth the health benefits of regular physical activity; (2) comprehensive community sport and recreation programs; (3) reinstatement of compulsory, quality, and daily physical education (PE) classes in all schools taught by qualified, trained educators; (4) provision of a variety of physical activity opportunities in addition to PE; and (5) development and implementation of a school wellness counsel on which local physician representation is encouraged (AAP 2006) [8].	×				×	Mayer, 2009[2] [88] McPherson et al., 2012 [89]
PCPs should advocate the AHA 2006 Diet and Lifestyle Goals for Cardiovascular Disease Risk Reduction: consume an overall healthy diet, aim for healthy body weight, and encourage regular physical activity (AHA 2006) [8].	×	×			×	
PCPs should advocate for the development and implementation of a school wellness counsel on which local physician representation is encouraged (AAP 2006) [8].					×	
PCPs should work with local governments to change their planning and capital improvement practices to give higher priority to opportunities for physical activity (IOM 2005) [2].	×				×	
PCPs and other members of the community should interact and advocate to improve all settings and organizations in which children spend time (e.g., child care facilities, schools, and youth programs). School and community resources should be considered as assets in developing strategies for the problems that children will face now and throughout their lives (AAP 2005) [35].					×	
PCPs should become comfortable with an interdisciplinary collaborative approach and advocacy effort to child health. Pediatricians can play an important role in coordinating and focusing new and existing services to realize maximum benefit for all children (AAP 2005) [35].					×	
PCPs should support and advocate for social marketing intended to promote healthful food choices and increased physical activity (AAP 2003) [9].	×	×			×	

AAP: American Academy of Pediatrics; ADA: American Dietetic Association; AHA: American Heart Association; Community Guide: The Community Guide to Preventive Services; IOM: Institute of Medicine; SG: Surgeon General's Call to Action to Support Breastfeeding; USPSTF: United States Preventive Services Task Force; WH: White House Task Force on Childhood Obesity; see the list of references for complete citation.

[1]Indicates article describing an intervention that had a statistically significant effect on participants' weight or weight status.

[2]Indicates review article.

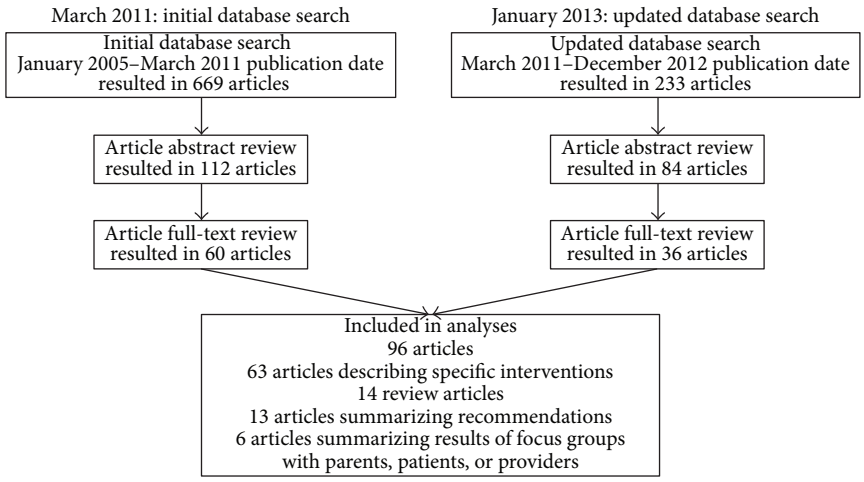

Figure 1: Literature review process.

Table 2: Literature review search terms.

Search term		Search term		Search term		Search term
Healthy weight OR	AND/OR	Child OR	AND	Intervention OR	AND	Community intervention OR
Overweight OR		Family OR		Program OR		Community health services OR
Obesity OR		Families		Initiative OR		Primary health care OR
Weight-loss				Strategy OR		Tribe OR
				Strategies OR		Tribal OR
						Native American OR
						First Nation OR
						American Indian
						Indian Health Service OR
						Indigenous OR
						Islander OR
						Primary care OR
						Primary health care OR
						Community health

Note: search limits included humans, English, United States, and publication date from January 1, 2005, to December 31, 2012.

It also recognizes the new imperatives or opportunities to do more based on the Affordable Care Act changes requiring preventive care as an essential health benefit and eliminating cost sharing for preventive services [27].

2. Materials and Methods

We conducted a review of clinic- and community-based obesity interventions with a primary care component to identify evidence of effective roles of primary care in addressing the epidemic. The first phase of the scan was conducted in March 2011 (Figure 1). We searched for literature published from 2005 to 2011 using search terms listed in Table 2. Our search included PubMed and other databases (ESCO Academic Search Premier, Cochrane Central Register of Controlled Trials, ERIC, and Health Technology Assessments) and resulted in 669 articles. For these articles, we reviewed abstracts for relevance and to ensure that the intervention took place in the United States, which refined the list to 147 articles. We retained the articles that described an obesity intervention for children and/or families that took place in a primary care setting, a school health center, or a community setting (community health center; pediatrician; tribal health center; Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) clinic; and so on) with some link to primary care. The elimination of unrelated school-based, policy, environmental change, and workplace interventions that did not include a link to the primary care setting, as well as articles that focused primarily on primary care recommendations (rather than primary care interventions), further refined the scan to 112 articles.

We reviewed the remaining 112 full-text articles to ensure that each article fits the original criteria and to document the findings. Of the full-text articles reviewed, 60 met the criteria. We updated the review in January 2013 for the literature published in 2011 and 2012. The additional review resulted in 36 articles that met our criteria, for a total of 96 articles considered in this paper. These sources included

63 articles describing specific interventions; 14 that reviewed existing interventions; 13 summarizing recommendations for the treatment and prevention of childhood obesity; and 6 that summarized the results of topic-related focus groups with parents, children, or clinicians. The full list of citations for articles considered in this review is available upon request from the authors.

3. Review Findings

The 96 articles that met the criteria for this review provide examples of how pediatricians, PCPs, and communities have implemented clinic- and community-based programs and initiatives targeting the prevention, screening, diagnosis, and treatment of obesity among children and adolescents. The interventions reviewed typically took place in a primary care clinic, pediatrician's office, community health center, school-based health clinic, university research program, WIC clinic, or other community setting. In this section, we summarize the paper findings regarding the efficacy of these efforts, when available, and describe how these interventions align with current recommendations for obesity prevention and treatment in the nine areas identified in Table 1. Because an article could address multiple primary care physician roles (e.g., weight assessment as well as treatment of obesity), articles can be cited in more than one category. Interventions reporting statistically significant improvements in child weight status are noted in Table 1. Methods used to assess changes in children's weight status include change in BMI; BMI z-score (i.e., the number of standard deviations of the value for an individual away from the mean value of the reference population); BMI percentile for age and gender; BMI velocity; kilograms or pounds lost; percent healthy weight, overweight, and/or obese; and waist and hip girth. The majority of interventions lasted between four and 12 weeks, and most follow-up efforts occurred over less than 12 months.

3.1. Weight Status Assessment and Monitoring. Annual assessment of weight status through the use of BMI compared with age-sex BMI percentiles in growth charts in children and adolescents is widely recognized as a standard of care in the primary care setting [2, 9, 28]. Although a healthy weight assessment routinely involves some form of measuring body weight, evidence suggests that a complete assessment should also include indicators of healthy diet, active living, and child and family health history [8, 9]. Most interventions reviewed included an evaluation of the patient's overall health through patient and/or parent discussions or questionnaires in addition to assessment of weight status by use of BMI or growth charts. Methods used to assess or monitor weight included BMI, BMI z-scores, and comparisons to reference growth charts and standards for overweight and obesity. McKee et al. [16] integrated parent-completed questionnaires into routine primary care visits to assess family history of diabetes and cardiovascular disease, parents' height and weight, child's television and play habits, and child's intake of meals in front of the television; information collected from parents was used to inform weight assessment and guide the content of counseling and goal setting for overweight patients.

Recommendations state that PCPs should track annual BMI assessments over time to assist clinicians in recognizing major changes in weight relative to height [8, 9]. Two articles reviewed suggested that integration of BMI assessment into frequently used electronic medical record (EMR) systems or hand-held personal digital assistants could facilitate increased use of BMI as a screening tool and as a method of effectively tracking BMI over time for the purposes of monitoring [18, 20]. However, only one article reviewed specifically discussed integration of BMI collection into EMR systems. Savinon et al. [29] found that customized EMR templates designed to facilitate assessment of BMI and screening and counseling for overweight patients increased the frequency of children screened for BMI, as well as the diagnostic rate for overweight and obesity.

Articles reviewed suggest that multiple barriers might limit the assessment and monitoring of BMI in the clinic setting, including lack of familiarity with the use of BMI; lack of agreement about the utility of BMI as a screening and intervention tool; lack of office time to gather background information from families; and lack of practice-level resources conducive to simple, frequent use of BMI [11, 18–21]. Several articles noted the importance of familiarizing clinicians with weight assessment tools, including BMI assessment calculators, Centers for Disease Control and Prevention guidelines for BMI interpretation, and educational materials to increase uniformity of screening and improve clinician self-efficacy [20, 30–32]. Perrin et al. [20, 31] suggested that age-specific office-based tools may assist practitioners in communicating results of BMI assessment to families and in evaluating the patient's readiness to change. Another study that promoted use of BMI tools found a significant decrease in BMI at 5 months, but not 12 months, among children participating in a primary care-based program that combined clinician training in weight assessment with an eight-week, family-based behavioral intervention [33].

3.2. Healthy Lifestyle Promotion. Multiple recommendations suggested that promotion of healthy lifestyle behaviors such as adherence to recommended dietary guidelines, increased participation in physical activity, and limiting screen time and sedentary behavior should be incorporated into standard clinical practices for clinicians who serve children and adolescents [7–9, 12, 34–36]. These recommendations apply to both prevention and treatment of obesity in the primary care setting. Healthy lifestyle promotion as used in clinic-based treatment interventions is discussed in more detail in the following section; here, we describe notable examples of healthy lifestyle promotion as it pertains to the prevention of overweight and obesity in children and adolescents. We identified significantly fewer articles in this category.

The IOM suggests that providers utilize a multifaceted approach to patient education, recognizing that patients may have different learning styles, needs, and preferences [37]. Incorporation of healthy lifestyle promotion in the primary

care setting may involve distribution or display of educational materials on nutrition, physical activity, and screen time in conjunction with verbal counseling of patients. Kubik et al. [15] described a prevention intervention that incorporates educational brochures on behavior-regulated activities, a Kid's Goal Board, and a Parent Tip Board in the waiting room area. Perrin et al. [20] suggested that PCPs should incorporate messages about healthy weight management, such as limiting screen time and sugar-sweetened beverages and increasing physical activity, into conversations with patients and parents during regular office visits. These conversations might be particularly important for children who are more likely to be overweight. Materials including healthy weight messages should be made available in multiple languages representative of the populations served by the clinic [38].

It is notable that recommendations by health organizations regarding reduced screen time have become more common in recent years [7, 12]. This is expected as screen time is a more recently accepted measure of inactivity (i.e., as one measure of physical activity) compared to more established measures such as healthy eating. It is also notable that, although several recommendations stated the need for PCPs to promote healthy weight gain during pregnancy, provide information and resources on breastfeeding, and promote guidelines for weaning children at the appropriate age [7, 9, 35, 36], few articles reviewed specifically addressed healthy lifestyle promotion among pregnant or breastfeeding mothers. Those that did [20, 21, 39] summarized recommendations for incorporating healthy lifestyle messages into prenatal or postnatal visits; however, none described specific health promotion interventions for pregnant or breastfeeding women in the primary care setting.

3.3. Patient Treatment. Although few health organization recommendations specifically addressed the role of the PCP in the treatment of overweight and obesity in children and adolescents [2, 12, 28], most of the articles reviewed that occurred in or were intended for the primary care setting involved interventions that were designed to treat the children who were identified as overweight or obese through BMI assessment. The format of the treatment and the intensity, frequency, and length of engagement with clinicians varied across studies. Many of the health organization recommendations on promotion of healthy lifestyle discussed in the previous section also apply to obesity treatment interventions; most of the interventions shown to be successful included promotion of improved nutrition and exercise habits and reduced screen time.

For children with a BMI above a specified percentile, treatment interventions that incorporated individual case management or patient-centered counseling as a means for achieving a child's healthy weight showed some evidence of success. Examples of individual case management include private, age-appropriate conversations with clinicians regarding achieving healthy weight; goal setting; motivational interviewing; and conversations with registered dieticians about patient readiness, diet, and exercise. Of the seven studies in this category, six measured positive results—including weight loss, improved lifestyle habits, or increased parent confidence using provider recommendations—after patients participated in multiple individual sessions with the providers [15, 40–45]. Successful studies emphasized the need for providers to engage the patient in a dialogue about lasting lifestyle changes and the benefits of training clinicians on how to address ambivalence about making behavioral changes. The tone and language used to communicate messages regarding obesity and being overweight is important. Two articles discussed strategies that PCPs could use to deliver diagnosis and treatment options. In focus groups, parents expressed preferences for health care providers to communicate using clinical terms to explain the rationale for their concern and to provide specific treatment recommendations [46, 47].

When a treatment plan is established for an individual, many primary care practices sponsor or refer patients to interventions that provide group classes or activities to support individuals and families. Content of primary-care-based group interventions was diverse, including in-person physical activities, educational grocery store visits, interactive nutrition and exercise sessions, family cooking courses, and group discussions. Though the PCP might make the initial referral to interventions of this type, his or her role in the actual group treatment intervention was less clear from the articles reviewed. Dalton et al. [48] described a group-based intervention for parents using the National Institute of Health's We Can! curriculum, which is facilitated by PCPs; McClaskey [49] described a community-health center intervention involving group nutrition and physical sessions led by physicians. However, dieticians, interventionists, or nurses carried out the majority of primary care-based group interventions.

Multiple recommendations from health organizations cited the role that PCPs can play in educating parents about healthy eating, physical activity, and reduced screen time [7–9, 35, 36]. Kwapiszewski and Lee Wallace [43] found it critical to have full support from all intervention partners (providers, parents, and children) in commitment to lifestyle changes to treat obesity. Most interventions in both the patient-based or group format involved some form of parent involvement, with parents present during individual or group counseling sessions with a PCP or in attendance at parent-only meetings with a focus on goal setting, modeling healthy behaviors, or nutrition and/or physical activity decision making.

3.4. Clinician Skill Development. Recommendations suggest that in order to effectively prevent, diagnose, and treat obesity and overweight in children and adolescents, clinicians must be adequately trained in standardized, evidence-based assessment and counseling techniques [7]. Moreover, clinicians must be comfortable communicating results of weight assessment and monitoring to patients and their families. Haemer et al. [50] suggested that trainings that include the full spectrum of care, rather than weight assessment alone, might be more effective in improving efficacy, as providers could be more likely to diagnose a child as overweight or

obese when they have the tools and comfort level to provide counseling and treatment.

Multiple articles reviewed suggested the need for physician training and decision support for use of techniques and tools for counseling on behavioral treatment approaches for childhood obesity [11, 24, 50, 51]. Seven of the articles reviewed involved training for physicians, nurses, and/or registered dieticians on the use of motivational interviewing techniques, goal setting for parents and children, and/or evidence-based tools for facilitating discussions on obesity. In most cases, training took place in person in a group format, though Stahl et al. [40] described a successful web-based training program for clinicians. Two studies described the results of provider education interventions. Clinicians trained on the use of a brief, structured intervention for school-age children involving the use of flash-cards and take-home games reported increased physician comfort and competence discussing obesity issues [52]. Pediatricians and registered dieticians who received training on motivational interviewing techniques reported the need for more role-playing activities and experience asking open-ended questions [53].

Web-based or in-person primary care clinician trainings for assessment of BMI, healthful eating, and active living habits among children and adolescents were found to be effective in increasing provider confidence in weight assessment [31, 40], rates of BMI assessment, and use of behavioral screening tools after at least a year [32, 38]. Trainings included reference charts for BMI and laboratory values, guidelines for discussion about healthy behaviors, and decision support charts. At least one training included guidance on assessment of parental readiness for change [31].

In 2004, the American Dietetic Association stated the need for PCPs to take into account regional and cultural differences when promoting healthy diet patterns among diverse populations and ethnic groups [34]. We examined five studies that took actions to make interventions culturally competent. Examples of ways that interventions took the cultural, linguistic, or literacy needs of their subjects into account included providing materials and activities in multiple languages, offering recipes to groups that incorporate cultural food preferences, or tailoring materials to families who might have low literacy levels. Of the three studies that explicitly described their efforts to adapt obesity interventions to their population(s), three reported improved weight status among participants [54–56]. These studies used diverse means to adapt to the needs of their populations, which included Latino families (bilingual and bicultural project staff), ethnically diverse youth (traditional recipes), and families with low literacy levels (adapted educational materials). Results from a focus group with Latino parents suggest that, among this population, health messages can be especially well received coming from a trusted health care provider [46]. However, a culturally competent health educator might help to extend the benefits of an obesity treatment program beyond a brief encounter with a provider [57].

3.5. Clinical Infrastructure Development. Few recommendations cited the need for PCPs to advocate for systemic changes in clinical practices to promote screening, diagnosis, and treatment in the primary care setting. However, five of the articles reviewed focused specifically on an intervention that implemented some form of capacity building within the clinic setting, such as improvements to organizational systems or care models used by providers. Each identified structural gap in primary care services and implemented systemic solutions focused on reorganizing clinical care delivery. One such study evaluated the implementation of a patient-centered medical home system in a community health center and found positive outcomes in lifestyle changes, reduced BMI, and increased physical activity in the patients one year after implementation [58]. Another study evaluated the adoption of principles of continuous quality improvement and adult learning theory in the office environment; physicians found these tools helpful, which resulted in increased BMI screening documentation [59]. A third study assessed the effectiveness of integrating practice-based pediatric obesity prevention and treatment clinics within existing primary care settings; these clinics were shown to be helpful in improving nutrition status among obese children [60].

Several studies reviewed involved systems changes targeted at multiple primary care clinics or health care organizations. Pomietto et al. [38] described the Steps to Health King County (STEPS) initiative, which promoted clinic staff training and integrated clinic systems changes across three local health care organizations. This effort eventually grew to a larger program used throughout the state of Washington. The Maine Youth Overweight Collaborative sought to improve clinical decision support in 12 primary care sites; findings showed increased assessment of BMI and use of behavioral screening tools, as well as increased parental satisfaction with services [32].

3.6. Community Program Referrals. An activity frequently cited in journal articles is the physician's role in the identification and recruitment of children and families into obesity prevention or treatment interventions. Of the 38 articles reviewed that described community-based interventions, 14 reported physicians referring their patients to research studies (8 articles) or other community-based programs (6 articles). However, physician recommendations rarely called out this role, with one exception. In 2010, the White House recommended that PCPs and insurance companies connect pregnant women and new mothers to breastfeeding support programs [7].

The obesity interventions described in these articles were mostly family-based counseling and treatment programs, lasting from eight weeks to six months, including group education sessions for parents and children, home visits, follow-up telephone calls, automated messages, and/or other family-oriented activities. Some were branded with program names and set curricula, including Kids on the Geaux [61], Kids N Fitness [62], Healthy Kids Healthy Weight [63], ENERGIZE! [64], Smart Choices for Healthy Families [65], and Family Insulin Resistance Management—FIRM [66]. Of

the 14 articles reviewed, nine reported positive outcomes, including weight loss or reductions in BMI scores [62–65, 67–71]. However, some study limitations included a small sample size [70] and a low participant retention rate [62, 65]. Factors that reportedly contributed to the success of the programs included the dosage of the intervention, the use of healthy eating strategies and behavior modification techniques, and family participation in physical activities [62].

Three of the articles assessed the value of the PCPs' referral role in the interventions. Pinard et al. [65] reported that, in the Smart Choices for Healthy Families program, physician involvement was seen as a valuable partnership. While physicians recognized the importance of referring patients to community-based programs that they did not have time to offer, program lay leaders saw the benefit of physician referrals, including improved behavior change among the provider's patients. Quattrin et al. [69] reported that parents perceived the obesity treatment program as an extension of their pediatrician's care because of the close partnership between the pediatrician and program trainers, the pediatrician's recommendation of the program, and followup with patients who were in the program. However, a third article compared physician referrals less favorably with other community program recruitment strategies. Because the number of physician referrals was not as high as expected, the program deployed additional recruitment methods, including the use of radio ads and posting of program flyers [72].

3.7. Community Health Education. Outside of their usual clinical role, PCPs have a unique opportunity to serve as role models, educators, and promoters of healthy lifestyle practices to their patients and other community residents. In 2005, the American Academy of Pediatrics encouraged physicians to make use of community-based resources outside of their traditional hospital and outpatient office settings to instruct residents on the effects of individual and community factors on child health status and to promote the well-being of all children in the community [35]. This might seem a natural role for physicians, extending their health promotion efforts with their patients to the community. Unfortunately, although many health care providers are aware of the childhood obesity epidemic, are concerned about its health impacts, and want to work on its prevention, they continue to see themselves primarily as clinical practitioners and not as health educators or advocates in the broader community [73].

PCPs can fill several roles in such community health education efforts by serving on leadership teams; providing advice on community messages; volunteering as institutional partners in the funding, planning, and evaluation of community awareness campaigns; and collaborating with community partners on marketing healthy food choices and physical activity. Of the articles reviewed, four focused on the physician's role in community-level obesity prevention initiatives. Health care providers served on the leadership team of the SWITCH program, which included a community awareness campaign to modify key health behaviors, increasing physical activity, improving nutrition, and reducing screen time [74]. PCPs also served on the community task force that led the Tioga County Fit for Life initiative, a comprehensive primary prevention program that used school-based health education classes, a virtual wellness club, and community health fairs to promote healthy nutrition and physical activity [75]. Two other studies reported that health care providers were involved in community initiatives that implemented the national We Can! program developed by the National Heart, Lung, and Blood Institute (although their roles were not specified) [76, 77].

Although it is important to note the participation of health care providers in these initiatives, outcomes were not reported in three of the four articles [74, 76, 77]. The fourth study, a five-year longitudinal analysis of grade-specific rates of overweight and obesity of participating children, showed that overweight and obesity rates increased in all cohorts. Factors cited for the program's failure included inadequate reach of key health messages and lag time between the messages' dissemination and uptake [75]. It is fair to assume that the involvement of PCPs in these initiatives was not responsible for their lack of reported success. In contrast, health care providers have played important roles in numerous more effective community interventions targeting both obesity prevention and treatment (see the next section).

3.8. Multisector Community Initiatives. Over the past decade, PCPs have been encouraged to build partnerships across disciplines to work collaboratively with public health departments and other colleagues, to identify and decrease barriers to the health and well-being of the children in their communities, and to coordinate and focus new and existing services for the benefit for all local children [34, 35]. In the articles we reviewed, health care providers participated in six multisector obesity prevention and treatment initiatives that achieved intermediate policy and systems goals [78–80]; changes in children's food and physical activity environments [80, 81]; and population-level health outcomes, including reduced BMI scores [82, 83] and changes in overweight and obesity prevalence trends [78, 79, 83].

