Hindawi Publishing Corporation
Journal of Obesity
Volume 2010, Article ID 868573, 8 pages
doi:10.1155/2010/868573

Review Article

Rising Burden of Obesity in Asia

Ambady Ramachandran and Chamukuttan Snehalatha

India Diabetes Research Foundation & Dr. A. Ramachandran's Diabetes Hospitals, 28, Marshalls Road, Egmore, Chennai, 600 008, India

Correspondence should be addressed to Ambady Ramachandran, ramachandran@vsnl.com

Received 9 February 2010; Revised 1 June 2010; Accepted 30 June 2010

Academic Editor: Rob Martinus Van Dam

Overweight and obesity have reached epidemic proportions in many Asian countries. These countries also face a grave burden of obesity-related disorders such as diabetes, hypertension, and cardiovascular diseases, which develop at a younger age than in Western populations. These disorders are also manifested in childhood. The major causative factors are related to the lifestyle changes occurring due to rapid socioeconomic transition. Asian populations show several differences in genetic factors when compared with the white population, and they also have lower cut points for environmental risk factors. National programmes targeting public awareness, education and improved structural facilities to facilitate healthy lifestyle are the keys to alleviate the economic and health care burden of the obesity-related disorders.

1. Introduction

Obesity is an epidemic of the 21st century, and is a major causative factor for many other metabolic disorders. According to a global estimate by the World Health Organization (WHO), in 2005 there were about 1.6 billion overweight persons aged 15 years and above and among them at least 400 million adults were obese [1]. The revision of definition of obesity to adjust for the racial differences, by the WHO, has resulted in a higher prevalence of 1.7 billion people classified as overweight. The WHO further projects that by 2015, approximately 2-3 billion adults will be overweight and more than 700 million will be obese [1].

The impact of obesity has been considerable in both developed and developing countries. According to a WHO report, obesity has been identified as a major cause of disability and premature deaths in less developed countries. This has been attributed to shifts in diet and lifestyle changes [2, 3]. The risk of many diseases including cardiovascular diseases (CVDs), hypertension, hyperlipidemia, diabetes mellitus, and certain cancers increases many folds in association with obesity [1–5]. It has been estimated that obesity accounts for 2% to 7% of total healthcare costs. There are also other costs to consider such as reduced quality of life and productivity loss attributed to medical leave [2].

2. Scenario in Asia

In most of the Asian countries the prevalence of overweight and obesity has increased many folds in the past few decades and the magnitude varies between countries [6–15]. South East Asia and Western Pacific region are currently facing an epidemic of diseases associated with obesity such as diabetes and CVD [5, 6]. India has the highest number of people with diabetes in the world and China occupies the second position [5]. Systematic national data on prevalence of obesity is not available from any Asian country. Wide differences exist in its prevalence. The countries and regions in Asia are at different phases of development. Some like Vietnam and Indonesia are in the early stages of development while others like Japan, Singapore, Malaysia, and Hong Kong are at more advanced stages.

Table 1 shows the prevalence of overweight and obesity in Asian countries in comparison with the USA. Many Asian countries have rates which are not very different from that in the USA [7–11]. The highest rate of obesity in Asia is in Thailand [15] and the lowest is in India [8] followed by Philippines [10]. China which once had the leanest of populations, is now rapidly catching up with the West in terms of prevalence of overweight and obesity which had occurred in a remarkably short time [3, 16].

Table 1: Comparison of prevalence of adult obesity in Asian countries versus the USA.

	Survey year (ref)	Prevalence of overweight adults (%)*	Prevalence of obese adults (%)†
USA	2007-2008 [7]	34.0	30.2
India	1998-1999 [8]	10.0	2.2
Malaysia	1996-1997 [9]	16.6	4.4
Philippines	1998 [10]	16.9	3.3
Taiwan	1993–1996 [11]	21.1	4.0
Japan	2001 [10]	23.0	3.0
Singapore	1998 [12]	24.4	6.0
China	1999-2000 [4]	25.0	4.0
Hong Kong	1996-1997 [13]	25.1	3.8
Korea	2001 [14]	27.4	3.2
Thailand	1998 [15]	28.3	6.8

* BMI 25 to <30 kg/m^2, † BMI $\geq$ 30 kg/m^2, Adopted from Yoon et al. [6] with permission.

The National Nutrition and Healthy Survey in Taiwan 1993–1996, showed that the prevalence of overweight and obesity were 22.9% and 10.5% for males and 20.3% and 13.2% for females, respectively, using the Taiwanese definition (BMI—24–<27 kg/m^2 and $\geq$27 kg/m^2, resp.) [11].

2.1. Socioeconomic and Life Style Changes. In many developing regions such as South Asia and Asia-Pacific regions, both obesity and undernutrition coexist mainly due to wide socioeconomic disparities. An example of an Asian country with both undernutrition and overnutrition paradox is the Philippines. While more than 30% of preschool and school children were underweight, less than 1% were overweight in 1998. Among adults, prevalence of underweight was 13.2% while the prevalence of overweight was 20.2% [17].

The relationship between obesity and poverty is complex. In world's poorest countries, poverty is associated with malnutrition and underweight whereas, in middle income countries, it is associated with an increased risk of obesity. Some countries face a paradox of families in which children are underweight and the adults are overweight. This has been attributed to the "thrifty phenotype" in which a low birth weight due to poor intrauterine growth followed by a rapid childhood weight gain promotes development of obesity and associated metabolic complications [10].

Relation between stunting and obesity are biological in origin. Low birth weight and exposure to undernutrition in utero are common in some Asian populations, especially in India, where 30% of infants are underweight [18]. It is estimated that 43% of preschool children in lower income countries are stunted [19]. In the past, stunting was associated with inadequate availability of food and poor socioeconomic conditions did not allow for the expression of obesity. But the association may not be the same now in countries undergoing nutritional transition [20]. The nutrition transition causing rapid shifts in the composition of diet and activity patterns and subsequent changes in body composition might lead to considerable obesity over the next several decades. Similarly, it is speculated that such transitions in lifestyle parameters are also congenial for increasing the complications related to stunting [20]. Many studies have also shown that nutritional stunting leads to many changes like lower energy metabolism, greater susceptibility to fat rich diets, reduced oxidation of fats, and impaired regulation of food intake [21]. More studies are required to understand the long lasting relationship between obesity and nutritional stunting.

The pandemic of obesity has been restricted to developed, high-income countries until few decades ago, but recently, it has penetrated even the poorest of nations in the world. Asia has undergone considerable socioeconomic transition in the last three decades which has resulted in increased availability of food, better transport facilities, and better health care facilities. The changing trend was seen first in the urban populations and in the recent years, with improving socioeconomic scenario in the rural areas, the changes were seen even among the urbanizing rural populations. The recent epidemiological data among urban and semiurban southern Indian populations, illustrates the changing scenario [22, 23].

Figure 1 shows the increasing trend in obesity among the urban and also in the rural population ($\geq$20 years) in Chennai, Southern India. In a decade, prevalence of obesity had increased by 1.7-fold in the city [22, 23]. Obesity rates were higher among women, as reported from many other countries [10]. The prevalence of overweight was lower among the urbanizing rural population, than in the urban areas. However, the rural population had a more rapid change as shown by nearly 8.6-fold increase in a period of 14 years [24].

The study indicated that the living conditions in rural areas had improved considerably. Transport facilities, medical care and food habits, educational status, and family income had dramatically improved which along with easy access to city and television watching resulted in changes in life style. These eventually lead to significant increase in BMI as well as abdominal obesity in both sexes as compared to a similar study