Two projects used a multisector intervention model that started as a community-based research study at Tufts University. In Shape Up Somerville, 50 medical professionals were trained on childhood obesity guidelines and current BMI screening practices as part of a community-wide effort in Somerville, Massachusetts, to increase daily physical activity and healthy eating through programming, physical infrastructure improvements, and policy work [82]. North Carolina's Health Department patterned its Childhood Obesity Prevention Demonstration Projects after Shape Up Somerville. The state offered grants, training, technical assistance, and state-level partnerships and other resources to support local obesity prevention and treatment efforts in five counties. This included training PCPs to assess and treat childhood obesity in their communities [80].

PCPs were also involved in BMI assessment and treatment in community initiatives in Delaware and California. Delaware's 5-2-1-Almost None initiative targeted multiple sectors, including schools, child care providers, and primary

care settings, to implement policy and practice changes, in addition to implementing a media-based social marketing campaign. PCPs promoted universal BMI assessment, preventive health messages, and early intervention and treatment of childhood obesity [78]. The California Endowment's Healthy Eating Active Communities program worked in six communities to prevent childhood obesity in five childhood environments—schools, after-school programs, neighborhoods, health care, and advertising. As part of the initiative, PCPs were trained on the importance of tracking BMI scores, delivering obesity prevention messages, linking families to community programs, and improving local nutrition and physical activity environments [81].

Two other communities included community-based BMI assessments in their multisector initiatives. In the Healthy Living Cambridge Kids program in Cambridge, Massachusetts, schools conducted BMI assessments and then referred students with high BMI scores to pediatricians for followup. The initiative included changes in city policies, implementation of a 5-2-1 community awareness messaging campaign, physical education enhancements in schools, food service reforms, family outreach, and farm-to-school-to-home programs [83]. In the Karanja research study, American Indian/Alaska Native tribes were randomly assigned to either a community-wide intervention that used five strategies—raising community awareness; providing health education; supporting behavior change; enhancing public health practice; and modifying local breastfeeding environments or policies to increase breastfeeding, limit consumption of sugar-sweetened drinks, and promote water consumption—or to an intervention that combined these community-wide activities with family-level interventions, including BMI assessment, counseling, and treatment. Health care providers conducted the BMI assessments in WIC clinics and maternal child health practices as part of routine visits [79].

Another promising initiative is the Healthy Weight Collaborative (HWC), a national quality improvement effort to share and spread promising and evidence-based practices to prevent and treat obesity among children [84]. In this learning collaborative, the National Initiative for Children's Healthcare Quality is working with about 50 community teams of primary care, public health, and community-based organizations to implement and test an integrated change package of strategies. These include (1) building a community coalition; (2) implementing a healthy weight messaging campaign; (3) conducting weight status assessments and follow-up plans; (4) integrating activities across community sectors; and (5) advocating for food and physical activity policy change. The HWC evaluation will be completed in 2013.

Seven other studies in the review featured school-primary care partnerships or primary care interventions in school-based health centers. In four projects, nurses, nurse practitioners, and physicians in a school-based health center or WIC clinic offered counseling and treatment services to students identified with high BMI scores. The results of these programs were either not evaluated [85], minimal [14, 86], or mixed [87]. The other articles described school BMI assessment projects and a student walking project, whose outcomes were not evaluated.

3.9. Policy Advocacy. Several recommendations encourage health care professionals to support and advocate publicly for a number of policy changes, including increasing funding for childhood obesity prevention research; prioritizing capital improvement projects and school and community sports programs to increase opportunities for physical activity among students; and social marketing to promote healthful food choices, breastfeeding, and other healthy behaviors [2, 8, 9]. Although multisector community initiatives have used policy advocacy successfully to alter obesogenic community environments [88], one article reported on an initiative to increase public advocacy activity among PCPs [89]. Funded by the Robert Wood Johnson Foundation, the project sought to recruit, train, and reinforce 160 PCPs to become change agents and leaders in community advocacy to prevent childhood obesity. Physicians received a six-hour training using an advocacy resources guide. Posttraining surveys showed that the training had increased participants' comfort and motivation advocating publicly for healthy behaviors, including active living (26%), healthy eating (25%), breastfeeding (24%), and school and worksite policies (15%).

4. Conclusions

Identifying successful models that integrate primary care, public health, and community-based efforts is important to accelerating progress in preventing childhood obesity. This review aimed to identify the roles that PCPs play in childhood obesity prevention and treatment initiatives in the United States and, in doing so, to determine effective or promising strategies for primary care and community settings. The review, based on 96 peer-reviewed articles published from 2005 to 2012 that met study criteria, demonstrates that PCPs are increasingly being included in childhood obesity interventions, consistent with current recommendations from scientific and professional organizations. The review indicated an average of about 10 relevant articles published yearly during the period from 2005 to 2011 and nearly twice that number in 2012, supporting the increased attention to health care providers in the prevention of childhood obesity.

The rise in obesity among children indicates the need for new strategies that encompass more than individual-level behavior change or postassessment treatment. The prenatal and early childhood periods are critical times for growth and healthy lifestyle development. In the first two years of life, primary care pediatricians, WIC clinics, and community health centers have several opportunities during well-child visits to counsel parents about healthy lifestyles, to model healthful behaviors, and to refer families to community resources. Outside of their clinical role, primary care physicians can also serve as role models, educators, and promoters of healthy lifestyle practices and serve as leaders in community obesity treatment and prevention initiatives. However, national survey data on health practitioners and research studies suggest that PCPs continue to see themselves primarily as

clinic-based practitioners and not as health educators or advocates in the broader community.

4.1. Study Limitations. Although this review identified nearly 100 articles addressing the topic, the ability to draw conclusions about the effectiveness of PCPs' roles in childhood obesity initiatives based on the review is limited by the lack of consistent reporting across studies about (1) specific PCP role(s) beyond referral and BMI assessment, (2) the level and duration of PCP involvement, and (3) child clinical outcomes or process outcomes. Interventions ranged from four to 12 weeks in duration, depending on the study and intervention methods. In addition, there was a general lack of long-term followup results; of the 20 interventions reviewed that had a significant impact on weight status, nine included followup over more than six months [33, 43, 54, 67, 70, 71, 79, 82, 83], and only three followed participants for more than one year [71, 79, 83]. In many cases, evaluations of the initiative were either not conducted or results were not reported. Interventions that did include an evaluation component used a range of outcome measures, including improved weight status, increased provider or parent knowledge, or increased rates of provider assessment of weight status or use of counseling tools, which made it difficult to compare the efficacy of results across articles reviewed. While change in weight or weight status was a frequently used outcome, the methods of weight assessment varied between interventions. Moreover, very few of the interventions reviewed utilized a randomized control study design, further limiting the ability to draw meaningful conclusions about the effectiveness of the interventions reviewed. For these reasons, the results of this review are primarily descriptive.

While it is difficult to draw conclusions about the efficacy of the interventions considered due to the limitations mentioned previously, multisector community childhood obesity initiatives with primary care involvement were more likely to report positive outcomes than obesity initiatives in a single setting (school or clinic based). Multisector obesity prevention and treatment initiatives that achieved intermediate policy and systems goals included partnerships across disciplines, including PCPs, addressed children at all points along the prevention continuum, and used an ecological approach targeting individual, organization, system, and policy change. Positive outcomes included improvements in children's food and physical activity environments, reduced BMI scores, and changes in overweight and obesity prevalence. Successful models that integrated primary care, public health, and community-based efforts also shared several similarities:

(i) multisector messaging within a community;

(ii) weight assessment training for clinicians;

(iii) modeling of healthy behaviors for children (to reinforce their understanding of the concept);

(iv) promotion of culturally competent approaches;

(v) parental involvement.

Because interventions of this type inherently involve multiple components, it is difficult to disentangle the roles to ascertain which individual components were especially successful or effective. Additionally, very few studies documented long-term effectiveness of interventions of this type, demonstrating a need for studies that measure the impact of multisector obesity initiatives over multiple years. Despite these limitations, this review provides a useful resource for PCPs, community organizers, researchers, and policymakers planning childhood obesity initiatives in their communities or primary care settings.

4.2. Next Steps. Future research on community-based childhood obesity interventions should collect and report information on the specific roles that PCPs played in the initiative, including the level of training and counseling skills, presence of role modeling, referrals to community resources, number and type of community partnerships, and public advocacy activity. Reporting on the process or implementation of the initiative as well as child-level and population-level outcomes will contribute to the evidence base for effective strategies by PCPs in the prevention and treatment of childhood obesity.

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Review Article

Systems Science and Childhood Obesity: A Systematic Review and New Directions

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As a public health problem, childhood obesity operates at multiple levels, ranging from individual health behaviors to school and community characteristics to public policies. Examining obesity, particularly childhood obesity, from any single perspective is likely to fail, and systems science methods offer a possible solution. We systematically reviewed studies that examined the causes and/or consequences of obesity from a systems science perspective. The 21 included studies addressed four general areas of systems science in obesity: (1) translating interventions to a large scale, (2) the effect of obesity on other health or economic outcomes, (3) the effect of geography on obesity, and (4) the effect of social networks on obesity. In general, little research addresses obesity from a true, integrated systems science perspective, and the available research infrequently focuses on children. This shortcoming limits the ability of that research to inform public policy. However, we believe that the largely incremental approaches used in current systems science lay a foundation for future work and present a model demonstrating the system of childhood obesity. Systems science perspective and related methods are particularly promising in understanding the link between childhood obesity and adult outcomes. Systems models emphasize the evolution of agents and their interactions; such evolution is particularly salient in the context of a developing child.

1. Introduction

Childhood obesity is widely considered a critical public health issue, but efforts to address it have yielded few clear-cut answers either for clinical care or public health. Reductions in childhood obesity have been attempted through a variety of means, ranging from clinical interventions to public policies. These failures to some degree reflect a misunderstanding of the nature of obesity itself but also more deeply how the multilevel nature of the phenomenon influences the way research must approach the problem.

As a public health problem, obesity operates at multiple levels, ranging from individual health (and other) behaviors to parent-child interactions to community and school characteristics to local, state, and federal public policies. These different levels influence each other in ways that are direct and intended as well as through subtle, unanticipated effects that appear over time. Take, for example, efforts to improve access to play spaces to reduce childhood obesity. Building a public park may offer individuals living within walking distance an opportunity to walk even more as well as play structures for children. Disruptions in traffic patterns, however, may make it more difficult for those living somewhat further away to walk at all. Matters may become more complicated if the park stimulates the development of relevant amenities (such as bars and ice cream parlors). Over time, housing prices in the area of the park may improve, changing the socioeconomic and racial composition of the neighborhood. Understanding the effects of the park requires considering both timing and the effect for whom. Even those originally benefiting from the park eventually may drive to the park (increasing traffic) and walk some, but less than they had walked otherwise. And of course, the park has a range of other effects that policy makers

and society value other than obesity, such as the time families spend together. Clearly, assessing whether individuals who live near the park exercise in the park a year after it is built is a very limited—indeed even misleading—perspective on its impact and merits.

Systems science offers a means of identifying and understanding the complex relationships involved in public health policies. It recognizes that policies are based on complex, interdependent, and evolving relationships and include heterogeneous agents (e.g., individuals, companies, or civic associations) acting in their own perceived self-interests. Time matters, as relationships among the agents have a history and, as a result, can develop stability or even inertia. In a complex system, intervention in one aspect will have unanticipated effects, often delayed and nonlinear. Such effects are not exceptions but the norm [1]. Feedbacks play a major role in the systems perspective, and they may be positive or negative. Negative effects often act to restore the system to its prior state and thus thwart any effort to change part of the system. Systems scientists call this tendency "policy resistance" [1, 2]. As with our public park, communities have a life of their own, reflecting and shaping the behavior of individuals within them.

Many of these notions are particularly salient for the study of obesity, especially obesity among children, which combines the complex nature of obesity with the developmental aspects of childhood. Obesity prevention and treatment among children has a long history of disappointing results, and such failures come as no surprise to systems scientists. Much of the research addressing childhood obesity—and thus the dissemination of this work to the practitioners who most need it—is conducted and grounded intellectually in traditional clinical and public health environments.

This paper describes the past use of systems thinking and models in health and obesity research and lays out an approach for future research, grounded in a systems model resting on nine properties characterizing obesity among children. We first review those properties and systematically review the use of systems tools in obesity research. We then present a systems model of childhood obesity.

2. Systems Science Methodologies

Systems science represents a comprehensive perspective for understanding broad social and health problems. One key tool is simulation modeling, grouped into three broad conceptual paradigms: system dynamics modeling (SDM), agent-based modeling (ABM), and discrete event simulation (DES) [3]. Many problems can be framed so that any of the three methods could be used, but the methods have distinguishing features that lend themselves to certain types of problems.

SDM is the oldest and arguably most common of these three methods [4]. Models in SDM emphasize causal feedback loops and unintended consequences. SDM acknowledges the exchange of resources among agents to produce both desirable and undesirable outcomes. This method is distinguished by an emphasis on stocks and flows. Stocks represent accumulations and characterize a system at a point in time; they provide systems with inertia and memory [2].

DES also describes complex systems over time and the conversion of inputs into outputs. DES revolves around "events" [5] that involve entities (e.g., individuals, firms) moving between different states (e.g., health, production). Key features are that different stages or different entities involve shared resources and the importance of timing. Entities move along different stages in the process in sequence, exiting one stage and moving to the next when space is available.

Agent-based modeling focuses on the broadly characterized pattern of interactions among individuals [6]. These models emphasize the "influence" individuals exert on each other, whether communication of diseases or interest in purchasing certain goods. These models can illuminate patterns of aggregate behavior that emerge from simple models of individual behavior; some of the former may be relatively robust to alternative models of the latter. This approach is dynamic: individuals or a population may accumulate experience that shapes further choices and development.

The three broad paradigms have many common elements, such as understanding unanticipated consequences of choices or aggregate patterns of behavior that were not explicable when judged from the ground up (at the level of the individual agent or entity). All have advantages over alternative approaches, such as Markov models one finds in economic evaluation of health policies [7]. The three paradigms have remained somewhat distinct partly for conceptual reasons, but these differences are smaller than in the underlying programming approaches. Current programming allows the various types of systems science to be combined, creating even more powerful ways of examining policies.

3. Systems Science in Health

Systems science methodologies are increasingly used in health services and public health research. This growth has been stimulated by a recent joint report from the Institute of Medicine and the National Academy of Engineering, "Building a Better Delivery System" [8]. Health care and public health have increasingly been recognized as complex systems, where addressing problems requires considering the entire system.

Some studies have demonstrated the utility of systems science models in a variety of health and health care situations. These include influence of individuals' interactions on risky drinking behavior [9], interventions to reduce childhood caries [10], and how altering personnel affects emergency department throughput [11]. The breadth of potential use for systems science models in health care demonstrates how they may become a critical tool in the development of health policy, including childhood obesity policy [12].

3.1. Nine Properties on Which to Build a Systems Model of Obesity. Obesity in general and childhood obesity in particular raise important issues of interest to system science [13–15]. Conventional obesity research suffers from many of the limitations that affect any effort to understand systems

without a system perspective. At its essence, obesity raises key systems questions for several reasons. A report from the Institute of Medicine, "Bridging the Evidence Gap in Obesity Prevention", discusses the systems science perspective and the needs in obesity research [16]. Although not directly drawn from "Bridging the Evidence Gap", we identify and propose the following nine properties as critical to obesity. Importantly, the effect of obesity-related public health policies requires considering all of the properties.

(1) Obesity prevention and treatment is a common resource allocation problem, and a full understanding of the entire system is required to make appropriate allocations.

(2) Obesity both shapes and reflects a range of other issues. That is, it is both an outcome of certain conditions and a cause of others.

(3) Both obesity and its consequences are evolving developmental processes, which offer multiple points for interventions.

(4) Obesity is determined in a social process that involves families and peers.

(5) Obesity occurs in an environment that moderates the influence of processes operating at other levels.

(6) Many interventions can be assessed only over time and have unanticipated effects.

(7) People are highly heterogeneous in their biological systems and predispositions toward obesity.

(8) Individuals all have a defined "space" within the system, both among other individuals and geographically, and that place influences obesity.

(9) Individuals have imperfect knowledge about obesity.

The properties were not identified because of their link to systems science, but rather because they are fundamental aspects of obesity. In their discussion of systems science in public health, Luke and Stamatakis [17] present some key features of systems science models. These items are listed in Table 1 and mapped to the above obesity properties. Foremost, obesity reflects a nexus of forces that all act to have individuals consume more energy than they expend. These forces include individual, family, and community. That obesity reflects a multilevel process is well established. What is lacking is an analytical method for understanding this process. Systems science is a natural fit for obesity research.

3.2. Past Use of Systems Tools in Obesity Research. Levy and colleagues [18] recently reviewed simulation models in obesity research, demonstrating a wide variety of model types used to address obesity. Our goal is to build upon this knowledge to provide a systematic examination of how systems science methods have been used to examine obesity from a clinical and public health perspective.

Table 1: Systems science properties and nine properties of obesity.

Systems science properties	Obesity properties
Breadth	Obesity prevention and treatment should be considered a common resource allocation problem
Feedback Loops	Obesity shapes and reflects a range of other issues
Dynamic systems in real time	Obesity and its consequences are developmental processes
Interactions of individuals actors	Obesity is a social process involving families, peers, and other individuals
Interactions between multiple levels	Obesity operates within a community environment that moderates family and individual levels
Complex relational structures	Interventions can only be assessed over time and can have unanticipated results
Heterogeneous actors	People are heterogeneous in their biological and behavioral predispositions towards obesity
Spatial	Individuals all have a space within the system
Bounded rationality	Individuals have imperfect knowledge about obesity

4. Methods

We performed a systematic literature review of studies that used systems science methodologies to study obesity in the context of public health. Although few studies use a full systems science perspective, we attempted to identify studies that are developing the pieces of useful models.

4.1. Search Strategy. We chose to focus on the types of models used in systems science as the basis for our search strategy. We searched PubMed and Web of Science (ISI) through March 2012 using "obesity" AND the following key words and phrases: ("simulation model"), ("agent-based"), ("discrete event"), ("system dynamics" OR "systems dynamics"), ("network analysis"), ("Markov simulation"), ("dynamic microsimulation"), and ("systems science"). For our purposes here, we chose not to search other databases in fields such as economics. Although these areas may include additional studies presenting relevant models, we hope to capture findings that are most consistently accessed by the audience of public health and clinical scientists seeking to understand—and intervene in—obesity.

Although network analysis and Markov simulation are not, themselves, systems science methods, we have included them in the keywords because studies using these methods may approach obesity from one of the nine properties listed in Table 1. Network analysis, in particular, provides critical information about the relationships among agents in

the system. We also recognize that this strategy may not represent comprehensive coverage of all obesity-related "systems science" studies. However, we believe it provides a reasonable representation of systems science as currently used in public health obesity research.

4.2. Inclusion and Exclusion Criteria. Inclusion of articles was based on the use of techniques that addressed any of the properties of systems science listed in Table 1. Our goal is to identify research that approaches obesity from a systems perspective, even incrementally. In order to be included in our review, studies had to meet all of the following criteria:

(1) must examine obesity in the framework of systems science or using one or more of the properties of systems science as described in Table 1,

(2) include original analyses, rather than discussing only how systems science could be used, and

(3) must include obesity in the model, as a predictor and/or outcome. Although obesity-related behaviors can be (and often are) modeled without obesity included, our intention is to see and determine how models have used obesity specifically.

We excluded studies that examined only the biological system of the individual. Although systems science approaches can be and have been used to understand the physiological mechanisms of obesity, we are primarily interested here in a discussion of clinical and public health, and of understanding the macrolevel use of systems science. We also excluded studies not published in English.

4.3. Review Process. One author (ACS) reviewed the abstracts of all articles that were retrieved from the search results to determine if they met inclusion criteria. We then obtained the complete article and applied the exclusion criteria to create the final list of included articles. We then reviewed the references of our included studies to identify additional articles of interest.

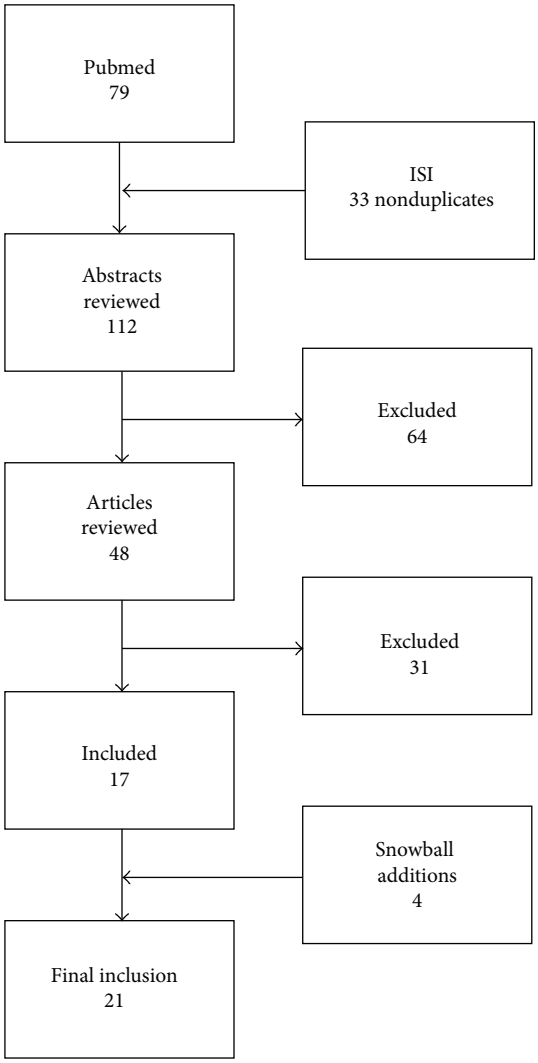

Figure 1: Schematic of search process.

5. Results

We identified 112 articles using the search criteria described above (Figure 1). We excluded 64 after abstract review: the most common reasons for exclusion were that the article addressed physiology and did not address obesity or were commentaries about systems science models. Of the 48 remaining articles, we excluded an additional 31 articles, primarily because they did not include obesity in their analyses, leaving 17 articles included in our review. We reviewed the references in the 17 articles to identify any potential articles that may have been missed using our other search methods, resulting in four additional articles included in our review.

The 21 included studies addressed four general areas of systems science in obesity: (1) translating interventions to a large scale, (2) the effect of obesity on other health or economic outcomes, (3) effect of geography on obesity, and (4) the effect of social networks on obesity. Table 2 demonstrates the properties of systems science that each article addressed.

5.1. Translating Obesity Interventions to a Large Scale. The most common systems science studies examine how interventions could change obesity or obesity-related outcomes on a large scale. Overall, efforts to use true systems science approaches have been most common in this area. These studies fall into two general categories: (a) those examining the effect of a hypothetical intervention or change and (b) those aggregating results of previously studied interventions to a large scale.

5.1.1. Hypothetical Interventions. Goldman and colleagues used a dynamic microsimulation model to examine the effect of risk factor prevention in Americans aged 51 and older [19]. The model defined an individual's probability of transitioning from one state (e.g., health) to another (e.g., cardiovascular

Table 2: Properties of systems science addressed in the included studies.

	Breadth	Loops	Dynamic systems	Interaction of agents	Multiple levels	Complex structures	Heterogeneous actors	Spatial	Bounded rationality
Interventions									
Goldman et al.			X						
Goris et al.					X				
Veerman et al.					X				
Jones et al.	X	X	X			X			
Bemelmans et al.			X		X	X			
Hoerger et al.	X	X	X			X			
Hoerger et al.	X	X	X			X			
Hall et al.			X						
Comorbidities/Costs									
Fesinmeyer et al.			X						
Kong et al.			X						
Losina et al.			X						
Neovius et al.			X						
Van Baal et al.			X						
Wang et al.			X						
Bibbins-Domingo et al.			X						
Lakdawalla et al.			X						
Thompson et al.			X						
Geography									
Edwards and Clarke								X	
MacDonald et al.								X	
Networks									
Christakis and Fowler				X				X	
Valente et al.				X				X	

disease) and demonstrated reductions in disease burden and costs from hypothetical treatment scenarios.

Goris and colleagues focused on the interaction of multiple levels in their examination of the effect of television food advertising on obesity in children in six countries [20]. By using estimated obesity prevalence and differences in advertising, they modeled the proportion of obesity related to advertising, demonstrating significant reductions with the hypothetical elimination of television food advertising. Veerman and colleagues use a similar framework to examine the effects of reducing television food advertising on obesity in US children. [21] They find that reducing television advertising to zero would result in a reduction of the prevalence of obesity in children by 2.5 to 6.5 percentage points.

Jones and colleagues describe the development of dynamic simulation model of population-level diabetes development and control [22]. This well-defined model estimates future increases in diabetes prevalence and diabetes complications. Additionally, the model is used to test the effect of several hypothetical scenarios of improvements in diagnosis, management, and reductions in obesity, all of which reduce the prevalence of diabetes and/or diabetes complications.

5.1.2. Previously Studied Interventions. Bemelmans and colleagues developed a dynamic simulation model to examine the effects and cost-effectiveness of applying previously developed intervention on a national level for obesity in The Netherlands [23]. Using states based on age, weight, and physical activity, they simulated how population-level interventions would affect the transition between states and the resulting effects on health outcomes and costs.

Hoerger and colleagues developed a Markov simulation model to examine the progression of diabetes and the effect of diabetes screening in the US population [24]. This dynamic model used several "modules"—screening, prediabetes, and diagnosed diabetes—and different, previously studied interventions for each state. They were able to demonstrate the cost-effectiveness of screening and a prevention-focused lifestyle intervention.

Using a similar model to the one described above, Hoerger and colleagues incorporated bariatric surgery in order to examine the effect of this intervention in individuals with newly diagnosed or established diabetes [25]. They find that bariatric surgery appears to be relatively cost-effective for

severely obese patients with diabetes although improvements in diabetes decline over time.

Hall and colleagues used a dynamic simulation model to examine a variety of weight-related outcomes and other factors. Specific to public health, they demonstrate that their dynamic simulation (as opposed to linear estimation) shows that a tax on sugar-sweetened beverages would have a much smaller effect on population-level weight than previous reports [26].

5.2. Effect of Obesity on Comorbidities/Other Outcomes. Studies to examine the effects of obesity on other outcomes, including comorbidities, have primarily used dynamic simulation models. However, these have not included the feedback loops or complex structures that have been used in studies that aimed to predict the effects of interventions. Rather, they have focused on the probability of changing states (e.g., no disease to disease) and the results on prevalence of conditions or costs.

Fesinmeyer and colleagues used a microsimulation model to examine the contribution of obesity to prostate cancer mortality [27]. Their model is based on previous work showing the relationship between prostate cancer and obesity. They were able to estimate how obesity increases the risk of prostate cancer and that despite the overall decreases in prostate cancer mortality, the declines were limited by the increase in obesity.

Kong and colleagues developed a disease simulation model of the how obesity affect esophageal cancer [28]. Using previously-studied relationships between obesity and esophageal cancer, they compared the expected trend given constant obesity since 1970 and the observed trend with the increase in obesity. The results showed that about 7% of the cancer cases were attributable to obesity.

Losina and colleagues used a policy model to examine the relationship between knee osteoarthritis, obesity, and morbidity [29]. The model is based on transitions between health states based on the combinations of obesity and arthritis. They showed that both of these conditions, and the combination of the two, had a significant impact on morbidity.

Neovius and colleagues developed a Markov simulation model to examine premature mortality attributable to obesity and smoking in Swedish men [30]. This simulation of cohort over 40 years demonstrated that a reduction in obesity would yield a reduction in premature deaths, but the reduction was small compared to that of eliminating smoking.

van Baal and colleagues used a chronic disease model to examine the effect of obesity on total lifetime health care costs [31]. Their model allowed comparison of lifetime costs under different scenarios of changes in incidence, health care costs, and relative risks. Although a substantial portion of health care costs can be attributed to obesity, the increased life expectancy with obesity reduction yielded no reduction in lifetime health care costs.

Wang and colleagues used a simulation model based on expected obesity trends in the US and the UK in order to examine the effect of obesity on health and costs [32]. They demonstrate that obesity makes significant contributions to morbidity, mortality, and costs.

Similarly, Lakdawalla and colleagues used a simulation model to examine life expectancy, disability, and costs associated with obesity at age 70, based on transitions among various disease states [33]. Not surprisingly, the results demonstrate increased costs and fewer disability-free years among obese individuals.

Bibbins-Domingo and colleagues use the Coronary Heart Disease Policy Model to examine how current adolescent obesity will affect future CHD prevalence [34]. They demonstrate varying increases in the prevalence of CHD in adulthood based on different assumptions about obesity change. They also show decreases in CHD prevalence based on successful treatment of hypertension and dyslipidemia.

Thompson and colleagues developed a dynamic model to examine the effect of age and obesity on the risk of developing several obesity-related diseases and the subsequent costs [35]. Their results demonstrated a combined effect of age and obesity on disease risk and projected costs.

5.3. Effect of Geography on Obesity. Two studies examined the influence of spatial position on obesity. Edwards and colleagues developed a spatial microsimulation model called SimObesity to examine small-area influences on obesogenic behaviors in the United Kingdom [36]. Their results demonstrate clear differences in how low social capital, obesogenic behaviors, poverty, and deprivation and safety affect obesity in different small areas.

MacDonald and colleagues used network analysis to examine the effect of distance to food outlets on BMI in an urban area of the United Kingdom [37]. They demonstrated very few relationships between distance to a food outlet and BMI.

5.4. Effect of Networks on Obesity. Two studies examined the interactions between agents (individuals) in the development of obesity. Christakis and colleagues developed a social network analysis to examine the spread of obesity among individuals in the Framingham Heart Study [38]. They demonstrated clear ties in the development of obesity among individuals with social relationships, particularly for same-sex friends, spouses, and siblings. Their model included geographic distance, which indicates that the immediate environment was less important than the social environment.

Valente and colleagues extended these findings to examine obesity among adolescents and their friends [39]. Although they did not have the benefit of longitudinal data, they were able to demonstrate significant clustering, with adolescents who have friends who are overweight more likely to be overweight themselves.

6. Discussion

A limited amount of research addresses obesity from a systems science perspective. Conspicuously few studies examine childhood obesity from a systems perspective, with only two focusing on children—one examining a hypothetical

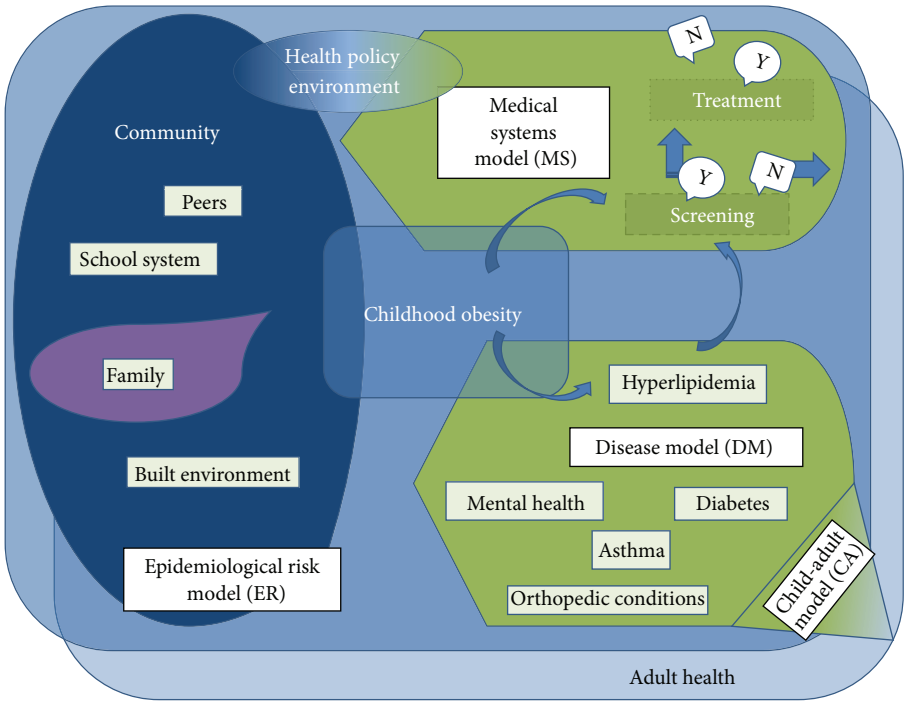

Figure 2: Systems model of childhood obesity.

intervention regarding food advertising and the other showing network clustering of obesity in adolescents. System dynamics modeling is the most common, consistent with its longer history of use in research. However, the largely incremental approaches used in current systems science lay a foundation for future work, and an examination of the shortcomings of current research provides critical insight into how such approaches can be used in ways that yield maximum benefit.

A myopic, ground-level view of obesity leads to interventions likely to fail; worse still, that same perspective infuses research, making it difficult for researchers to develop a system-level perspective. A program seems to fail; yet that intervention may very well have been necessary but not sufficient to change the behaviors that influence energy intake and obesity as a result.

What does a system-level perspective reveal about obesity? Obesity in an individual does not occur in isolation. That individual acts within a particular genetic, social, and environmental milieu. Although understanding isolated factors is useful, how we improve obesity from a public health perspective requires a much deeper examination of how all these factors interact.

One of our inclusion criteria—that obesity be either an outcome or a predictor—reveals a critical failure in our current understanding of the obesity epidemic. The world for which obesity interventions are designed focuses heavily on obesity as an outcome. However, in the real world—the system in which people live—obesity is both a predictor and an outcome. It is this feedback loop that is critical to understanding how to address obesity.

Another critical failure in understanding how to address the childhood obesity epidemic is the lack of long-term studies that demonstrate the effect of interventions in childhood on adult obesity and disease. This is, of course, due to the difficulty in developing long-term studies, and exploring the effect of the entire menu of childhood interventions on adult health is likely an impossible task.

6.1. A Model of Childhood Obesity for Systems Science. Overall, systems science is developing a clear foundation for application in obesity. Using systems science methods is most critical in childhood obesity, where the effects of behaviors or interventions on long-term outcomes cannot be fully tested using standard research methods. the development of effective interventions requires an understanding of the physical and social environments, the role of the medical system, the progression of disease, and the effect of this system in childhood on future adult outcomes. In order to guide future systems science approaches, we have developed a model that includes the overall system in which childhood obesity develops and perpetuates (Figure 2).

Figure 2 describes the conceptual model on which systems science models of childhood obesity can build. It is built upon the nine properties of obesity research discussed earlier, as well as the limitations identified in the literature review. The model as a whole (1) considers the effect of allocating resources to different areas for prevention and treatment, (2)

demonstrates that obesity is both a cause and an outcome, and (3) that obesity is a dynamic, developmental process; the (4) relationships among individuals and (5) their interactions with the environment can affect the components other than behavior and obesity itself. By combining multiple submodels, it (6) emphasizes the complex relational structures and (7) the heterogeneity of the individual in their risk for obesity and for related diseases. Finally, (8) each individual has a "space"—both geographically and among others, and (9) the knowledge available to the individual can influence all other aspects of the system.

6.2. A Vision for Future Research. Limitations of current research are the basis for development of our vision of future research, which is reflected in our model of childhood obesity. Specifically, current studies, for the most part, do not combine the effects of interventions with the resulting outcomes. Systems science methodologies can bring to public health and obesity the ability to model how a particular intervention might affect a larger population—including interaction with other interventions, implementation, how individuals interact with others, and what health improvements and cost differences would be attributable to that intervention. A second limitation with the current approaches is that there is little consistency in the outcomes predicted in terms of time, such as health expenditures. These models yield vastly different interpretations, from obesity being a significant contributor to health care costs to no differences in lifetime expenditures. A third limitation is that current studies examining what influences behaviors have typically not extended the results to the effect on obesity. Although such studies [40–46] provide important foundations to understanding how environments and networks affect behaviors, using these results in public health requires additional understanding of how changes in behaviors result in obesity changes. The limitations of the current research should only be construed in terms of their limitations toward a broad understanding of childhood obesity. Understanding of systems requires research on the individual components as well as the broader picture. Current research is not inherently limited—it simply has not been used to its maximum potential. Systems science is one way to expand current knowledge in ways highly applicable to policy development.

Our description of a hypothetical park hardly strains the imagination of anyone who has been to a park. Indeed, our suspicion (and hope) is that the reader thought of examples of places s/he had been as s/he read that paragraph. As noted, however, a single study or line of research generally does not capture the complexity implied by our example. To do so requires a new vision for obesity research that we outline here.

First and foremost, no single study can provide the data needed to understand these processes. It has become clear that in many areas, research has to be combined in an overarching vision. A single study has to offer a partial view for a range of reasons (including but not limited to research budgets). In terms of childhood obesity, which results from actions at multiple levels, appropriately combining multiple studies is the only way to fully understand the problem. Related to this, a vision that combines multiple studies offers a means to prioritize research. When one tries to complete such a model, it is often quite clear that a duplicative multitude of studies are available for one part of a model with little, if any, research on another part.

Second, no single field can provide the theoretical insights, methods, and guidance required for this vision of research. Studies outside of the "obesity literature" have an important role to play in the model. In the case of our park, it seems clear that expertise in a range of topics is needed–exercise physiologists, nutritionists, recreation scientists, transportation researchers, real estate experts, to name just a few.

Third, research in this area needs a broader understanding and greater emphasis on time. Research at a microlevel points the way in that regard. A key issue with weight loss is not losing weight but maintaining the loss. A dynamic model (biological and behavioral) highlights the role of feedback to understand how and why individuals tend to regain weight lost [47]. Research that begins with the presumption that "all else is held constant" is doomed to fail. Systems are continuously changing. Obesity well illustrates how quickly population health can change. For example, the percentage of children who are obese in the United States increased by nearly one-third between 1999-2000 and 2007-2008. In the last two years, however, rates have actually declined [48]. Obesity itself is an ever-moving, dynamic target which means that research based on ceteris paribus will never reach maximum impact—and obesity is but a single summary of a large, complex system.

This work also rests on a broader understanding of the development of research as well. A model like we are describing here would not be developed, used to answer a specific question or test a single hypothesis, and then put aside. Rather it would continue to grow as new studies shed (better) light on key aspects of it. Indeed new agents or participants would enter the model over time. Currently, we often think of the research process as a series of studies, rather than one study that both continues perpetually (not unlike a longitudinal cohort study) and changes constantly (very much unlike most longitudinal studies). Pushing forward such as innovative and forward-thinking research will require understanding of the nature of systems science by the overall research community.

One might argue that the vision of research here is too ambitious—that it involves the determinants and consequences of obesity for everyone at different time points in the lives of individuals and communities. However, this vision is exactly what we want public health policy makers to do—to make decisions that improve the public health now and in the future. There are many examples where a failure to embrace such a vision leaves key questions unanswered. For example, translational research involves developing clinical interventions and implementing them in public health systems. Often such efforts to make this transition fail and we know relatively little about how to make successful transitions from bench to bedside (type 1) and bedside to curbside (type 2). With a systems model and the understanding it provides, these failures, if not prevented, then could inform the systems model and improve the chances of future transitions.

7. Conclusion

What does a system-level perspective reveal about childhood obesity? Obesity in an individual does not occur in isolation. That individual acts within a particular genetic, social, and environmental milieu. Although understanding isolated factors is useful, how we improve obesity from a public health perspective requires a much deeper examination of how all these factors interact. Systems science methods have been used to help understand the complex physiology of obesity within an individual [49, 50]. Ideally, we would eventually combine these as additional levels to the overall "obesity system." However, to do so will require significant interdisciplinary teamwork, including basic scientists, clinical scientists, public health researchers, and researchers with systems science knowledge and the skills to apply it to many different levels, and only then will we improve our ability to undertake such examinations, from a truly dynamic, system perspective.

Conflict of Interests

The authors have no conflict of interests to disclose.

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Research Article

Designing Insurance to Promote Use of Childhood Obesity Prevention Services

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Childhood obesity is a recognized public health crisis. This paper reviews the lessons learned from a voluntary initiative to expand insurance coverage for childhood obesity prevention and treatment services in the United States. In-depth telephone interviews were conducted with key informants from 16 participating health plans and employers in 2010-11. Key informants reported difficulty ensuring that both providers and families were aware of the available services. Participating health plans and employers are beginning new tactics including removing enrollment requirements, piloting enhanced outreach to selected physician practices, and educating providers on effective care coordination and use of obesity-specific billing codes through professional organizations. The voluntary initiative successfully increased private health insurance coverage for obesity services, but the interviews described variability in implementation with both best practices and barriers identified. Increasing utilization of obesity-related health services in the long term will require both family- and provider-focused interventions in partnership with improved health insurance coverage.

1. Background

The secular rise in obesity among American youth has been well documented. Among children and adolescents aged 2 to 19 years, 16.9% have a body mass index (BMI) for age at or above the 95th percentile and 31.7% have a BMI percentile at or above the 85th percentile [1, 2]. An estimated 60% of overweight 5- to 10-year-olds already have a cardiovascular disease risk factor or hyperinsulinemia and more than 20% have two or more risk factors [3, 4]. The impetus to address rising obesity rates is driven also by the trajectory of health care costs [5–7]. By recent estimates, the annual burden of obesity has risen to almost 10% of health care spending, amounting to $147 billion in 2008 [8].

With frequent access and opportunities to engage families, a 2005 Institute of Medicine (IOM) report concluded that physicians, nurses, dietitians, and other clinicians are in a key position to influence children and their parents to adopt healthy lifestyles [9–12]. Despite these recommendations, a national population-based survey found that obesity was diagnosed at only 18% of well-child visits for children with known obesity, and diet and activity counseling was documented for only 51% of known obese children [13]. One barrier is that few health insurance plans have covered the costs of obesity prevention or treatment, leaving providers with a disincentive to offer the services and families facing significant out-of-pocket expenses if it is offered [14]. The Alliance for a Healthier Generation, founded in 2005 by the American Heart Association and the William J. Clinton Foundation, collaborated with private health insurance companies and large self-insured employers nationally to promote health insurance coverage for the prevention, assessment, and treatment of childhood obesity. Insurers agree to pay for at least four follow-up visits with the child's primary care provider and at least four visits with a registered dietitian per year for children in the eighty-fifth percentile or higher of BMI for age. Over 2.5 million children are currently covered by participating organizations. Insurers and employers also agree to distribute annually at least two targeted communications to all eligible beneficiaries to educate and

promote utilization as well as monitoring utilization by sharing administrative claims data yearly. The American Academy of Pediatrics (AAP) and the Academy of Nutrition and Dietetics (Academy) collaborated on the development of educational materials, provider webinars, care coordination resources, and family resource materials. The purpose of this study is to review the early experience, lessons learned, and key success factors from this novel initiative to address childhood obesity through insurance redesign.

2. Methods

2.1. Overview. This was a qualitative study to identify facilitators and barriers to increasing the provision of obesity-related counseling services through key informant interviews. Administrative claims data were used to measure the use of obesity-specific services by eligible children.

2.2. Key Informant Interviews. In 2010-11, interviews were conducted with the implementation coordinators from all 16 insurers or employers who had offered the coverage for at least a year. The interview contained both closed and open-ended questions about the coverage offered, eligible population, roll-out process, and implementation strategies to explore successes, barriers, and lessons learned (Table 1). The questions were developed from a review of the literature and pilot tested with subject matter experts to ensure that key implementation domains were included and that the prompts elicited the desired information. After the first pilot interviews the guide was again revised. Dissemination strategies were described both in terms of the target audience and the intensity of outreach. Informants were also asked about their use of marketing and educational materials. Similar interviews were also held with participating staff from the AAP and Academy who represent pediatricians and registered dietitians, respectively. Interviews were tape-recorded with consent of the participants. The transcripts and hand written notes were reviewed by two team members (SK and JH) who used them to identify common themes and create a summary statement for each of the questions covered.

Follow-up interviews were conducted with 10 organizations that had more than two-year experience offering the coverage. The goal of these interviews was to identify any changes made after the initial launch in administering the coverage, promoting it to beneficiaries and/or providers, and any new facilitators or barriers to implementation. The research team conducted a 30-minute phone interview with key informants using a tailored interview guide that was developed in a similar process to the initial guide.

2.3. Administrative Claims Data Review. Key informants were asked about changes in utilization of obesity-specific health care services and deidentified health plan administrative claims data were reviewed to monitor the use of obesity-related counseling codes. Overweight and obesity were identified by an ICD-9 diagnosis code of 278.XX or V85.5X.

3. Results

3.1. Baseline Interviews. Ten of the sixteen organizations interviewed were health plans and six were employers (Table 2). The key findings are summarized in Table 3 and discussed in the following.

3.1.1. Administrative Barriers to Offering New Coverage. Most indicated that there has been little if any cost associated with offering the coverage although that had been an initial concern of the underwriters. Only two indicated that premiums increased as a direct result of offering the coverage.

3.1.2. Claims Processing. For four insurers, claims processing for the obesity benefit are handled manually. Providers must collect BMI information and enter it manually into the tracking system. Six insurers have electronic systems to process and pay claims. Each insurer provides a set of billing codes (diagnosis, CPT, and HCPCS) for participating physicians to use for reimbursement. The billing codes are similar overall but unique due to each insurer's contractual requirements.

3.1.3. Coverage Offered. Six organizations allow a higher number of PCP or registered dietitian (RD) visits than the initiative required; three do not have any age restriction and five do not restrict the coverage based on BMI. Eleven allow direct billing by RDs but 5 required that counseling be provided by a physician only or by an RD working out of a physician's office. Thirteen required a copayment from families for PCP visits and ten required a co-payment for RD visits. Co-payments ranged from $20 to $75 per visit.

3.1.4. Enrollment Process for Families. Eleven organizations have no formal enrollment and/or pre-certification process required before receiving services. Members simply make an appointment with a PCP and/or dietitian of their choice. One employer requires members to call a toll free number to speak with an RD for eligibility determination. Two require that members have a referral to a dietitian. One requires that children participate in a disease management program in order to receive services. Two require that the child take an enrollment form to their initial baseline assessment with a physician. The physician then determines if they qualify for the counseling services and manually enters the information into an electronic tracking system. Organizations identified several barriers to engaging families. A lack of coordination between insurers and employers makes it difficult for either to identify and reach out to the families of overweight children without the support of the other.

Although originally designed to facilitate the identification of overweight children, requiring enrollment forms or placing the services within a larger disease management program created barriers to utilization. Organizations that required an enrollment form found that many parents downloaded the forms from the website but never actually took their child to see the doctor and there was no way to track or contact the parent who downloaded the forms. The manual

Table 1: Key informant interview domains with sample questions.

Domain	Sample questions
Process of offering the coverage	Please describe the process used to roll out the new coverage in your organization (1) What steps are involved in launching it? (2) What steps have you completed? (3) Who is leading/led the initiative? (4) Who structured the roll-out process? (5) Please describe your roll-out process to providers (6) Please describe your roll-out process to eligible beneficiaries (7) What aspects of the rollout have gone well? (8) What aspects of the rollout have not gone well? (9) What, if any, additional barriers do you anticipate?
Enrollment process for families	According to your survey, there is (is not) some type of application/precertification process required. *Follow-up questions:* (a) If yes, please describe the process (b) Did your company have to create or modify any systems in order to handle this process? Please describe
Marketing efforts	(1) Have you received feedback from beneficiaries regarding your marketing/outreach activities? (a) If yes, what comments have you received? (2) Have you received feedback from your providers/employer groups regarding your marketing/outreach activities? (a) If yes, what comments have you received?
Engaging providers	(1) How do you regularly communicate with providers? (2) Are your dietitians a contracted provider? (3) Did you already have enough dietitians in the network, or did you have to contract more? Approximately how many?
Engaging families	In addition to the marketing materials described in your survey, please describe any additional approach(es) you are using to engage, inform, and/or educate families. (*Read through all prompts*) (a) Telephone prompts (b) Beneficiary incentives (c) Internet (d) Other

tracking and processing of forms required by some insurers also placed an administrative burden on providers.

3.1.5. Marketing. Insurers tended to do more outreach to providers while employers engaged their employees through targeted mailings to those with children and email blasts. The marketing materials targeted to providers are distributed by email, intranet, direct mailing, and in-person. Marketing materials targeted to beneficiaries were distributed during the benefit open enrollment period by email, intranet, health fairs, direct mailing, and in-person.

3.1.6. Engaging Providers. The organizations took varied approaches to engaging providers. Three target providers participating in a primary care physician incentive plan while another is piloting the coverage in a single large pediatric practice. No organizations target specific dietitian groups. Respondents perceived that many providers are unaware of the coverage or do not know how to code visits appropriately to take advantage of the coverage. Several organizations reported that it is difficult to know if communications sent to providers ever actually reach them.

Two of the three organizations with the highest usage rates are insurers who directly interacted with providers—sending network managers to meet directly with providers and go over a checklist of items including the obesity benefit and conducting in-service sessions about coding and the referral process. Four of the ten that directly contract with dietitians were concerned about an insufficient number of RDs in their network. Some organizations are developing alternative solutions such as allowing members to visit RDs at health departments or hospitals when contracted providers are not available in their area. Access to dietitians was seen as a particular challenge for rural areas. One insurer spent a year recruiting, credentialing, and contracting with RDs to build a referral network. At the same time, they had to educate RDs about how to work with medical practices and bill for services.

3.1.7. Professional Organization Perspectives. Staff from the AAP and Academy perceived that most pediatricians needed

Table 2: Summary of participating organizations.

Type of organization	Geographic reach	Eligible children between ages 3 and 18
Health insurance plan	Pennsylvania	754,699
Health insurance plan	North Carolina	560,097
Health insurance plan	Virginia	488,423
Health insurance plan	Massachusetts	288,661
Health insurance plan	New York	86,010
Health insurance plan	Kentucky	46,225
Health insurance plan	National	30,400
Health insurance plan	Wisconsin	24,000
Health insurance plan	Wisconsin	212*
Health insurance plan	California	130*
Employer	National	53,000
Employer	National	20,175
Employer	Ohio	18,700
Employer	New York	9,018
Employer	National	1,256
Employer	National	624

*Targeting individual physician practices.

tailored practice strategies to facilitate the identification of overweight children and the creation of a referral network of dietitians, health educators, and fitness counselors to work with those children and families. More education around coding for obesity-related services and training sessions for office managers was also recommended, given the range of potentially appropriate codes and variability amongst insurers. Given that claims with obesity diagnoses have not been traditionally eligible for reimbursement most physician practices are not accustomed to documenting obesity or BMI status on billing forms. Similarly, it was felt that RDs would benefit from education about working with insurers, billing codes, and the processes required for reimbursement.

3.1.8. Engaging Families. Both employers and insurers use their benefits open enrollment period to introduce the coverage to members. Enrollment packets included a description of the obesity benefit and most signatories post information about the coverage on their websites and intranets. One employer sent email blasts to all employees who opted in with their email addresses. Some companies use targeted mailings that go only to members with children in the appropriate age range. Four organizations use claims data to identify children in families where a child and/or parent had been diagnosed with obesity and/or diabetes. One employer is using gift cards as incentives for members to complete their visits.

3.2. Changes in Implementation over Time

3.2.1. Benefit Changes. When asked whether any modifications had been made to implementation of the coverage, one insurer reported dropping the deductible for PCP and RD visits. Another removed the requirement to enroll in a disease management program. Both changes were made in an effort to increase participation.

3.2.2. Engaging Beneficiaries. Most organizations reported no change in their strategic marketing approach to beneficiaries, despite recognizing a need to increase member awareness of the coverage. Successful strategies that were reported include a video based on an employee who lost weight after receiving a Sports Authority gift card, a marketing campaign to members of a disease management program, and the publication of employee success stories in company newsletters. Privacy concerns prevent some organizations from sending targeted communications to obese children identified in claims data. One is offering a new wellness incentive to help motivate employees with those completing biometric screening eligible for a health plan premium discount.

3.2.3. Engaging Providers. Several organizations initiated new activities to engage providers. One insurer developed a provider training video on motivational interviewing which is available on the provider portal. Three organizations sponsored an educational webinar produced by the Alliance, AAP, and the Academy with CME credits. Most organizations felt that barriers remain. Two organizations find it challenging to promote the coverage to geographically dispersed provider groups and several noted that providers find it difficult to identify covered children when caring for patients covered by a range of insurance plans. Several organizations reported that providers continue to need education on the correct codes to bill for the services.

3.3. Use of Obesity-Specific Services. During the interviews, key informants reported that their internal data show low use of obesity-related services after one year of offering the coverage. Of the 10 organizations with the longest experience, several reported fewer than 50 children receiving counseling services and three reported between 100 and 1000 users with numbers increasing after the second year. Review of claims data from the organizations found that it was challenging to identify paid claims processed for obesity-related services. In order to track use, the provider must bill using a procedure or diagnosis code indicating that some type of weight-related education was performed (e.g., nutritional or exercise counseling). In order for administrators to be able to monitor service usage and patient outcomes, claims should also include the V85.5x diagnosis code that specifies the patient's BMI percentile. Based on review of claims paid, however, both physicians and dietitians used the less specific 278.0x diagnosis codes and counseling was rarely documented through diagnosis codes. The number of children with a documented diagnosis of obesity increased across the organizations after joining the initiative. The number of children with a diagnosis of obesity who had at least one preventive medicine visit also increased. The use of dietitian services varied widely and, not surprisingly, insurers that allowed direct billing by dietitians had the highest rates of dietitian use.

Table 3: Lessons learned from expansion of health insurance coverage.

Key processes	Findings
Claims processing	(i) Challenging to integrate BMI information with claims processing (ii) Insurer-specific billing codes are challenging for providers who bill to multiple insurers
Benefit structure	(i) Most offered more generous coverage than required by the initiative (ii) Most but not all allow direct billing by registered dietitians (iii) Copayments varied and were often significant
Coordination with other wellness programs	Programs often not coordinated
Enrollment requirements	(i) Pre-certification and disease management enrollment requirements created barriers to utilization (ii) Manual enrollment processes created barriers to provider participation
Marketing	(i) Insurers tend to focus outreach on providers (ii) Employers tend to focus outreach on employees
Engaging providers	(i) Difficult to know if materials ever reach the provider (ii) Direct interaction with providers is the most successful (iii) Insufficient number of registered dietitians available in some networks (iv) Providers have educational needs around motivational interviewing, billing codes, and effective care coordination between physician practices, dietitians, and health educators
Engaging families	(i) Most marketing efforts focused on open enrollment period (ii) Need for coordination between employers and insurers to effectively identify and reach overweight children
Monitoring utilization of obesity-related health services	(i) Infrequent use of BMI-specific billing codes (ii) Infrequent use of counseling-specific billing codes

BMI: body mass index.

4. Discussion

This study describes the early challenges of a unique, voluntary initiative to expand health insurance coverage in the United States for childhood obesity prevention and treatment services. These findings are relevant to many preventive health goals and can be used to improve the effectiveness of future efforts to promote preventive care through insurance redesign. The goal of the initiative to expand health care coverage for obesity services has been successful with all participating organizations able to implement and offer the coverage. Translating access into utilization, however, has been more challenging and participants identified several potential barriers that have impeded the increased utilization of obesity-related services. Making providers and families aware of new coverage for obesity services is challenging. Insurers have focused on making information available to providers using existing provider portals while employers have focused on outreach to their employees, particularly during open enrollment periods. From the provider perspective, varying requirements for documentation and varying acceptance of billing codes across insurers increase the complexity for providers who care for patients covered by a range of insurance plans. Precertification or enrollment requirements may allow insurers to identify and reach out to overweight children, but at the same time they increase the burden on families, thus discouraging participation. Copayments for primary care and dietitian visits varied widely and they discourage return visits because the copayment is applied to each individual visit. Finally, low use of BMI-specific diagnosis codes and counseling billing codes makes it difficult for organizations to monitor whether obesity prevention and counseling services are being used.

Development of effective and feasible strategies for prevention and treatment of childhood obesity in primary care settings is critical [15, 16]. Attitudinal and informational barriers are exacerbated by system barriers that make it difficult to provide proactive prevention and counseling services [17]. Previous studies of Medicaid programs have found that although the existing standards for Early and Periodic Screening Diagnostic and Treatment (EPSDT) allow coverage for comprehensive obesity-related care, only 11 states covered obesity-related nutritional and behavioral therapies and many created barriers to service delivery [18–20]. The Healthier Generation Benefit was recently highlighted as a promising example of payment strategies for comprehensive obesity prevention and treatment services and the lessons learned here are directly applicable to the expansion of first dollar coverage for approved preventive services under the Affordable Care Act [14].

This study has several limitations that must be noted. First, the implementation findings are dependent upon self-report and were not independently confirmed. To maximize accurate reporting, the interviews were performed and coded by the independent evaluation team. Also, the utilization data was independently analyzed by the evaluation team and the reported rates of utilization were generally confirmed. Secondly, the participating organizations joined the initiative

voluntarily and may not be representative of private health insurers and employers nationwide.

The number of insurers and employers offering the Healthier Generation Benefit is growing with five new organizations joining the initiative in 2012. The early findings reported here are being used to assist new organizations in maximizing the impact of offering coverage. The AAP and Academy are collaborating on a provider outreach campaign. The campaign includes speaking engagements, webinars with continuing medical education credit, tools to make it easier to identify eligible beneficiaries, and an accurate coding campaign to encourage coding practices in line with AAP and USPSTF recommendations. Pilot projects are focusing on partnerships with specific providers to develop effective models for care coordination and patient outreach. Organizations continue to monitor utilization through claims data analysis and share best practices. Both reaching and engaging families are critical to long-term success. There is a clear need for more research exploring effective messaging to families about childhood obesity and promoting the use of available counseling resources.

In sum, this study reports on the early findings from a unique initiative to expand childhood obesity prevention and treatment services through a voluntary partnership. The growing interest and participation in the initiative point to a recognition on the part of employers and insurers that the complicated problem of childhood obesity must be addressed. Reducing financial barriers to appropriate screening and prevention services is a necessary but not sufficient component of what by necessity must be a multifactorial approach. The experiences of these early adopters provide important lessons that can be used to guide the use of insurance incentives to promote broad public health goals in a decentralized health care system.

5. Conclusion

This paper reviews the lessons learned from a voluntary initiative to expand private health care coverage for childhood obesity prevention and treatment services. Large variability in implementation, best practices, and significant barriers were identified.

(i) The findings are relevant to many preventive health goals and can be used to improve the effectiveness of future efforts to promote preventive care through insurance redesign.

(ii) Making providers and families aware of new coverage is challenging.

(iii) Varying requirements for documentation and varying acceptance of billing codes across insurers increase the complexity for providers.

(iv) Low use of BMI-specific diagnosis codes and counseling billing codes makes it difficult for organizations to monitor whether obesity prevention and counseling services are being received.

Reducing financial barriers is a necessary but not sufficient component of efforts to increase the utilization of obesity-related services.

Conflict of Interests

Ms. Bogard and Ms. Brown are employed by the Alliance for a Healthier Generation. Neither was involved in the data collection or analysis for this paper. Both did review and provide edits for the final version of paper. All authors from Emory University have indicated that they have no other financial relationships relevant to this paper to disclose.

Author's Contribution

Drs. Rask and Gazmararian, Ms. Kohler, and Mr. Hawley participated in the conceptualization, analysis, and interpretation of data described in this work and take public responsibility for appropriate portions of the content. They were either responsible for the drafting of the paper or revising it for intellectual content. All authors provided revisions and final approval of the paper.

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Clinical Study

School-Based Health Center Intervention Improves Body Mass Index in Overweight and Obese Adolescents

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Adolescents Committed to Improvement of Nutrition and Physical Activity (ACTION) was undertaken to determine feasibility of a school-based health center (SBHC) weight management program. Two urban New Mexico SBHCs were randomized to deliver ACTION or standard care. ACTION consisted of eight visits using motivational interviewing to improve eating and physical activity behavior. An educational nutrition and physical activity DVD for students and a clinician toolkit were created for use as menu of options. Standard care consisted of one visit with the SBHC provider who prescribed recommendations for healthy weight. Sixty nondiabetic overweight/obese adolescents were enrolled. Measures included BMI percentile, waist circumference, insulin resistance by homeostasis model assessment (HOMA-IR), blood pressure, triglycerides, and HDL-C levels. Pre- to postchanges for participants were compared between groups. Fifty-one students (mean age 15 years, 62% female, 75% Hispanic) completed pre- and postmeasures. ACTION students ($n = 28$) had improvements in BMI percentile ($P = 0.04$) and waist circumference ($P = 0.04$) as compared with students receiving standard care ($n = 23$). No differences were found between the two groups in blood pressure, HOMA-IR, triglycerides, and HDL-C. The ACTION SBHC weight management program was feasible and demonstrated improved outcomes in BMI percentile and waist circumference.

1. Introduction

The prevalence of childhood obesity in the USA has tripled since 1980 and now affects 12.5 million school-age children and adolescents [1, 2]. Associated with this epidemic is the rising prevalence of metabolic syndrome among adolescents, particularly in obese teens (12.4 to 44.2%) [3]. The components of metabolic syndrome are typically described as a clustering of cardiometabolic risk factors that includes central adiposity, elevated blood pressure, dyslipidemia, and impaired glucose metabolism [4–6]. These derangements increase the risk for cardiovascular disease and type 2 diabetes [7], and weight loss through behavioral modification is the recommended first step in the prevention and treatment of metabolic syndrome [8].

A challenge in delivering behavioral modification interventions is that adolescents seek medical care infrequently [9]. School-based health centers (SBHCs) that provide health care services to students on school campuses offer an opportunity to reach adolescents at a location where they spend a significant portion of their day [10]. SBHCs are designed to focus on the uninsured and underserved, and providers work with a large segment of the adolescent population during a key stage of development characterized by increased individuation and autonomy. The role of SBHCs in the battle against obesity has not been well investigated. We explored the feasibility of Adolescents Committed to Improvement of Nutrition and Physical Activity (ACTION), a SBHC weight management intervention for overweight, and obese students that was created and tested with two urban high schools. We

Table 1: General content of clinician toolkit used as a "menu of options" during clinical encounters with participants.

DVD sections:
Adolescent motivation for change
Strategies targeting energy balance and nutritional quality
Physical aerobic dance and strength training
Print materials:
Weight loss guidelines for clinicians
Motivational interviewing for clinicians
Newsletter for caregivers
Clinic displays
Adolescent session tools (e.g., goal setting, internet resources, and activity/food journal)

hypothesized that overweight and obese students receiving ACTION would have a greater reduction in BMI percentile when compared with students receiving standard care.

2. Methods

2.1. Study Design. Two SBHCs were randomized to deliver either the intervention or standard care over the academic year of 2009-2010. This design was chosen to decrease contamination between the two groups. The SBHC clinician delivering the intervention was a family medicine nurse practitioner, and standard care was delivered by a family medicine physician.

2.2. Participants. Participants were recruited through classroom presentations made by the research team. Students were given study packets with health history survey and bilingual consent/assent forms which they reviewed and returned to the SBHCs. Pre- and posttest assessments were conducted at the SBHCs for all participants. The protocol was approved by the University of New Mexico (UNM) Human Research Protections Office and the Research, Development, and Accountability Department of both high schools.

Students were eligible to participate if they were in the 9th to 11th grades and had a BMI ≥85th percentile [11]. Exclusion criteria included BMI ≥40 kg/m^2, previous diagnosis of diabetes, blood pressure in the range of stage 2 hypertension [12], antipsychotic or corticosteroid medications, or if the adolescent was not ambulatory. Withdrawal conditions included anorexia nervosa, bulimia nervosa, psychosis, suicidal ideation, hospitalization, and pregnancy.

A total of 60 students and their caregivers were enrolled (Figure 1). 28 of 31 student-caregiver dyads at the intervention high school and 23 of 29 student-caregiver dyads at the control high school completed pre- and postmeasures.

2.3. Study Groups

2.3.1. Intervention Group. ACTION, based on the Transtheoretical Model [13], included three primary components: (1) clinical encounters with the SBHC clinician every two to three weeks for a total of eight visits over one academic year, (2) use of motivational interviewing (MI) [14, 15], and (3) obesity risk reduction strategies from a toolkit that was cocreated with a community advisory group made of overweight and obese adolescents and their parents. The toolkit included a DVD and print materials to provide a "menu of options" during clinical encounters (Table 1).

The intervention SBHC provider received a two-day training workshop in MI. To determine competency, three pilot MI sessions were audiotaped and reviewed by the trainers prior to starting the intervention. Audio recording of the clinical visits followed by coaching occurred four times throughout the intervention period to ensure fidelity.

At the first visit, participants randomized to ACTION received the DVD, a DVD player and a summary of medical results (BMI, blood pressure, fasting glucose, and lipids) along with American Academy of Pediatrics (AAP) obesity prevention/treatment recommendations [11]. The first visit was dedicated to reviewing pertinent personal and family history, physical exam and laboratory findings, and an assessment of dietary and physical activity behavior. Feedback was provided to the adolescent about their status relative to national recommendations, and the adolescent's readiness to change was elicited. Participants were asked to review the DVD and to follow-up in two to three weeks with topics they would like to discuss. Subsequent visits were individually tailored to the adolescent's stage of change with the intention of moving towards goal setting for healthier eating and physical activity.

Students brought home a newsletter to their caregivers that included obesity risk reduction strategies for the home. After each visit, telephone updates were given to the caregiver, during which the SBHC clinician used MI to encourage caregivers to adopt the risk reduction strategies.

2.3.2. Standard Care Group (SCG). The clinician was trained on the study protocol and procedural materials prior to initiating the trial. Participants in the SCG received one clinic visit at the beginning of the trial that was similar in content to the first visit of the intervention group except they were not given the DVD or DVD player. The AAP "Balance for a Healthy Life" booklet and medical results summary with AAP recommendations [11] were also provided to participants.

2.4. Data Collection and Measurements. Anthropometric, blood pressure, biochemical, and behavioral measures were obtained at baseline (September-October 2009) and after the completion of the intervention (April-May 2010) in both groups.

2.4.1. Anthropometric Measures. Anthropometric measures were conducted by a registered dietitian. Height and weight were measured twice without shoes and averaged for analysis. Weight was measured to the nearest 0.1 kg on a strain-gauge digital scale (Secca Model 770) and height was measured to the nearest millimeter using a Schorr vertical measuring board. BMI was calculated as kg/m^2. A CDC software program was used to calculate precise BMI percentiles based on

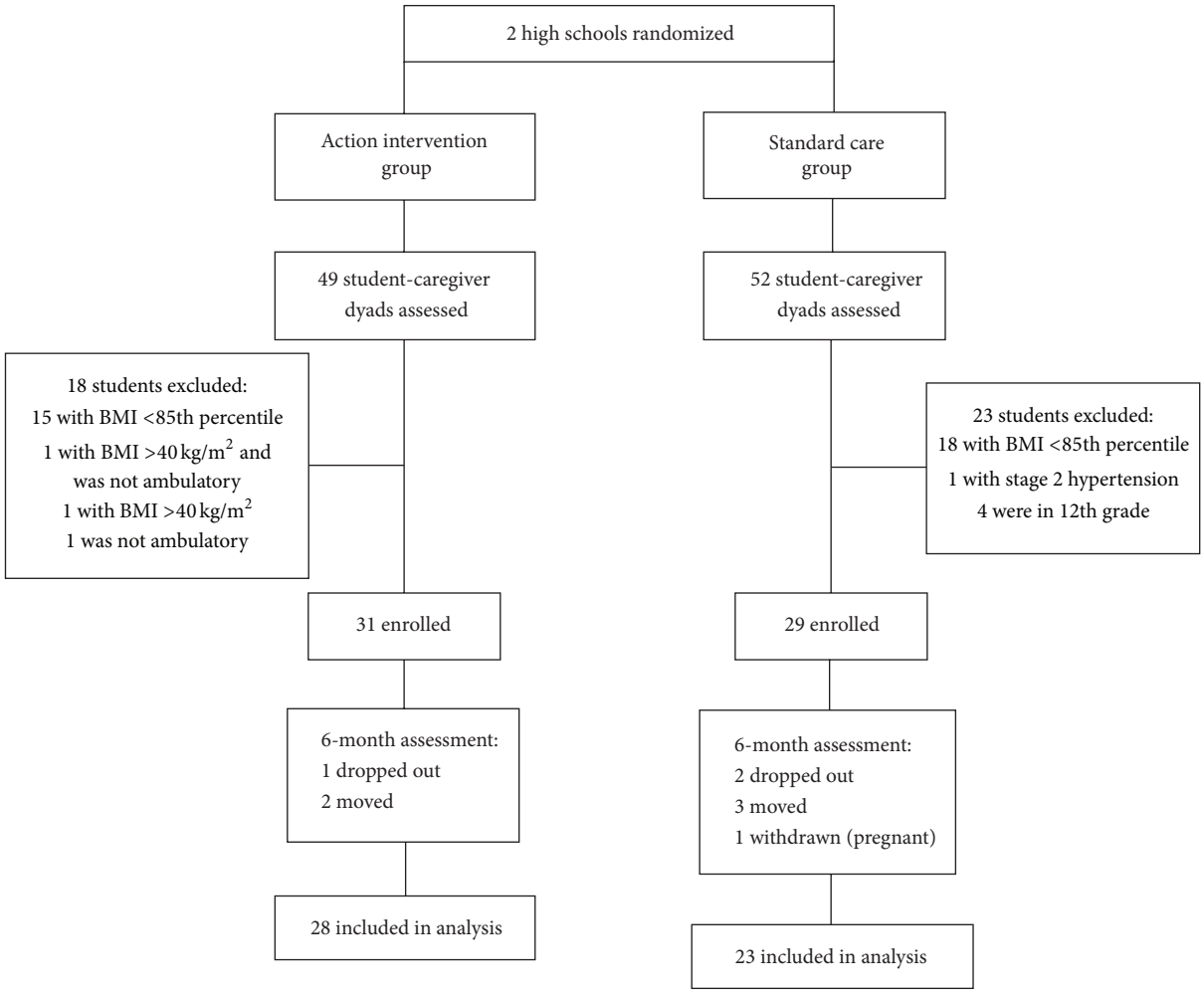

Figure 1: Diagram of randomization, enrollment, and attrition.

participants' height (cm), weight (kg), sex, and age (months) [16]. Waist circumference was measured twice to the nearest millimeter with a steel tape and averaged.

2.4.2. Blood Pressure. Three seated blood pressures (BPs) were measured in the right arm with a Welch Allen aneroid sphygmomanometer (Skaneateles Falls, NY, USA) by a research pediatric nurse after 5 minutes of sitting and 1 minute between each measurement. The second and third measurements were averaged. BP percentiles for gender, age, and height were determined according to established guidelines [12].

2.4.3. Biochemical Measures. Blood samples were drawn after a 10-hour overnight fast. Samples were allowed to clot at room temperature for 15 minutes and centrifuged for 10 minutes. The serum fraction was aliquoted and stored at −80°C. Glucose was determined using the ACE Glucose Reagent from Alfa Wassermann Diagnostic Technologies, LLC (West Caldwell, NJ, USA). Insulin was measured using the Immulite/Immulite 100 Insulin assay from Siemens Healthcare Diagnostics Products Ltd. (Llanberis, Gwynedd, UK). Insulin resistance was calculated using the homeostatic model assessment insulin resistance index [17, 18]. Triglyceride was measured using the ACE Triglycerides Reagent Kit from Alfa Wassermann Diagnostic Technologies, LLC, and HDL cholesterol was determined using the Vitros Slide Technology kit.

2.4.4. Behavioral Measures (Dietary, Physical Activity, and Television Viewing). Dietary intake was assessed using the Youth/Adolescent Questionnaire (YAQ), a food frequency questionnaire designed for children ages 9–18 years [19]. Physical activity was assessed using the 3-Day Physical Activity Recall (3-D PAR) instrument and the RT3 Triaxial Research Tracker accelerometer (Stayhealthy Inc., Monrovia, CA, USA). Detailed instructions for completing the 3 D PAR were given using a standardized script. The 3 D PAR has been validated in adolescents based on concurrent observation with motion sensors [20, 21]. Standard scoring procedures [22] were used to estimate the number of 30-minute blocks per day participants spent in moderate or vigorous physical activity. RT3 Triaxial accelerometers recorded the intensity, frequency, and duration of participants' physical activity [23].

Written and verbal instructions for proper use of the RT3 were given to participants using a standardized script. They were instructed to wear the accelerometer on the right hip, except when sleeping or involved in water activities. Participants were reminded daily by either text message or phone call to wear their accelerometers. After one week of wear, accelerometer data were downloaded to a computer using a docking station provided with the RT3. Triaxial activity was captured as counts per minute, which represents the frequency and amplitude of acceleration events occurring over each minute of wear. Activity count data was converted to measures of physical activity intensity (metabolic equivalents or METs) using the RT3 proprietary equation. Moderate or vigorous physical activities were defined as ≥3 METs. Minimal wear requirement for a valid day was 10 hours, and four valid days of data per measurement wave were required to be included in the analysis.Television viewing time for each day of the week was recorded from an 11-item Television and Video Measure used in the Planet Health school-based intervention study [24]. Hours were appropriately weighted and summed to obtain a total hours-per-day viewing estimate.

2.4.5. Process Measures. Process evaluation was conducted to monitor how well the study was implemented. In addition to monitoring the fidelity of MI used by the intervention clinician, participant attendance, length of clinic visit, and participant satisfaction were collected in both groups. In the intervention group, phone contacts with caregivers were tracked.

2.5. Data Analysis. Determination of sample size was based on previous reports of short-term weight loss interventions [25]. Twenty-one participants per group were estimated to have sufficient power (>0.80) with a significance level of 0.05 to detect a large effect size (Cohen's $d = .84$) between the two groups with respect to BMI changes [26]. We accounted for a 20% attrition rate and set to recruit 26 students per group.

Baseline equivalence of conditions across demographics, BMI, and other outcome variables of interest were assessed with t-tests or Wilcoxon rank sum test on continuous items and χ^2 tests or Fisher's exact test on discrete items. Pre-post changes in BMI and other variables were compared between groups using two-sample t-tests for normally distributed data and Wilcoxon rank sum tests for skewed distributions using SAS (Cary, NC, USA). Analysis included participants who completed pre- and postassessments regardless of the number of clinical visits attended.

3. Results

3.1. Participants. There were no significant differences by group on demographic variables (Table 2) or baseline anthropometric measures (Table 3). The mean age of students in the intervention group was 15 ± 1 year compared to 14.6 ± 0.7 year for the SCG. The majority of the students were Hispanic and females. Reported family history of type 2 diabetes among first or second degree relatives was 52% and hyperlipidemia 43%. Enrolled caregivers were primarily mothers (70%) and were Hispanic with 41% having less than a high school graduate level education. Using the definition from the National Heart, Lung, and Blood Institute [27], six percent of enrolled students met criteria for metabolic syndrome defined as having three or more of the following: systolic ≥130 mmHg or diastolic ≥85 mmHg, fasting glucose ≥100 mg/dL, large waist circumference (male ≥102 cm, female ≥88 cm), low HDL cholesterol (male <40 mg/dL, female <50 mg/dL), or triglycerides ≥150 mg/dL. Forty-three percent had one component and ten percent had two components of the metabolic syndrome. Most of the students were in the action or maintenance stage of change.

3.2. Process Evaluation. 93% of students completed all eight clinical visits in the intervention group. Sessions averaged 47 minutes for the first session and 24 minutes for subsequent sessions. Student satisfaction scores averaged 4.4 for the intervention (0 = not satisfied, 5 = very satisfied).

88% of caregivers completed the feedback survey with an overall satisfaction mean score of 4.4 (0 = not satisfied, 5 = very satisfied). Caregivers of twenty-four children (86%) spoke at least one time with the SBHC clinician.

The SBHC clinician delivered an average of 7.9 clinical sessions per participant and made phone contact with caregivers for an average of 41% of the time. Two of the four recorded encounters did not meet MI proficiency (Sessions 3 and 5) while the latter two did meet proficiency (Sessions 6 and 8).

In the SCG, 100% of the students met with the SBHC clinician. Sessions averaged for 28 minutes. Students rated an average satisfaction score of 4.2 (0 = not satisfied, 5 = very satisfied).

3.3. Anthropometric Outcomes. The height and weight of students in both groups increased from baseline to postintervention in these growing teenagers (Table 4). There were no between-group differences in students' height and weight. After converting height and weight to a BMI percentile for age and sex, a median decrease of 0.3% was observed in the intervention group. The SCG's BMI median percentile increased by 0.2% leading to a significant between-group difference of −0.6% ($P = 0.04$). The mean waist circumference in the intervention group remained unchanged and increased by 1.7 cm in the SCG, resulting in a significant between-group difference of −1.7 cm ($P = 0.04$).

3.4. Behavioral Outcomes. Television viewing was significantly reduced during weekdays in the intervention group by −0.4 hours/day, while the viewing time increased in the control group (0.2 hours/day) (Table 4). The median difference between the two groups was −0.7 hours/day ($P = 0.03$).

Physical activity as measured by the 3DPAR and RT3 accelerometer revealed no significant between-group differences. No between-group differences in total caloric intake, sweetened beverage consumption, and fruits and vegetable intake were observed (Table 4).

Table 2: Characteristics of the ACTION and standard care groups at baseline.

Characteristics	ACTION $N = 28$ N (%)	Standard care $N = 23$ N (%)	P value
Race/ethnicity			
Asian	4 (14%)	1 (4%)	0.10
Hispanic	21 (75%)	14 (61%)	
Native American	0 (0%)	3 (13%)	
Multiple	3 (11%)	5 (22%)	
Sex			
Female	17 (61%)	13 (57%)	0.78
Male	11 (39%)	10 (43%)	
Family history of diabetes			
No	9 (32%)	12 (52%)	0.43
Yes	17 (61%)	10 (43%)	
Don't know	2 (7%)	1 (4%)	
Family history hyperlipidemia			
No	9 (32%)	9 (39%)	0.88
Yes	12 (43%)	10 (43%)	
Don't know	7 (25%)	4 (17%)	
Caregiver years of education			
0–6	3 (11%)	2 (9%)	0.99
7–11	8 (29%)	8 (35%)	
12 (high school graduate)	6 (21%)	5 (22%)	
13–15	7 (25%)	6 (26%)	
16 or more	4 (14%)	2 (9%)	
Caregiver preferred language			
Spanish	10 (36%)	10 (43%)	0.11
English	13 (46%)	12 (52%)	
English and Spanish	5 (18%)	0 (0%)	
English and other	0 (0%)	1 (4%)	
Metabolic syndrome components[a]			
Large waist circumference (Men: ≥102 cm; Women: ≥88 cm)	2 (7%)	3 (13%)	0.65
High blood pressure (Systolic ≥130 and/or diastolic ≥85 mm Hg)	0 (0%)	0 (0%)	—
Low HDL cholesterol (Men: <40 mg/dL; Women: <50 mg/dL)	5 (18%)	6 (26%)	0.51
Elevated triglycerides (≥150 mg/dL)	8 (29%)	6 (26%)	1.00
Elevated fasting blood glucose (≥100 mg/dL)	0 (0%)	0 (0%)	—
Stages of change			
Precontemplation	0 (0%)	3 (13%)	0.22
Contemplation	4 (14%)	1 (4%)	
Action	16 (57%)	13 (57%)	
Maintenance	8 (29%)	6 (26%)	

[a]Defined by the National Heart, Lung, and Blood Institute.

Table 3: Anthropometric measurements of ACTION and standard care groups at baseline.

Characteristics	ACTION $N = 28$ Mean (SD)	Standard care $N = 23$ Mean (SD)	P value
Height (cm)	164.4 (8.1)	163.1 (10.9)	0.64
Weight (kg)	78.5 (12.5)	78.1 (18.1)	0.92
BMI percentile	94.5 (4.1)	94.4 (4.6)	0.94
Waist circumference (cm)	89.9 (8.5)	89.9 (9.1)	1.00

3.5. Biochemical and Blood Pressure Outcomes. Fasting glucose increased in both groups, but the increase was smaller in the SCG (Table 5). No other significant between-group differences in changes were seen in triglycerides, HDL-cholesterol, fasting insulin, HOMA-IR, and blood pressure.

4. Discussion

Obesity, especially central adiposity, is a critical contributor to the development of metabolic syndrome. High school students participating in the SBHC weight management program, ACTION, had significantly better results in BMI percentile and waist circumference compared to students receiving standard care. Waist circumference of these overweight and obese students in ACTION remained unchanged, but students in the SCG experienced an increased waist circumference over the six months. These findings are promising in light of the general challenge of weight management in adolescents and the high prevalence of type 2 diabetes (52%) and dyslipidemia (43%) in the family history of these youths, with six percent of the student participants already meeting criteria for metabolic syndrome and 43% manifesting at least one component.

Reduced television viewing is a modifiable behavior that has been demonstrated to be associated with preventing obesity and lowering BMI [28, 29]. Students in ACTION reported reduced television viewing during weekdays compared to the standard care group. In the current study, reduction of television viewing was the only behavior that showed a significant improvement and may have contributed to the decrease in BMI percentile.

Hours of contact have been calculated to represent treatment intensity in obesity behavioral trials [30]. ACTION would be categorized as a very low- (<10 hours) intensity intervention. The finding of an improved BMI percentile is consistent with two other low-intensity primary care intervention trials that reported short-term outcomes and included adolescents [25, 31]. The study by Saelens and coworkers used a computer program to assess lifestyle habits and incorporated physician counseling and interaction with a behavioral specialist to learn food self-monitoring [25]. Participants were followed by telephone counselors weekly for the first eight calls and then biweekly for the last three calls, combined with three mailings designed to help adolescents acquire behavioral skills for weight control. Similar to our findings, Saelens and colleagues reported an increase in BMI among controls compared with the slight decrease of BMI among intervention participants. While their study relieves the primary care provider of some of the burden of conducting the intervention, it is not possible to determine if using behavioral specialists and telephone counselors is widely applicable to settings with limited resources such as SBHCs. Our study, however, uses the primary care provider at the SBHC to deliver all of the intervention and therefore should be generalizable to other similar clinical settings or SBHCs.

Evidence indicates that primary care behavioral intervention trials of moderate to high intensity (>25 hours) which included adolescent participants consistently show a more beneficial effect on BMI than low-intensity interventions [32–35]. However, these interventions include components that require meetings with the physician, group meetings with a behavior specialist, regular meetings with a dietician, and/or weekly supervised exercise episodes that may not be possible in "real-world" settings. High attrition from such studies is also problematic [32, 33]. While our study demonstrated modest improvement in BMI percentile when compared to moderate- and high-intensity interventions, the potential to increase the length of the intervention over students' four year high school experience is possible and may reveal greater improvements in BMI. Additionally, because SBHCs are located on school grounds, access is more convenient than off-site primary care clinics.

Minority status and poverty have been shown to contribute to obesity among youth because of long parental work hours [36] and a built environment that lacks access to physical activity and healthy food choices [37, 38]. Our study using SBHCs with schools serving a primarily Hispanic population has broader public health implications. Given that there are over 1,900 SBHCs in the US [39], mostly located in low-income minority communities, SBHCs may provide a focal point for efforts to intervene with overweight and obese youth. Our study provides preliminary evidence for the acceptability and short-term efficacy of such an approach for weight management.

One limitation of our study is the small sample size and therefore results may not be generalizable. Another limitation is the short duration of followup in this trial. While it is important to evaluate long-term efficacy of this intervention, our primary objective was to ensure the feasibility and acceptability of our SBHC approach before launching a larger and longer trial.

5. Conclusions

In the first known study to evaluate the feasibility of conducting a weight management program through SBHCs, we demonstrated that a primary care clinician can be taught to use motivational interviewing and that the approach received high satisfaction scores from both the caregivers and student participants. Our findings may help to reduce obesity and prevent metabolic syndrome among adolescents who typically have limited access to preventive care [9, 40]. In minority populations where obesity, metabolic syndrome,

Table 4: Comparison of anthropometric and behavioral changes between ACTION and standard care groups.

Measures	ACTION group $N = 28$ Mean (95% CI)	Standard care group $N = 23$ Mean (95% CI)	Between-group difference Mean (95% CI)	P value
Height (cm)				
Pre	164.4 (161.2, 167.5)	163.1 (158.4, 167.8)		
Post	165.0 (161.7, 168.2)	164.1 (159.1, 169.0)		
Difference	0.6 (0.0, 1.2)	1.0 (0.3, 1,6)	−0.4 (−1.2, 0.5)	0.31
Weight (kg)				
Pre	78.5 (73.7, 83.4)	78.1 (70.3, 85.9)		
Post	80.2 (74.9, 85.6)	80.6 (72.5, 88.8)		
Difference	1.7 (0.2, 3.2)	2.5 (0.8, 4.3)	−0.8 (−3.1, 1.4)	0.12
BMI percentile[d]				
Pre	97.0 (92.8, 97.4)	96.2 (91.6, 97.8)		
Post	96.3 (92.1, 97.4)	96.1 (91.9, 98.5)		
Difference	−0.3 (−0.6, 0.3)	0.2 (−0.1, 0.8)	−0.6 (−1.2, 0.1)	0.04
Waist circumference (cm)				
Pre	89.9 (86.6, 93.2)	89.9 (84.9, 94.8)		
Post	89.9 (86.3, 93.4)	91.5 (86.5, 96.5)		
Difference	0.0 (−1.4, 1.4)	1.7 (0.4, 2.9)	−1.7 (−3.6, 0.2)	0.04
YAQ[a] calories/day				
Pre	1916 (1807, 2225)	2270 (1852, 2687)		
Post	2086 (1700, 2473)	2017 (1642, 2392)		
Difference	170 (−300, 641)	−252 (−729, 224)	422 (−239, 1084)	0.21
YAQ[a] sweetened drinks (glasses/day)[d]				
Pre	0.76 (0.34, 1.08)	0.58 (0.30, 0.79)		
Post	0.19 (0.15, .44)	0.43 (0.16, 0.59)		
Difference	−0.12 (−0.47, −0.08)	−0.16 (−0.57, 0.22)	−0.08 (−0.57, 0.41)	0.23
YAQ[a] fruits and vegetables (servings/day)[d]				
Pre	2.81 (2.06, 4.36)	1.91 (1.70, 3.52)		
Post	2.48 (2.04, 3.44)	1.71 (1.46, 2.12)		
Difference	−0.22 (−0.72, 0.41)	−1.16 (−0.56, −0.02)	0.42 (−0.32, 1.26)	0.47
MVPA[b] by 3DPAR[c] (30 minute blocks/day)[d]	$N = 27$	$N = 20$		
Pre	1.4 (0.7, 3.7)	2.0 (1.0, 3.3)		
Post	1.7 (0.7, 3.3)	1.0 (0.0, 4.0)		
Difference	0.0 (−2.0, 0.7)	−0.9 (−1.3, 0.4)	0.6 (−1.6, 2.0)	0.63
MVPA[b] by accelerometer (mins/day)	$N = 14$	$N = 8$		
Pre	49.4 (37.7, 61.2)	64.7 (41.8, 87.6)		
Post	65.9 (47.6, 84.2)	57.6 (39.9, 75.4)		
Difference	16.5 (−2.8, 35.8)	−7.1 (−22.9, 8.7)	23.6 (−3.4, 50.5)	0.08
Television weekday viewing (hours/day)[d]				
Pre	1.8 (1.0, 2.4)	1.6 (1.4, 2.2)		
Post	1.0 (0.6, 1.4)	1.8 (1.1, 2.4)		
Difference	−0.4 (−1.0, 0.2)	0.2 (−0.3, 0.6)	−0.7 (−1.6, 0.0)	0.03
Television weekend viewing (hours/day)[d]				
Pre	1.9 (1.5, 3.0)	2.2 (1.5, 5.5)		
Post	1.6 (0.8, 3.0)	3.0 (2.2, 3.0)		
Difference	−0.1 (−0.8, 0.0)	0.5 (−2.0, 1.5)	−0.6 (−1.9, 1.3)	0.17

[a]YAQ: Youth Adolescent Questionnaire food frequency survey.
[b]MVPA: moderate or vigorous physical activity.
[c]3DPAR: 3-Day Physical Activity Recall.
[d]Results are reported as median (95% CI). Wilcoxon rank sum test was used for P value and bootstrap procedure was used for confidence intervals.

Table 5: Comparison of biochemical measures between ACTION and standard care groups.

Measures	ACTION group $N = 28$ Mean (95% CI)	Standard care group $N = 23$ Mean (95% CI)	Between-group difference Mean (95% CI)	P value
HDL-C (mmol/L)				
Pre	1.07 (0.98, 1.16)	1.06 (0.97, 1.16)		
Post	1.07 (0.98, 1.17)	1.03 (0.9, 1.13)		
Difference	0.0 (−0.09, 0.09)	−0.04 (−0.09, 0.02)	0.04 (−0.07, 0.14)	0.50
Triglycerides (mmol/L)				
Pre	1.4 (1.2, 1.7)	1.3 (1.0, 1.5)		
Post	1.5 (1.1, 1.9)	1.4 (1.1, 1.6)		
Difference	0.1 (−0.3, 0.4)	0.1 (−0.1, 0.3)	0.0 (−0.4, 0.4)	0.95
Fasting glucose (mmol/L)				
Pre	4.5 (4.4, 4.7)	4.7 (4.6, 4.8)		
Post	4.8 (4.7, 4.9)	4.8 (4.6, 4.9)		
Difference	0.3 (0.1, 0.4)	0.1 (−0.1, 0.2)	0.2 (0.03, 0.4)	0.04
Fasting insulin (pmol/L)[d]				
Pre	93.4 (69.4, 134.0)	96.5 (67.4, 112.5)		
Post	85.1 (67.4, 112.5)	83.3 (67.4, 120.1)		
Difference	−10.1 (−23.8, 34.4)	1.4 (−19.4, 25.0)	−5.7 (−39.6, 40.3)	0.59
HOMA-IR[a,d]				
Pre	2.6 (1.9, 3.9)	3.1 (2.1, 4.1)		
Post	2.5 (2.0, 3.6)	2.5 (2.0, 3.6)		
Difference	0.0 (−0.6, 1.1)	0.7 (−0.7, 2.1)	−0.1 (−0.6, 0.9)	1.00

[a] HOMA-IR: homeostatic model assessment insulin resistance index.
[d] Results are reported as median (95% CI). Wilcoxon rank sum test was used for P value and bootstrap procedure was used for confidence intervals.

and type 2 diabetes are disproportionately high, SBHCs warrant further research as venues to help adolescents decrease the risk of developing complications of obesity in adulthood.

Abbreviations

SBHC: School-based health center
ACTION: Adolescents Committed to Improvement of Nutrition and Physical Activity
SCG: Standard care group
MI: Motivational interviewing
YAQ: Youth Adolescent Questionnaire
MVPA: Moderate or vigorous physical activity
METs: Metabolic equivalents.

Disclosure

The authors have indicated they have no financial relationships relevant to this paper to disclose.

Conflict of Interests

The authors have indicated that they have no conflict of interest relevant to this paper to disclose.

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This trial has been registered at http://www.clinicaltrial.gov/ (identifier NCT00841334).

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Research Article

Body Image Dissatisfaction Is Increased in Male and Overweight/Obese Adolescents in Botswana

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Introduction. The purpose of this study was to examine linkages between obesity, physical activity, and body image dissatisfaction, with consideration of socioeconomic status (SES) and urbanization in adolescents in Botswana. *Materials and Methods*. A nationally representative, cross-sectional survey in 707 secondary school students included measured height and weight to determine overweight (OW) or obesity (OB) using World Health Organization standards; physical activity (PA) using the International Physical Activity Questionnaire; and body image satisfaction using the Body Ideals Questionnaire. SES was described by private school versus public school attendance. *Results and Discussion*. OW/OB students felt farther from ideal and greater dissatisfaction with their weight and body proportions than optimal weight students. Boys felt greater difference from ideal and more dissatisfaction with muscle tone, chest size, and strength than girls. Lower SES students and those from rural villages had more minutes of PA than higher SES or urban students. In this rapidly developing African country, these trends reflect the nutrition transition and offer opportunity to motivate OW/OB students and boys for PA as a health promotion obesity prevention behavior. *Conclusions*. As urbanization and improved SES are desirable and likely to continue, the public health system will be challenged to prevent obesity while preserving a healthy body image.

1. Introduction

Developing countries undergoing economic transition are grappling with the phenomenon of nutrition transition, characterized by a shift from under-nutrition to overweight (OW) and obesity (OB), or their coexistence [1]. Given that OB is a risk factor for metabolic syndrome, diabetes, hypertension, and other cardiovascular diseases, its growing prevalence in developing countries leads to more complex problems for their health systems that remain overburdened by infectious disease.

OW and OB are associated with body-image dissatisfaction and low self-esteem [2]. In adolescents from 24 countries and regions across Europe and North America, 43%–51% of those surveyed were dissatisfied with their body weight [2]. Although this pattern was thought to occur predominantly in western culture, it is increasingly affecting developing countries [3, 4]. Dieting and physical activity behaviors for weight management, and a preference for thinness, are increasingly prominent across the globe, especially among women and adolescent girls. Unfortunately, there has been little research on body image dissatisfaction in African populations, though diet and exercise behaviors found in western populations may also exist there.

Cash and Szymanski [5] defined body image as a "multifaceted psychological construct that includes subjective

attitudinal and perceptual experiences about one's body, particularly its appearance." Body image concerns an individual's perceptions, thoughts, and feelings about one's body across dimensions of body size, attractiveness, and body. The construct of body image is based on the self-discrepancy theory [6], a conceptualization that seeks to explain negative emotions experienced by individuals who hold two conflicting beliefs about themselves. One belief is based on how one actually sees his or her self, considered to be the "actual self," and the other is based on attributes as judged by others considered to be the "ideal self." When the two selves do not match, there is a discrepancy with the resultant effect of negative emotions or dissatisfaction. The self-discrepancy theory has been widely used to conceptualize body image dissatisfaction, to develop assessment instruments, and to demonstrate various facets of the construct [5, 7].

Body image may be linked with socioeconomic status (SES) and urbanization. In a cross-cultural study comparing body image perception among women from 26 countries in 10 regions across the globe, ideal body weight was reported to be slimmer in contexts of high compared to low SES, in more westernized societies and among individuals exposed to idealized body image by the media [4]. Among Malaysian and South African participants, rural participants in both countries reported significantly higher actual and ideal body ratings, as well as lower body dissatisfaction. In fact, thinness may be negatively perceived as a sign of ill health, especially among individuals from low SES, while a heavier body is culturally perceived as a sign of health, beauty, prestige, and prosperity [4, 8, 9]. However, in developed countries, body dissatisfaction has been suggested as a protection against excessive weight gain and binge eating behaviors [10, 11]. These conflicting findings suggest the need for more investigations into body image dissatisfaction and how it relates to OW/OB and other factors such as physical activity (PA) and general self-esteem.

Urbanization has been associated with reduced PA [12]. Higher body dissatisfaction and pressure to lose weight have been linked to a lack of motivation for PA among adolescents with higher BMI [13]. Girls experiencing higher body dissatisfaction and criticism about their weight are less likely to engage in vigorous PA, compared to those who faced criticism without body dissatisfaction [14]. These findings indicate the possible impact of higher body dissatisfaction and/or pressure to lose weight on the likelihood to engage in PA. Given that physical inactivity is a risk factor for OW/OB, attention has to be paid to understanding the possible reciprocal relationship between body image dissatisfaction, weight status, and PA. Such an understanding, especially with adolescents, will be critical to the developing of appropriate, multifaceted, and long-term obesity intervention strategies.

Like many developing countries, Botswana is undergoing the nutrition transition with a rapid increase in the prevalence of OW/OB in adolescents. Our group has demonstrated adolescent OW and OB prevalence of 12% and 5%, respectively, with much higher levels in urban areas (17% and 9%, resp.) compared with rural areas (5% and 0%, resp.) [15], and that school personnel are very concerned about the issue in students [16]. We have also shown that adolescents in Botswana are influenced by teachers, coaches, and parents to participate in PA, especially competitive sports [17]. However, interventions to prevent obesity among children and adolescents in Botswana are lacking. Furthermore, the prevalence of body dissatisfaction and how it may vary by gender, PA, SES, or urbanization has not been reported. Thus, the purpose of this study was to examine whether OB or PA predict body image dissatisfaction in adolescent students in Botswana and to determine whether age, gender, SES, and level of urbanization modify the likelihood of body image dissatisfaction.

2. Materials and Methods

The study protocol was approved by the Institutional Review Board at the University of Pennsylvania and the Ministry of Education in Botswana. All the students approached for participation were given IRB-approved parental consent forms written in English and Setswana to be returned to the school if consent was granted. All participating students also had to give assent.

The study had a two-stage stratified sampling process to select participating schools with the aim to include both urbanization and SES representation. We followed the designation of the Botswana Housing Census in assigning levels of urbanization. In Botswana, localities are largely classified by levels of urban infrastructure and population density (Botswana CSO Housing Census 2001). Cities have the highest levels of urbanization and population density of 80,000–200,000 people. Towns have similar infrastructure to cities, but the population is 15,000–50,000. Urban villages have more traditional infrastructure and similar population to towns. Rural villages maintain the most traditional infrastructure and have populations <5,000 people.

In developing countries such as Botswana, individual SES varies both by income levels and by the level of infrastructure development within one's area of residence. Public schools do not require payment of tuition and represent a mixture of SES circumstances with a significant representation of lower SES, while private schools require payment of tuition fees that are generally out of reach for lower SES families. However, in rural villages, private schools are not typically available. The physical infrastructure that provides electricity and running water directly into family residences may be more limited in rural villages as well as in impoverished sections of cities, towns, and urban villages than in wealthier areas.

The first stage of the sampling process involved random selection of districts on the basis of the Botswana educational statistics at the time of the survey [18], and the second stage involved random selection of schools within these districts. From the 274 total secondary schools in Botswana, 17 secondary schools were randomly selected to represent urbanization: seven from cities, four from towns, three from urban, and three from rural villages. Of the 17 schools sampled, 12 were public and 5 were private schools, to represent lower and higher SES. Within each school selected, a convenience sample of approximately 50 students was enrolled.

Data were collected by two research assistants who were trained on questionnaire administration and protocol-based collection of anthropometric data by expert researchers at the University of Botswana.

Anthropometric interassessor reliability was assessed by measuring 20 randomly sampled volunteers of the target population as part of pilot testing from a school that did not participate in the final data collection and comparing the results to those of the expert anthropometrists. Of the variables reported in this paper, certification was granted when measurements were within ±0.3 cm for height. Anthropometric equipment was checked and calibrated before every assessment session. All data collection sessions at schools were supervised by faculty researchers from the University of Botswana to ensure continuous quality and reproducibility.

All data collection sessions were conducted in a semiprivate section of the classroom or school cafeteria to ensure privacy regarding physiological measures. Body weight was measured to the nearest 0.1 kg in light clothing on a digital scale (Tanita, Tokyo, Japan). Height was measured without shoes using a stadiometer (Seca, Hamburg, Germany).

BMI was calculated as weight (kg)/height (m^2) and evaluated against World Health Organization (WHO) norms for age and gender using AnthroPlus software (Geneva, Switzerland: World Health Organization, 2009) to determine adolescent weight status: underweight, desirable weight, overweight, and obese. We confirmed the OW and OB classifications using the International Obesity Taskforce cut-offs [19].

Participants completed a demographic survey that included gender, age, and SES variables. SES was evaluated by attendance at a tuition-free public (low SES) or tuition-requiring private (high SES) school and by self-reported responses of household assets (television, refrigerator, electricity, water, and toilet). We coded 3–5 assets as high SES and 0–2 assets as low SES.

Body image satisfaction was assessed using the Body-Image Ideals Questionnaire (BIQ) with permission of the author [5]. The BIQ requires respondents to evaluate how different their ideal body is from their perceived actual body, and how important it is for them to attain the perceived ideal body. The questionnaire uses a 4-point Likert scale to assess each of 11 physical attributes (facial features, hair texture and thickness, skin complexion, height, muscle tone and definition, body proportion, weight, chest size, physical strength, physical coordination, and overall appearance). The range for composite BIQ score is from −3 (very important congruence across all physical attributes) to +9 (very important and maximum discrepancies across all physical attributes). Thus, higher BIQ scores indicate higher body image dissatisfaction.

Physical activity was measured using the International Physical Activity Questionnaire—Short Form (IPAQ), which characterizes PA based on days and hours spent per day on activities classified as "walking," "moderate activity," and "vigorous activity" [20]. Based on IPAQ scoring guidelines, data for walking, moderate, and vigorous time variables exceeding 3 hours per day were truncated to reflect maximal daily activity levels of 3 hours per day for each PA category. Sedentary behavior was represented by the total minutes per week spent sitting from the IPAQ.

The sample size was calculated using the population survey approach in STATCALC (EpiInfo, 2002, CDC, Atlanta, GA, USA). Because the actual prevalence of OW and OB was unknown, the prevalence was estimated at the high rate of 50%. To have 90% power to detect a significant difference at $P < 0.05$, the calculated sample size was 661. Taking into account a nonresponse rate of 10% observed in our prior research there, the target recruitment was 728 adolescents. In total, 754 students enrolled in the study.

Measures of central tendency are reported as mean (SD) or number (%). Differences in minutes of PA and BIQ difference from ideal and dissatisfaction were compared across gender, SES, urbanization, and BMI groups using unpaired t-tests or ANOVA. To test whether body image dissatisfaction varies with physical activity levels or BMI group, separate linear regression models predicting composite BIQ score were used. Next, the models were adjusted for age, gender, SES, and level of urbanization. For all comparative analyses and statistical models, because urban villages and towns represent similar levels of economic development and because there were no statistical differences between, these groups in BIQ scores, these groups were combined. Likewise, because of low rates of OW and OB in rural areas, these groups were combined to increase sample size for statistical analyses. Data were analyzed using STATA statistical software version 11 (StataCorp LP, College Station, TX, USA, 2000) and SPSS version 19 (IBM Statistics, Chicago, IL, USA). Because of the multiple comparisons, statistical significance for all analyses was set at $P < 0.01$.

3. Results

A total of 857 students were approached to participate, of whom 754 returned parental consent forms and gave student assent, a response rate of 88%. A summary of demographic information is provided in Table 1. The mean age of students was 14.9 years, and 61% were girls. The low SES variables included 30% with low household assets and 69% attending public schools, while 70% had high assets and 31% attended private schools. The representation of students within the urbanization groups was rural villages (24%), urban villages (24%), towns (20%), and cities (32%). For BMI groups, 5% were underweight, 78% were desirable weight, 12% were overweight, and were 5% obese. The mean total physical activity reported was 695 minutes/week (1.7 hours/day), by contrast to 2612 minutes/week (6.2 hours/day) spent sitting. The duration of PA was examined across gender, SES, urbanization, and BMI groups (Table 2). There were no significant differences in any level of PA in boys versus girls or in the BMI groups (data not shown). Public school students (lower SES) had significantly more minutes of sitting, vigorous PA, and total PA than students at private schools (all $P < 0.01$). Students living in rural villages reported more minutes/week of sitting than students from cities. While minutes of walking were not significantly different by urbanization group, students from rural villages had more minutes of moderate PA,

Table 1: Demographic information.

Variable	Mean (SD) or N (%)
Age (years)	14.91 (1.32)
Female/male	464 (61.4%)/292 (38.6%)
Socioeconomic status	
Public/private school	523 (68.8%)/237 (31.2%)
Household assets (low/high)	225 (30.4%)/515 (69.6%)
Urbanization of residence	
Rural village	184 (24.2%)
Town	148 (19.8%)
Urban village	182 (23.9%)
City	246 (32.4%)
BMI group	
Underweight	35 (5%)
Desirable weight	554 (78.4%)
Overweight	82 (11.6%)
Obese	36 (5.1%)
Physical activity (minutes/week)	
Sitting	2612.38 (910.87)
Walking	287.94 (297.89)
Moderate PA	188.96 (267.79)
Vigorous PA	219.59 (275.89)
Total PA	695.45 (568.82)
Composite BIQ score	1.53 (2.06)

vigorous PA, and total PA than students from towns/urban villages or cities.

The composite BIQ score was 1.53 (SD 2.06) (Table 1). The BIQ variables did not differ significantly by SES group (data not shown). However, significant differences in students' perception of their own features relative to ideal and of how dissatisfied they were with these features are reported by gender, urbanization group, and BMI group in Table 3. Boys reported greater difference from and dissatisfaction with their ideal muscle tone, chest size, and strength, relative to girls ($P < 0.01$). Students from towns/urban villages indicated greater difference from their ideal body proportions and overall appearance (both $P < 0.01$) than adolescents from cities; however, their level of dissatisfaction with these two factors did not reach statistical significance. OW/OB students reported greater difference from ($P < 0.01$) and dissatisfaction with ($P < 0.001$) ideal body weight and proportions than optimal weight students. In regression analyses, none of the potential predictor variables (total PA, BMI group, age, gender, school type, and urbanization), separately or in combination, predicted composite BIQ score (data not shown).

4. Discussion

Our purpose was to examine whether OB or PA predict body image dissatisfaction in adolescent students in Botswana and to determine whether age, gender, SES, and level of urbanization modify the likelihood of body image dissatisfaction. We found boys were more dissatisfied with their muscle tone, strength, and general appearance than girls. Students from higher SES and more urbanized areas had less vigorous and total PA, and OW/OB students perceived their proportions and body weight as farther from the ideal and expressed greater dissatisfaction with these attributes than optimal weight students. Understanding the relationship between OW and OB, PA and body image satisfaction is important for intervention designs because perception about one's self-image affects motivation for physical activity [17, 21].

These findings describe significant linkages between urbanization and reduced PA that are most likely associated with increased vehicular transport and/or reduced personal safety of students in an urban environment [22]. The lower PA reported by students from higher SES private school backgrounds suggests that increasing family wealth may play a role in access to motorized transportation or required indoor activity as parents are working outside the home. This is particularly ironic since PA is compulsory in private schools but only optional in public lower SES schools in Botswana. Since data from this same sample have also described increased OW/OB among urbanized and higher SES children [15] and increased intake of snack foods and fewer traditional Botswana meals in cities [23], this series of findings is consistent with the nutrition transition and bodes a public health challenge as urbanization is likely to continue.

Our findings are in concert with some other studies. In adolescent girls in Britain, a strong association between body dissatisfaction and body fatness was reported, but no association between body dissatisfaction and PA [21]. In South Asian children, perceived body size was positively related to weight status, and OW/OB youths were more likely to select a thinner ideal body size than healthy weight children [24]. A study of motivation for physical activity in the UK found that adolescent boys with higher body satisfaction were more likely to maintain leisure-time PA, whereas dropping out of physical exercise and a reduced likelihood of taking up exercise were predicted by higher BMI and pressure to lose weight [13]. The cross-sectional nature of our study does not enable us to make this comparison in terms of change in or maintenance of PA. Any disconnect between PA and body image satisfaction may impact the effectiveness of PA interventions due to lack of motivation, as it has been argued that adolescent body image perceptions have an effect on their motivation for physical activity [17, 21].

A recent study in Taiwan found that adolescent girls were more likely to be dissatisfied with their body and their physical appearance than boys, and that higher BMI was associated with greater body dissatisfaction [3]. In this survey in Botswana, higher BMI was associated with more dissatisfaction with body proportions and weight, but girls were not more dissatisfied than boys, even though they had a greater prevalence of OW [15]. Another study found that girls experiencing higher body dissatisfaction and criticism about their weight were less likely to engage in vigorous PA, compared to those who faced criticism without body dissatisfaction [14]. We did not ask about criticism experienced by girls in this study; however, their PA was not different from boys, nor was the composite BIQ score.

Table 2: Physical activity by socioeconomic status and urbanization.

Physical activity (min/week)	Socioeconomic status		Urbanization		
	Public school	Private school	City	Town/urban village	Rural village
Sitting	2705.1 (863.8)	2446.9 (996.9)**	2325.7 (1044.8)	2772.1 (880.4)	2758.1 (691.9)*** versus city
Walking	297.7 (308.3)	265.7 (274.2)	284.6 (302.6)	292.8 (296.9)	283.6 (298.4)
Moderate PA	207.0 (286.4)	155.9 (222.3)	167.7 (259.4)	164.0 (222.9)	271.4 (336.8)** versus other groups
Vigorous PA	245.3 (293.4)	158.8 (219.4)***	201.9 (268.3)	194.3 (252.9)	288.4 (314.9)** versus other groups
Total PA	746.2 (594.9)	588.1 (499.6)**	661.7 (601.7)	648.9 (484.9)	832.9 (654.1)*** versus other groups

Data as mean (SD) and P values by unpaired t-test or ANOVA.
** $P < 0.01$; *** $P < 0.001$.

Table 3: Body Image Questionnaire difference from ideal and dissatisfaction scores.

BIQ factor	Gender		Urbanization			BMI group		
	Male	Female	City	Town/urban village	Rural village	Underweight	Optimal BMI	Overweight/ Obese
Difference from Ideal								
Height	0.9 (1.5)	0.7 (1.4)	0.6 (1.4)	0.8 (1.5)	0.8 (1.4)	1.1 (1.5)	0.8 (1.4)	0.5 (1.4)
Skin complexion	0.5 (1.4)	0.5 (1.4)	0.5 (1.4)	0.6 (1.4)	0.6 (1.5)	0.2 (1.4)	0.6 (1.4)	0.3 (1.3)
Hair texture	0.4 (1.4)	0.7 (1.5)	0.5 (1.5)	0.6 (1.5)	0.5 (1.5)	0.2 (1.4)	0.6 (1.5)	0.4 (0.5)
Facial features	0.4 (1.4)	0.6 (0.5)	0.4 (1.4)	0.5 (1.5)	0.4 (1.5)	0.6 (1.5)	1.5 (4.5)	0.4 (1.5)
Muscle tone	**1.2 (1.4)**	**0.8 (1.4)*****	0.4 (0.1)	1.5 (0.1)	1.4 (0.1)	1.2 (1.2)	0.8 (1.4)	0.9 (1.5)
Body proportions	0.8 (1.4)	0.9 (1.4)	**0.7 (1.40)**	**1.1 (1.4)****	0.8 (1.4)	0.7 (1.5)	**0.8 (1.4)**	**1.3 (1.4)****
Weight	0.8 (1.5)	0.9 (1.5)	1.5 (0.1)	1.5 (0.1)	1.5 (0.1)	**1.3 (1.4)**	**0.6 (1.5)****	**1.6 (1.4)**
Chest size	**0.9 (1.5)**	**0.6 (1.5)****	1.4 (0.1)	1.5 (0.1)	1.5 (0.1)	1.0 (1.4)	0.6 (1.5)	0.8 (1.6)
Strength	**1.1 (1.4)**	**0.8 (1.4)****	0.8 (1.4)	1.0 (1.4)	0.9 (1.4)	1.2 (1.4)	0.9 (1.4)	0.8 (1.4)
Coordination	0.6 (1.4)	0.7 (1.4)	0.6 (1.4)	0.7 (1.5)	0.7 (1.4)	0.5 (1.4)	0.6 (1.4)	0.7 (1.3)
Overall appearance	0.9 (0.4)	0.8 (1.5)	**0.8 (1.4)**	**1.1 (1.4)****	**0.7 (1.4)**	0.7 (1.5)	0.8 (1.4)	1.0 (1.4)
Dissatisfaction								
Height	1.8 (3.4)	1.4 (3.3)	1.1 (3.3)	1.8 (3.4)	1.7 (3.4)	1.8 (3.4)	1.6 (3.4)	1.1 (3.3)
Skin complexion	0.9 (3.2)	0.9 (3.2)	0.9 (3.3)	1.1 (3.2)	1.0 (3.2)	−0.03 (3.0)	1.2 (3.2)	0.5 (3.1)
Hair texture	0.8 (3.1)	1.3 (3.5)	1.2 (3.4)	1.1 (3.3)	0.9 (3.4)	−0.15 (2.6)	1.1 (3.3)	0.9 (3.4)
Facial features	0.7 (3.3)	1.0 (3.6)	0.8 (3.4)	1.0 (3.5)	0.8 (3.6)	0.6 (3.3)	0.9 (3.4)	0.8 (3.6)
Muscle tone	**2.6 (3.7)**	**1.5 (3.3)****	1.5 (3.2)	2.2 (3.6)	1.9 (3.5)	1.6 (3.0)	1.8 (3.4)	1.9 (3.8)
Body proportions	1.7 (3.4)	1.9 (3.4)	1.6 (3.4)	2.2 (3.4)	1.5 (3.4)	1.2 (3.2)	**1.5 (3.2)**	**2.7 (3.7)*****
Weight	1.6 (3.5)	2.2 (3.8)	1.7 (3.6)	2.3 (3.8)	1.7 (3.5)	2.4 (3.2)	**1.3 (3.4)**	**3.6 (3.7)*****
Chest size	**1.8 (3.4)**	**0.9 (3.2)*****	1.1 (3.2)	1.3 (3.4)	1.4 (3.2)	1.7 (3.2)	1.0 (3.2)	1.4 (3.5)
Strength	**2.5 (3.7)**	**1.5 (3.2)*****	1.8 (3.4)	1.9 (3.4)	1.9 (3.6)	2.5 (3.5)	1.8 (3.3)	1.9 (3.7)
Coordination	1.3 (3.4)	1.3 (3.1)	1.2 (3.1)	0.3 (3.3)	1.3 (3.2)	0.8 (3.3)	1.2 (3.2)	1.3 (3.1)
Overall appearance	2.1 (3.5)	1.9 (3.8)	1.7 (3.6)	2.4 (3.8)	1.6 (3.5)	1.0 (3.2)	1.7 (3.6)	2.4 (3.6)
Composite BIQ score	1.6 (2.1)	1.5 (2.1)	1.4 (1.9)	1.7 (2.1)	1.4 (2.0)	1.2 (1.7)	1.4 (1.9)	1.7 (2.3)

Data as mean (SD); ** $P < 0.01$; and *** $P < 0.001$.

Our group has previously shown that the prevalence of obesity differs substantially between urban and rural areas, with urban areas having higher OW/OB prevalence than rural areas [15]. However, levels of urbanization were not significantly linked with body dissatisfaction scores in this study, though students from towns/urban villages reported greater discrepancy from the ideal body proportions and overall appearance. This may suggest an early awareness of discrepancy that risks increasing to outright dissatisfaction if cultural influences are increased in a negative direction.

OW/OB adolescents were more dissatisfied with their body proportions and weight. This suggests that interventions targeting weight loss for OB adolescents may benefit from incorporating body image training into program design as a way to motivate adolescents to commit to the interventions. It would, however, be important to measure and account

for the relationship between perceived weight status and actual weight status so that such interventions do not lead to eating disorders by normal weight adolescents wanting to "attain the ideal." This is particularly important as it has been demonstrated that perceived weight status was a better predictor of weight loss intent than actual body fatness in a multiethnic sample of adolescent girls [21]. A study of Brazilian adolescents found that girls tended to overestimate their weight, while boys were more likely to underestimate theirs [25]. Little is known about the influence of cultural pressures and norms on the development of body satisfaction or dissatisfaction in Botswana thus, it is imperative to consider both actual and perceived body weights in interventions with OW/OB students.

These findings should be viewed in light of the study's strengths and limitations. The strengths of this study include its population-based design with surveys for adolescents across regions and SES contexts collected in the school setting. At the time of this, study Botswana census data showed that 94% of 12- to 18-year-olds attend school [18], and that the percentage of the population living below the poverty line had decreased to about 30% in 2002-2003 similar to our SES data [26] thus, our school-based survey is likely to provide a good representation of the national obesity prevalence in this age group. Height and weight were obtained by measurement, using well-trained research assistants and a rigorous protocol. Unfortunately, body weight data were lost on 38 students at one school due to a malfunctioning scale, requiring that BMI be excluded to, though all other student information were included. The major limitations of the study are related to the self-reported measures of body image satisfaction, physical activity, and socioeconomic status. Objective measurement of physical activity, using accelerometers, would provide stronger data but was beyond the scope of this project. Since adolescents are unlikely to be knowledgeable about family income or parental education levels, we needed to limit SES questions to items that they could easily describe.

5. Conclusion

Our study has shown that OW and OB among adolescent students in Botswana is associated with body image dissatisfaction, particularly of body proportions and weight, while PA is not. The discrepancy from ideal and dissatisfaction that boys have with muscle tone, chest size, and strength might be used as a motivation for increased physical training and PA. These associations should be used to inform targeted obesity prevention interventions as well as programs for adolescent psychosocial development in Botswana.

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Review Article

The Relationship between Executive Function and Obesity in Children and Adolescents: A Systematic Literature Review

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The objective of this paper is to examine the relationship between the development of executive function (EF) and obesity in children and adolescents. We reviewed 1,065 unique abstracts: 31 from PubMed, 87 from Google Scholar, 16 from Science Direct, and 931 from PsycINFO. Of those abstracts, 28 met inclusion criteria and were reviewed. From the articles reviewed, an additional 3 articles were added from article references ($N = 31$). Twenty-three studies pertained to EF (2 also studied the prefrontal and orbitofrontal cortices (OFCs); 6 also studied cognitive function), five studied the relationship between obesity and prefrontal and orbitofrontal cortices, and three evaluated cognitive function and obesity. Inhibitory control was most often studied in both childhood (76.9%) and adolescent (72.7%) studies, and obese children performed significantly worse ($P < 0.05$) than healthy weight controls on various tasks measuring this EF domain. Although 27.3% of adolescent studies measured mental flexibility, no childhood studies examined this EF domain. Adolescents with higher BMI had a strong association with neurostructural deficits evident in the OFC. Future research should be longitudinal and use a uniform method of EF measurement to better establish causality between EF and obesity and consequently direct future intervention strategies.

1. Introduction

In the past forty-five years, the incidence of obesity in the pediatric population in the United States has more than tripled, with approximately one in three children aged 2–19 classified as overweight (body mass index (BMI) 85–94% for age and sex) or obese (BMI ≥95% for age and sex) [1]. While it is clear that obesity correlates with negative health outcomes such as hypertension and Type II Diabetes, mounting evidence now links obesity to poorer adult cognitive functioning [2–4]. Specifically, studies demonstrate an association between adult obesity and decreased cortical gray matter volume with poorer performance on cognitive assessments [2, 3, 5–8]. One theory is that decreased cognition results from the hypertensive effects, often comorbidity with obesity [9]. Elias and colleagues determined that hypertension and obesity together have a cumulative negative relationship with cognition; however they also predict poorer cognition independently [10]. The interplay between obesity and brain function relates to executive function (EF), which refers to self-regulatory cognitive processes that are associated with monitoring and controlling both thought and goal-directed behaviors [4, 11]. There are several domains of EF, including (1) inhibitory control (suppression of actions that are inappropriate in a given context and that interfere with a goal-driven behavior), (2) attention (the ability to maintain a consistent behavioral response during continuous and repetitive activity) and the closely related concept of mental flexibility (disengagement of an irrelevant task set and subsequent engagement of a relevant task set despite interference and/or priming), (3) reward sensitivity (the relative dominance of the behavioral activation system driving motivated behavior

associated with risk-taking behavior), and (4) working memory (active maintenance and flexible updating of goal/task relevant information with limited capacity). Because the vast majority of studies investigating the relationship between obesity and varying domains of executive function are cross-sectional rather than longitudinal, there is a question of directionality in the relationship [4, 12].

Predisposition to obesity could include a dysregulation of specific limbic neural circuits connected with the orbitofrontal cortex [9, 12], given that these limbic circuits and the orbitofrontal cortex are associated with the inhibitory dimension of EF. In prior studies, the orbitofrontal cortex volume is positively associated with high quality food choices and performance on measures of executive function [13]. Rothemund and colleagues compared activity levels of the dorsal striatum, associated with reward anticipation and habit learning, and the OFC in obese versus lean adults with functional magnetic resonance imaging (fMRI) [14]. Obese adults exhibited higher levels of activation in both the dorsal striatum and OFC [14]. Stice demonstrated comparable results in adolescents [15]. This comparative hyperactivation of the OFC in obese individuals could suggest that this cortical area is working harder to suppress chronically hyperactive appetite-stimulating areas [16].

Alternatively, obesity could induce development of neural dysfunction. In a longitudinal study, Sabia and colleagues examined the extent to which lifetime obesity influences midlife cognition [17]. BMI measurements were attained from subjects during early adulthood (mean age = 25), early midlife (mean age = 44), and late midlife (mean age = 61). Results revealed that being obese at 2-3 of these time points was associated with lower scores of executive function, even after adjusting for age, sex, and education difference. Poorer executive function was also associated specifically with a large increase in BMI between early and late midlife [17]. In a separate longitudinal study, Gustafson determined that risk of atrophy of the temporal lobe increased 13–16% per 1.0 kg/m^2 increase in BMI [18]. However, the study did not find significant evidence of atrophy in the frontal, occipital, or parietal lobes [18].

If obesity does have a detrimental effect on the brain, it would stand to reason that it is important to prevent the development of obesity during a critical period of brain development, particularly during the development of executive function which has been closely correlated with academic success, social function, and emotional control [19–21]. For example, working memory and inhibition are associated with achievements in English, mathematics, and science for 11- and 12-year-old children [19]. Several studies have shown that children aged 3–5 undergo significant and rapid development of executive function which continues to mature into adolescence [22–26]. The prefrontal cortex so closely associated with executive function may be the last region of the brain to mature, and each dimension of EF (e.g., inhibition, shifting, and working memory) may have its own developmental trajectory and timeline [20, 25, 26]. Therefore, executive function is quite vulnerable to a stressor such as obesity during childhood.

There is an obvious need for novel prevention and intervention strategies to curb the childhood obesity epidemic. Enhancing our understanding of neural mechanisms associated with pediatric obesity could direct these future strategies [27]. As evidenced above, there is a relationship between BMI and executive function in adults, but there still remains a question of causality. In children and adolescents, the relationship between these two variables is less clearly established. Therefore to guide future pediatric obesity prevention efforts, this systematic literature review will seek to answer the question, "What is the relationship between executive function and obesity in children and adolescents?" To better understand the potential mechanisms that might link EF and obesity, we also included an assessment of the neurostructural published studies and obesity. Lastly, we collected data regarding how frequently cognitive function was evaluated, given that it is considered a possible mediator of executive function.

2. Methods

2.1. Literature Search Strategy. We conducted a systematic literature review, with eligibility criteria and search strategy created a *priori* and based on *The Cochrane Handbook of Systematic Reviews* [28]. The databases searched included PubMed, Google Scholar, PsycINFO, and Science Direct. A broad search was conducted using the keywords: executive function, children, and obesity, to determine the central executive function (EF) domains evaluated in current studies. Inhibitory control, attention/mental flexibility, reward sensitivity, and working memory were the four recurrent domains determined. As a result of this preliminary search, the final keywords utilized for the investigation were executive function, inhibitory control, attention, mental flexibility, reward sensitivity, working memory, cognitive function, prefrontal cortex, orbitofrontal cortex, BMI, obesity, adolescence, pre-school, and healthy children.

The search was conducted by one reviewer (K. R. S. Reinert). The reviewer assessed the abstract for inclusion criteria and then examined each full-text report for quality assessment and data extraction. Inclusion criteria included English language ages 2–18 all races, ethnicities, and genders, healthy participants, excluding obesity and randomized controlled trials (RCTs), meta-analysis, longitudinal studies, cross-sectional studies, prospective and retrospective review studies and those published since the year 2000. Failure to meet at least one of these criteria resulted in study exclusion. When in doubt, the complete paper was screened using the same criteria. Studies excluded measured EF performance in children who had additional diagnoses in addition to being overweight (e.g., ADHD, Type II Diabetes, and sleep apnea), instituted an intervention which altered EF performance (e.g., aerobic exercise), or measured fitness rather than obesity. Studies were organized according to variables evaluated: executive function (EF) orbitofrontal (OFC) and prefrontal (PFC) cortices, or cognitive function. For studies included pertaining to EF, information extracted during the literature review included BMI or BMI percentile of subject groups, age

of pediatric population studied, method of measurement of EF, and comparative differences in EF task performance. For studies included pertaining to OFC or PFC imaging, information extracted during the literature review included weight classification of subjects, age of pediatric population studied, method of OFC and PFC imaging, and comparative differences in OFC and PFC structure and function. For studies pertaining to cognitive functioning, information extracted included whether this variable was measured as a mediator of EF or independent of EF, method of cognitive function assessment, and results.

3. Results

We reviewed 1,065 unique abstracts: 31 from PubMed, 87 from Google Scholar, 16 from Science Direct, and 931 from PsycINFO. Of those abstracts, 28 met inclusion criteria and were reviewed. From the articles reviewed, additional 3 articles were added from article references ($N = 31$). Twenty-three studies pertained to executive function (2 also studied the prefrontal and orbitofrontal cortices; 6 also studied cognitive function), five studied the relationship between obesity and prefrontal and orbitofrontal cortices, and three evaluated cognitive function and obesity.

4. Executive Function and Obesity

Of the 31 abstracts which met inclusion criteria, 23 examined executive function (EF). Table 1 summarizes the results, examining each of the EF domains measured, specifying the age of participants, indicating the method of EF domain assessment, and relating the association of each EF domain with obesity. Table 2 illustrates the relative distribution of the total number of studies conducted in childhood versus adolescent pediatric subjects, specific to EF domains.

4.1. Childhood. Thirteen articles examined our research question with children aged 2–12 years old. The 4 EF domains examined were inhibitory control, reward sensitivity, attention, and working memory (Table 1). Inhibitory control was most often examined (76.9%) in the childhood studies (Table 2). A range of tasks measured this EF domain and included Delay of Gratification Task, Self-Control Task, Children's Behavior Questionnaire, Classroom Engagement, Social Behavior Questionnaire, Go-No Go Task, Behavioral Rating Inventory of Executive Functioning (self-report), and Incompatibility Task of Attention Assessment Battery. Despite the great variability in assessment methods, the studies together demonstrate an association between higher childhood BMIs for age and poorer performance on inhibitory control tasks [29–36]. Additionally, some studies demonstrated the predictive value of inhibitory control at a young age: poorer performance at a young age (2–7 years) predicted a higher BMI at a later age (5.5–15 years) (refer to Table 1). Conversely, a better inhibitory performance at age 6 predicted a healthier BMI at age 10-11 [31].

The remaining 3 alternative EF domains (attention, reward sensitivity, and working memory) each had few representative studies and therefore corresponded to only 38.4% of the total number of studies examining the relationship between EF and obesity in the pediatric population. Obese females were shown to have poorer ability to focus attention compared to healthy females, but this relationship was not evidenced in males [37]. Reward sensitivity was associated with impulsivity and proven to significantly predict BMI indirectly through propensity to overeat, assessed by parent-reported Child's Eating Behavior Questionnaire ($P < 0.001$) [38]. Huh et al. elucidated five latent classes of obesity risk in 4th grade children based on their behavior: [39] (1) high sedentary behavior, high fat/high sugar (HF/HS) intake, and weight conscious; (2) high sedentary behavior, HF/HS intake, and not weight conscious; (3) dieting without exercise, weight conscious; (4) active, healthy eating; (5) low healthy, snack food, inactive, and not weight conscious. They noted a significant association between classification and child weight status ($P < 0.001$) [30]. Specifically, Riggs et al. determined that youth who were classified as class 1, 2, or 3, demonstrated significantly poorer working memory than children in the two healthier classes ($P < 0.001$) [30].

4.2. Adolescence. Eleven articles examined our research question with adolescents aged 13–18 years old. There were 4 main EF domains evaluated: inhibitory control, attention/mental flexibility, reward sensitivity, and working memory. Inhibitory control was assessed in most of these (72.7%). A range of tasks measured inhibitory control and included Go-No Go Task, Incompatibility Task of Attention Assessment Battery, Stop Signal Task, Iowa Gambling Task, Stroop Task, Five-Digit Test, and Computerized Cognitive Test Battery. Obese individuals demonstrated less inhibitory control than healthy weight adolescents, and poor performance on inhibitory control tasks was associated with smaller orbitofrontal cortex volume in obese teenagers (refer to Table 1). One study which aimed to evaluate inhibitory control suggested that the variability of responses to their tasks indicated lapses in attentional ability rather than inhibitory control [34].

The second most examined EF domain in adolescents was both mental flexibility and attention, which were evaluated by 27.3% of the adolescence studies (Table 2). Included studies used the following tasks: Trail-Making Test, Wisconsin Card-Sorting Test, Computerized Cognitive Test Battery, Five-Digit Test Switching, Color-Word Interference Test Stroop, and D2 Attention Endurance Test (refer to Table 1). For every one of these tasks, obese adolescents performed worse than healthy weight participants (Table 1). Within obese participants, BMI was inversely related to performance on the Color-Word Interference Test Stroop (Table 1). Working memory and reward sensitivity had only one representative study each (9.0%) (Table 2). Similar to attention/mental flexibility, working memory performance of obese adolescents was significantly worse than that of the healthy weight controls, even after controlling for IQ (110.7 ± 13.3 versus 99.4 ± 13.8; $P < 0.001$) [12].

4.3. Cognitive Function. Nine of the 31 articles (29.0%) included in this paper included cognitive function as well as

Table 1: Association between EF and obesity in childhood versus adolescence.

EF Domain	Participant age	Measure used	Findings	Source
		Childhood		
(I) Inhibitory control	2–5.5 yrs	Delay of gratification task	2 yrs performance predictive of 5.5 yrs obesity when considered with emotional regulation	Graziano et al. (2010) [29, 40]
	3–12 yrs	Self-control (age 3) Delay of gratification (age 5) Children's Behavior Questionnaire (age 5)	Children with poorer performance at ages 3 and 5 had significantly higher BMI at all subsequent time points and had the most rapid gain in BMI 3–12 yrs	Francis and Susman (2009) [32]
	6 yrs	Classroom engagement Social behavior questionnaire	Better performance at age 6 correlated with healthier weight in 4th grade	Piché et al. (2012) [31]
	5–15 yrs	Child behavior questionnaire	Subjects with low inhibitory control at age 7 tended to have higher BMIs at all follow-up measurements and experienced greater weight gain at age 7–15	Anzman and Birch (2009) [35]
	7–9 yrs	Go-No Go Task	Higher BMI correlated with poorer performance	Kamijo et al. (2012) [33, 41]
	8-9 yrs	Behavioral Rating Inventory of Executive Function (self-reporting)	Highly sedentary children who were not weight conscious and consumed high fat and high sugar snacks exhibited less inhibitory control than children who were active and consumed fruits and vegetables. EF proficiency negatively correlated with substance use, high-calorie snack food intake, and sedentary behavior, while positively associate with fruit and vegetable intake as well as out-of-school physical activity	Riggs et al. (2012) [30, 42]
	8–11 yrs	Go-No Go and Incompatibility Tasks of Attention Assessment Battery	High impulsivity linked to higher body weight	Pauli-Pott et al. (2010) [34]
	8–12 yrs	Delay of Gratification Task (nonfood reward)	O/OW less likely to delay gratification than HW and overweight* peers	Bruce et al. (2011) [27]
		Go-No Go Task	O/OW had lower response accuracy for No Go component of task than healthy weight controls	Kamijo et al. (2012) [41]
(II) Attention	1–6 yrs	Attention span persistence	Among boys, greater persistence at age 1 associated with reduced standardized weight gain and reduced obesity risk through age 6	Faith and Hittner (2010) [43]
	4–8 yrs	Modified "Bavarian Model" for school entry examinations	O/OW females had greater prevalence of inability to focus attention than HW females (but not males)	Mond et al. (2007) [37]
(III) Reward sensitivity	6–13 yrs	Sensitivity to punishment and sensitivity to reward questionnaire for children	Performance significantly predicts BMI indirectly through overeating	Van den Berg et al. (2011) [38]
(IV) Working memory	8-9 yrs	Behavioral Rating Inventory of Executive Function (self-reporting)	Children who were highly sedentary and consumed high fat and high sugar foods exhibited poorer working memory and poorer organizational skills than children considered active and who ate fruits and vegetables. EF proficiency negatively correlated with substance use, high-calorie snack food intake, and sedentary behavior, while positively associate with fruit and vegetable intake as well as out-of-school physical activity	Riggs et al. (2012) [30, 42]

Table 1: Continued.

EF Domain	Participant age	Measure used	Findings	Source
		Adolescence		
(I) Inhibitory control	12–15 yrs	Go-No Go and Incompatibility Tasks of Attention Assessment Battery	Variability of responses and tendency for relationship of body weight and performance to be inverse indicate attentional lapses rather than distinctly inhibitory lapses	Pauli-Pott et al. (2010) [34]
	12–15 yrs	Stop Signal Task	O/OW have less inhibitory control than HW	Nederkoorn et al. (2006) [44]
	13–16 yrs	Iowa Gambling Task	O/OW performed significantly worse than HW controls	Verdejo-García et al. (2010) [45]
	12–21 yrs	Go-No Go Test Stroop Task Five-Digit Test Computerized Cognitive Test Battery	O/OW showed significantly more false positive responses and shorter reaction time than HW; significant association between disinhibition, OFC volume, and BMI	Batterink et al. (2010) [46]; Maayan et al. (2011) [12]; Verdejo-García et al. (2010) [45]
	7.5–15 yrs	Go-No Go Task Interference task	High impulsivity predicted successful weight loss in adolescents	Pauli-Pott et al. (2010) [47]
	10–14 yrs	The stop task Circle drawing task Opposite worlds task Maudsley Index of Childhood Delay Aversionand Door-Opening Task	Association was found with overweight children and less efficient inhibitory control	Verbeken et al. (2009) [48]
	12–17 yrs	Letter-Number Sequencing Stroop and Iowa Gambling Task	Greater improvement in cognitive inhibitory control skills was associated with greater reductions in BMI	Delgado-Rico et al. (2012) [49]
(II) Attention/Mental flexibility	12–19 yrs	Trail making test Wisconsin card sorting test Computerized Cognitive Test Battery Five-Digit Test-Switching Color-Word Interference Test Stroop D2 Attention Endurance Test	O/OW performed significantly worse than HW on all tasks; BMI inversely related to Stroop-switching performance for O/OW subjects	Lokken et al. (2009) [50]; Cserjesi et al. (2007) [51]; Verdejo-García et al. (2010) [45]; Delgado-Rico et al. (2012) [52]
(III) Reward sensitivity	12–15 yrs	Door-Opening Task	O/OW were more sensitive to reward and kept gambling longer than HW	Nederkoorn et al. (2006) [44]
(IV) Working memory	13–21 yrs	Working memory index of WRAML and Letter-Number sequencing	O/OW performed worse than HW controls	Maayan et al. (2011) [12]

Obese/Overweight (O/OW) versus Healthy Weight (HW): subjects classified as overweight or obese met the criteria of BMI $\geq 30\,kg/m^2$ or >95 percentile for BMI for age and gender; subjects classified as healthy weight met the criteria of BMI $<25\,kg/m^2$ or within 5–85 percentile for BMI for age and gender.
*Overweight: BMI between 85 and 95%.

EF. A third of these studies examined cognitive function as a mediator of executive function and therefore controlled for the subject's intelligence quotient or academic performance when determining the association between EF and obesity. All of these studies noted an inverse relationship between excess weight and performance on EF tasks even after controlling for general cognitive function. The remaining two-thirds of articles examined the association between general cognitive function and obesity. Half of these studies found a null relationship. One study examined this in children using the planning subtest of the Cognitive Assessment System, which pertains to aspects of EF including strategy generation and application, self-regulation, intentionality, and utilization of knowledge. Performance was significantly inversely related to both waist girth ($P < 0.05$) and body fat ($P < 0.01$) of children 7–11 year olds [53].

5. Brain Imaging and Obesity

Brain imaging indicates specific areas of the brain where different domains of EF function, specifically the dorsolateral prefrontal cortex (DLPFC) and the orbitofrontal cortex (OFC) [4, 54, 55]. In our systematic literature review, we found 7 studies which examined the relationship between these areas of interest in the brain and obesity in adolescents (refer to Table 3). Two of these studies had also examined EF. All 7 of the included studies evaluated the OFC, while only 3

Table 2: Comparative distribution of each EF domain included in childhood versus adolescence studies.

Function measured	% of total included studies which examine the EF domain in children (% of childhood studies which examine the EF domain)	% of total included studies which examine the EF domain in adolescents (% of adolescence studies that examine the EF domain)	% of total included studies that examine the EF domain
Inhibitory control	43.5% (76.9%)	34.7% (72.7%)	73.9%
Attention	8.7% (15.3%)	13.0% (27.3%)	21.7%
Mental flexibility	0% (0%)	13.0% (27.3%)	13.0%
Reward sensitivity	4.3% (7.7%)	4.3% (9.0%)	8.7%
Working memory	8.7% (3.8%)	4.3% (9.0%)	13.0%
Total studies included	56.5%	47.8%	

assessed the DLPFC. The literature research yielded no data available for the pediatric population under the age of 9 years old. Three studies examined the reactivity of the DLPFC and OFC in response to food images using functional magnetic resonance imaging (fMRI) (Table 3). Obese subjects demonstrated significantly ($P < 0.001$) greater activation of the PFC (before meal) and significantly ($P < 0.001$) less reduction of activation of the PFC (aftermeal) compared to healthy weight controls [36]. Davids et al. also found that obese subjects had hyperactivity in the DLPFC compared to healthy weight controls in response to food cues (left DLPFC, $T = 3.23$, $P < 0.001$; right DLPFC, $T = 2.65$, $P < 0.006$), but did not explicitly control for pre- and after meal states [56]. The OFC of obese subjects was also highly activated in obese subjects after meal compared to healthy weight controls ($P < 0.001$) [36]. Batterink et al. more directly evaluated the relationship between EF and obesity by using fMRI to evaluate the OFC, while female participants performed a Go-No Go Task, a classic test of inhibition [46]. This behavioral task presents stimuli in a continuous stream, and subjects perform a binary decision with each stimulus. One stimulus requires a motor response (go), while the other requires the withholding of a response (no go). Body mass index was negatively correlated with OFC activation during performance of the task ($P = 0.05$) [46]. Maayan et al. also combined imaging analyses with performance of a Go-No Go Task and used magnetic resonance imaging to significantly negatively correlate subject performance with individual OFC volume (32.3 ± 3.68 versus 33.3 ± 3.99; $P = 0.005$), thereby linking higher BMI with poorer performance on inhibitory control tasks and smaller OFC grey matter volumes [12]. This indicates that neurostructural deficits associated with obesity and exhibited in behavioral cognitive tasks are apparent by the age of adolescence.

Burger and Stice correlated the dietary restraint score of subjects to their activation of the OFC and DLPFC in response to milkshake anticipation, milkshake receipt, and food images. Elevated activity of right OFC ($r = 0.57$) and bilateral DLPFC (right, $r = 0.49$; left, $r = 0.55$) in subjects in response to milkshake receipt was positively correlated with restraint scores. This relationship suggests hypersensitivity to reward during ingestion of food, which could potentiate risk for obesity. There was no correlation of frontal cortical area activity in neither response to milkshake anticipation nor in response to food images.

6. Discussion

As we strive for progress in the development of interventions to curb the pediatric obesity epidemic, we review what we know in order to direct us towards what we need to know. Many studies have revealed the interplay between executive function (EF) and obesity in the adult population; however, few studies demonstrate the extent to which this relationship exists in children and adolescents. We examined 31 studies which met inclusion criteria, and 23 of these evaluated at least one of the 4 common EF domains in our population of interest. In both childhood and adolescence, inhibitory control is associated with BMI and with less control associated with higher BMIs. Four of the studies implicated a predictive nature related to inhibitory control. Poor performance on inhibitory control tasks at age 2 was correlated with higher BMI at age 5.5 even after controlling for age 2 BMI [40]. Poor performance at ages 3 and 5 correlated with higher BMI up to at least the age of 12 and the most rapid weight gain 3–12 years; however, this study did not control for baseline BMI [32]. Poor performance at age 7 significantly predicted BMI at each subsequent time point of ages 7 ($P < 0.001$), 9 ($P < 0.001$), 11 ($P < 0.001$), 13 ($P < 0.001$), and 15 ($P < 0.001$), but this study only examined Hispanic female children [35]. Better performance at age 6 significantly correlated with a healthier weight at ages 9-10, even after controlling for baseline BMI, sports participation, child cognitive skills, and preexisting family characteristics ($P = 0.030$) [31].

The orbitofrontal cortex correlates with inhibitory behavior as measured by functional magnetic resonance imaging (fMRI) and magnetic resonance imaging (MRI). The studies identified through this systematic literature review revealed that both the function and the anatomy of the OFC were altered as evidenced by fMRI and MRI data (see Table 3). However, it is important to note that this relationship was only investigated in youth aged 9 and older. Thus, it isnot clear when the structure and the function were initially altered or if this could be reversed. While obese adolescents showed a decreased level of activation of OFC before meal versus healthy weight controls, they showed elevated OFC activity after meal, functioning inversely to the patterns seen in the lean controls. This could suggest the development of resistance to signaling in the obese adolescent. Before meal the obese adolescent does not demonstrate an inhibitory control signal as strongly as a healthy weight subject, but after meal

Table 3: Association between BMI and brain imaging of dorsolateral prefrontal cortex (DLPFC) and orbitofrontal cortex (PFC).

Brain region	Participant age	Measure used	Findings	Source
DLPFC	9–18 yrs	Activation response before meal and after meal to pleasant, neutral, or food images (fMRI)	O/OW showed greater activation in DLPFC (before meal) and less reduction of activation in PFC (after meal) compared to HW in response to food images	Bruce et al. (2010) [36]; Davids et al. (2010) [56]
DLPFC	14–16 yrs	Activation in response to milkshake receipt, milkshake anticipation, and food images (fMRI)	Dietary restraint scores positively correlated with activation in bilateral DLPFC in response to milkshake receipt	Burger and Stice 2011
OFC	9–18 yrs	Activation response before meal and after meal to pleasant, neutral, or food images (fMRI)	O/OW showed greater OFC activation versus HW (after meal)	Bruce et al. (2010) [36]; Davids et al. (2010) [56]
OFC	10–14 yrs	Activation while viewing food and nonfood logos	O/OW had significantly less activation versus healthy weight in response to food logos	Bruce et al. (2012) [57]
OFC	14–16 yrs	Activation response during Go/No-Go Task (fMRI)	Negative correlation between BMI and level of OFC activation during task	Batterink et al. (2010) [46]
OFC	14–16 yrs	Activation in response to milkshake receipt, milkshake anticipation, and food images (fMRI)	Dietary restraint scores positively correlated with activation in right OFC in response to milkshake receipt	Burger and Stice 2011
OFC	14–17 yrs	Activation in response to most and least appetizing food images subject previously rated (fMRI)	BMI correlated positively with activation during initial orientation to food cues and predicted future increases in BMI	Yokum et al. (2011) [58]
OFC	15–19 yrs	Magnetic resonance imaging	BMI negatively correlated with OFC volume and positively correlated with greater number of commission errors	Maayan et al. (2011) [12]

the obese adolescent shows an elevated inhibitory signal compared to the healthy weight subject, showing a compensatory effect in which the brain ramps up its signaling in attempt to produce a "stop" behavior. Additionally, Batterink et al. correlated higher BMI with a greater number of errors in an inhibitory control behavioral task [46]. Maayan et al. contributes to this finding by revealing that there is a negative correlation between BMI, overall performance on an inhibitory control behavioral task, and OFC gray matter volume [12]. This indicates that there is a difference in neuroanatomy of obese individuals that is detectable behaviorally by the early age of 15 years [12]. This difference in orbitofrontal volumes is especially important during the adolescent years, when the patterning of activity in the OFC of adolescents resembles that of children, and the nucleus accumbens (reward center) patterning of activity resembles that of adults, which serves to predispose adolescents to risk-taking behavior with little self-regulation [59].

In addition to inhibitory control alterations, this paper found differences in the EF domains of attention/mental flexibility, reward sensitivity, and working memory, associated with obesity in both child and adolescent populations. Unfortunately, each of these domains and age groups had few representative studies. In addition, the studies that evaluated multiple domains disagreed about the validity of the differences evidenced in each. For example, Verdejo- García et al. studied adolescents aged 13–16 and found significant differences in obese versus healthy weight subjects within the EF domains of inhibition and mental flexibility [45]. However, the study did not find significant differences in the EF domains of working memory, planning, and reasoning. In contrast, Cserjési et al. found significant differences in working memory as well as attention, but not for intelligence or verbal fluency [51]. The reason for contrary findings among studies may be due to variability of testing method, as evidenced in Table 1. Despite the advantage that the studies included in this paper examined different age ranges, this was confounded by the variability among EF assessment method, even when evaluating the same EF domain. Future research should aim to use a more uniform assessment method, to allow for better comparison of findings and the formation of a more accurate account of the relationship that exists between obesity and executive function in youth. The National Institutes of Health has recently developed an Executive Functioning toolkit to create clearer consistency of methodology and assessment.

This systematic review reveals a consistent inverse association between obesity and executive function in children and adolescents. Therefore, it is imperative to first determine the directionality of this association. This could be accomplished by longitudinal assessments that apply uniform measurement approaches to assess the executive function of participants.

Baseline measurements of children's BMI and performance on EF tasks can serve to confirm the existence of a negative correlation between these two variables, while later time points can examine how the EF changes overtime in accordance with changing BMI. Given that cognitive function may be a mediator of executive function, future studies should consider controlling for the intelligence quotient or baseline academic success of participants when evaluating EF. If it is determined that executive dysfunction could predispose a child to obesity, this would inform early intervention strategies. Additional studies would need to establish the extent of decline exhibited as children and adolescents develop and the possibility of reversing the dysfunction. It is important to note that physical activity has been associated with improving EF in children and therefore should remain an integral part of any obesity intervention strategy [53]. This is especially crucial considering that EF is so intimately associated with academic performance [60]. Conversely, if it is determined that lower EF abilities predispose a child to obesity, prevention and intervention strategies should focus on the early improvement of the child's executive function in addition to the teaching of healthy behaviors.

This, too, is possible. Riggs et al. emphasized changing child impulse control, decision making, and social competence in an intervention strategy [30]. The study found that children demonstrated significant changes in positive attitude towards both self-regulation and appetitive behavior. Children even exhibited positive changes in actual food choices and television viewing patterns [30]. Pauli-Pott et al. studied children aged 7.5–15 years and found that performance on inhibitory control tasks was positively associated with the ability to lose weight during a 1-year intervention program, but this association pertained more to adolescents than younger children [47]. Taken together, these studies evidence the idea that perhaps a successful intervention program would focus on the improvement of executive function, with particular emphasis on the inhibitory control domain, *in addition* to healthy behaviors such as eating well and exercise. Perhaps it is not sufficient to focus solely on how children eat and move, but it is necessary to build on how they think.

7. Limitations

This paper included only the published literature; therefore, unpublished work was excluded. This type of publication bias could lead to an incomplete understanding of the current state of knowledge about the association between EF and childhood/adolescent obesity.

8. Conclusion

Future research examining the link and directionality between EF and childhood obesity should be longitudinal rather than cross-sectional and use a uniform method of EF measurement to direct future intervention strategies.

Conflict of Interests

The authors declares there is no conflict of interests.

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Research Article

Association of Serum Ceruloplasmin Level with Obesity: Some Components of Metabolic Syndrome and High-Sensitive C-Reactive Protein in Iran

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Background. One of the mechanisms that has been suggested for obesity related metabolic disturbances is obesity-induced inflammation. Pro-inflammatory cytokines generated in adipose tissue can increase hepatic synthesis of inflammation-sensitive plasma proteins (ISPs) including ceruloplasmin (Cp). In this study we aimed to investigate the relation between serum Cp level and obesity. *Methods*. 61 persons with body mass index (BMI) $\geq 25\,\mathrm{kg/m^2}$ (case group) and 61 persons with BMI $< 25\,\mathrm{kg/m^2}$ (control group) were included in this study with a case-control design. Serum Cp levels, triglyceride level, fating blood glucose, total cholesterol, LDL-cholesterol, HDL-cholesterol and hsCRP were measured in both groups. *Results*. We did not observe any significant association between serum Cp level and BMI in all subjects [OR: 1.02 (CI, 0.967 to 1.07)] and in case ($\beta = 0.012$, $P = 0.86$) and control groups ($\beta = 0.49$, $P = 0.07$) separately. However, in control group, this positive association was marginally significant. We found a positive correlation between serum Cp level and serum triglyceride level. *Conclusion*. Serum Cp level was not related to obesity in this group of subjects. None of the baseline variables could predict obesity in this group of subjects, including serum Cp level, FBS, total cholesterol, LDL and HDL- cholesterols and hsCRP.

1. Introduction

Obesity is a continuously worldwide public health problem that is closely associated with chronic diseases like dyslipidemia, metabolic syndrome, type 2 diabetes, atherosclerosis, and cardiovascular diseases [1, 2]. Different studies were done in order to recognize the involved mechanisms in pathophysiology of obesity and obesity-related diseases [3, 4]. Among these mechanisms, obesity-induced inflammation proposed as the potential link of obesity-related metabolic disturbances and chronic diseases [5].

Some studies have reported the positive correlation between body fat mass and inflammation-sensitive plasma proteins or ISPs, along with other inflammatory markers [4, 6, 7]. Kim et al., in a cross-sectional study with proteomic approach, reported that ceruloplasmin and fibrinogen were overexpressed in obese subjects [8]. In addition, in a cohort study on healthy men, aiming to study ISPs effects on modifying cardiovascular risk in obese subjects, there was not any association between ceruloplasmin level and BMI [9]. Proinflammatory cytokines produced in adipose tissue can increase hepatic synthesis of ISPs, which are known as important cardiovascular disease risk factors [7, 8].

Ceruloplasmin (Cp) is a member of ISPs family that is used in clinical practice to measure the degree of inflammation. Accumulating epidemiological data have reported that serum ceruloplasmin level increases in subjects with cardiovascular disorders, like atherosclerosis, abdominal aortic aneurysm, unstable angina, vasculitis, peripheral vascular diseases, and also in type 2 diabetes [10–19]. Most attention in recent years has been devoted to the concept that obesity elicits a chronic, low-grade systemic

inflammatory response [20]. Limited studies investigated the association between serum ceruloplasmin level and obesity [6, 8], and mainly, these studies focused on the association of this protein and cardiovascular diseases [9, 21–24]. We have no study in our country about this issue. Because serum Cp levels are affected by genetic and environmental factors, we can expect different results in different population studies [21], on the other hand, because obesity pattern in Iran is different from those in other countries, conducting such studies appears to be necessary. This study aims to investigate the association between serum ceruloplasmin level and obesity and some of the metabolic and inflammatory indexes, in order to recognize new biomarkers for obesity.

2. Methods

2.1. Study Design. The study was conducted in case-control design. The subjects with BMI above or equal to 25 kg/m^2 were placed in case group and with BMI lower than 25 kg/m^2 in control group. This was based on their body mass index or BMI. Collecting data was from March 2012 to July 2012. The subjects in case group (61 subjects) were selected from overweight and obese subjects, referring to nutrition clinics that had the qualification to enter the study (aged between 25–60 years), in continuous manner and for the control group (61 subjects), we selected one subject with normal weight per each case, that again, was qualified to enter the study. Factors like age and sex were controlled for sampling. Subjects with diseases like coronary artery disease, stroke, peripheral vascular diseases, type 2 diabetes, liver or kidney dysfunction, history of regular use of any medication that could affect cardiovascular function, and pregnant women excluded from the study. To determine sample size, we used the following expression:

$$n = \frac{z_{1-\alpha/2}^2 [p_1(1-p_1) + p_2(1-p_2)]}{d^2}, \quad (1)$$

where $z_{1-\alpha/2}$ is the study confidence coefficient 95% and equal to 1/96, (p_1) obesity ratio 30%, (p_2) normal ratio 50%, and (d) sampling error and equal to 0/17.

2.2. Anthropometric and Biochemical Parameters. Body Weight and height were measured by a digital scale and with the minimum clothing and without shoes. BMI obtained by dividing weight (kg) by height square (m^2). Waist circumference was measured by a flexible meter at the level of minimum circumference. venous blood specimens after 14 hours of fasting were collected by an experienced specialist for measuring serum ceruloplasmin level, fasting blood sugar (FBS), lipid profile including triglyceride, total cholesterol, LDL cholesterol (light-density lipoprotein), HDL cholesterol (high-density lipoprotein) and high-sensitive C-reactive protein level (hsCRP). Serum ceruloplasmin level was measured with colorimetric method, hsCRP with immunoturbidimetric method and FBS, total cholesterol, LDL, and HDL cholesterol were measured with enzymatic method. Before entering the study, the purpose of this study was explained for all the participants and the written consent was obtained. Baseline characteristics of the participants, including demographic characteristics, anthropometric parameters, and medical history, were collected by measurement and completing a questionnaire.

2.3. Statistical Methods. The SPSS software version 18 (version 18, SPSS Inc, Chicago) was used for statistical analysis. Each variable was examined for normal distribution. Pearson correlation coefficient was used to evaluate correlation between variables, and we used linear multiple regression to determine the relation between ceruloplasmin level with BMI and other variables. The effect of variables like age, sex, smoking, hypertension, total cholesterol, LDL and HDL cholesterol, triglyceride, and hsCRP was adjusted as confounder variables. P value less than 0/05 was considered statistically significant.

3. Results

Baseline characteristics of the participants are shown in Table 1. In this study, 122 subjects (55 male and 67 female) were investigated, 61 subjects were in case group and 61 subjects in control group. There was a significant difference in LDL cholesterol level between two groups, as we see in Table 1. 5% of subjects was found with hypertension (subjects with blood pressure ≥140/90 mmHg) and 15/6% with hyperlipidemia (subjects with serum triglyceride level ≥200 mg/dL, or total cholesterol level ≥200 mg/dL, or LDL cholesterol level ≥130 mg/dL were considered hyperlipidemic). There was no significant difference between sex, hypertension, hyperlipidemia, hyperthyroidism ratios, and also drug consumption between the two groups.

The mean serum Cp level in control group was 29/7 ± 7/1 mg/dL and in case group was 30/8 ± 7/6 mg/dL. The difference of mean serum Cp level between two groups was not significant ($P = 0/4$). There was not any significant association between serum Cp level and BMI in all subjects (Table 2), and when we investigated this association in case and control groups separately, this association was not significant again; however, in control group, this positive association was close to significance level (Table 3). Correlation analysis showed that there was a positive significant correlation between serum Cp level and serum triglycerides ($P < 0/05$, $r = 0/21$). But the correlation was not significant for serum Cp level and other variables like FBS, total cholesterol, LDL and HDL cholesterols, hsCRP, age, and sex. In multivariate analysis model, there was no significant association of serum ceruloplasmin level with waist circumference and BMI [$F(2, 48) = 2/2$, $P = 0/122$]. Also, there was not any significant association between serum ceruloplasmin level with body weight and height [$F(2, 111) = 0/33$, $P = 0/71$].

In linear multiple regression, none of the baseline variables could predict obesity in this group of subjects, including serum Cp level, FBS, total cholesterol, LDL and HDL cholesterols, and hsCRP.

Table 1: Baseline and serum characteristics of study subjects. Data are presented as means ± SD.

	Control group ($n = 61$)	Case group ($n = 61$)	P value
Age (years)	41/1 ± 9/6	41/8 ± 10/2	0/7
Males/females	32 : 29	34 : 27	0/88
HTN (%)	5/1	4/8	0/93
Hyperlipidemia (%)	13/6	17/5	0/55
Hypothyroidism (%)	3/4	7/9	0/28
BMI (kg/m^2)	23/5 ± 1/3	30/3 ± 4/3	<0/001
WC (cm)	87/3 ± 6/9	96/6 ± 11/8	<0/001
FBS (mg/dL)	95/7 ± 8/9	97/4 ± 9/1	0/3
Total cholesterol (mg/dL)	150/6 ± 28/7	155/5 ± 29/3	0/35
Triglyceride (mg/dL)	126/6 ± 61	142/2 ± 62/5	0/16
LDL cholesterol (mg/dL)	82/4 ± 18/9	90/5 ± 22/8	<0/05
HDL cholesterol (mg/L)	47/9 ± 11/1	47/7 ± 9/3	0/9
hs-CRP (mg/L)	1/88 ± 0/96	2/14 ± 1/15	0/17
Ceruloplasmin (mg/dL)	29/7 ± 7/1	30/8 ± 7/6	0/4

WC indicates waist circumference.
HTN indicates hypertension.

Table 2: BMI in relation to serum ceruloplasmin level. Results for logistic regression analysis.

	BMI		
	OR*	P value	95% CI
Ceruloplasmin	1/021	0/46	(0/967–1/077)

*Odds ratio adjusted for age, gender, smoking, hypertension, FBS, total cholesterol, LDL-cholesterol, HDL-cholesterol, triglyceride and hs-CRP.

4. Discussion

In this case-control study, there was no significant association between serum Cp level and obesity in all subjects and in case and control groups separately. However, in control group, this positive relation was close to significance. Also, we found a significant positive correlation between serum Cp level and serum triglyceride level. So far, the association between serum Cp level and obesity has not been investigated in Iran. Cp is a copper-containing α-2 glycoprotein which contains seven copper atoms per molecule and accounts for 95% of the total circulating copper in healthy adults. It is involved in coagulation, angiogenesis, defence against oxidant stress and iron homeostasis [8].

A limited number of studies have investigated the association between serum Cp and obesity, and most of them have reported a positive correlation between body fat mass and inflammation-sensitive plasma proteins or ISPs, like Cp, along with other inflammatory markers [6, 8]. Proinflammatory cytokines generated in adipose tissue can increase hepatic synthesis of ISPs. These proteins are recognized as cardiovascular disease risk factors and some of them like haptoglobin, fibrinogen, α_1-antitrypsin, and Cp were used in clinical practice to measure the degree of inflammation [8]. In this study, there was no significant association between serum Cp level and obesity in all subjects, and Engström et al. study [9] in (2004) supports this finding. In that study, in addition to Cp, they investigated some of the other ISPs, among which Cp and α_1-antitrypsin, had not any association with BMI. Serum Cp level can be affected by genetic and environmental factors like diet, life style, and diseases [21]. Thus, we may find different results in the study of different populations. The mechanisms by which Cp is related to obesity has not been identified; however, it is possible that Cp is involved in the inflammatory pathway linked to obesity [8]. In addition, obesity is associated with oxidative stress. Therefore, elevated serum Cp levels may signal abnormally high oxidant stress [9]. Göçmen et al. [21] showed that Cp can act, depending on its concentration, as antioxidant or prooxidant in laboratory conditions. In this study, we tried to investigate the association between serum Cp level and some of the metabolic syndrome elements and also hsCRP, in addition to obesity. Among these indexes, Cp had a significant positive correlation with serum triglyceride level.

One of the limitations of the study is not to measure other ISPs along with Cp, as we explained earlier, the association between obesity and ISPs can differ by their types. Another limitation is the small sample size of this study, due to which, perhaps the association is not significant between Cp and obesity in all subjects. Not measuring the dietary intakes in study subjects is considered the other limitation, because, in one hand, the intake of some micronutrients, like copper, can affect serum ceruloplasmin level, and on the other hand, it has been found that the degree of macronutrient intake affects the severity of inflammation [9]. Because the use of oral contraceptive pills or OCPs can affect serum ceruloplasmin level the other limitation is not to consider their consumption in the study.

We propose for future studies to consider other ISPs in addition to Cp, to conduct intervening studies in this basis,

Table 3: BMI in relation to serum ceruloplasmin level and other variables, in case and control group separately. Results for linear multiple regression analysis.

	BMI < 25		BMI ≥ 25	
	β^* (95% CI)	P value	β (95% CI)	P value
Ceruloplasmin	0/49 (−0/005–0/1)	0/072	0/012 (−0/15–0/13)	0/86
FBS	0/002 (−0/03–0/04)	0/91	0/127 (−0/02–0/27)	0/1
Total cholesterol	0/01 (−0/03–0/01)	0/33	0/005 (−0/05–0/06)	0/88
Triglyceride	0/004 (−0/004–0/01)	0/13	0/002 (−0/02–0/02)	0/88
LDL cholesterol	0/009 (−0/01–0/03)	0/54	0/031 (−0/12–0/06)	0/51
hs-CRP	−0/19 (−0/01–0/03)	0/225	0/54 (−1/72–0/64)	0/36

*β indicates regression coefficient that is adjusted for age, gender, smoking, hypertension, FBS, total cholesterol, LDL-cholesterol, HDL-cholesterol, triglyceride and hs-CRP.

and also to conduct this kind of investigations in children. As we discussed earlier, serum Cp level is affected by genetic and environmental factors and we may find different results in the study of different populations. This study is the first one to investigate the association between serum cp level and obesity in Iran.

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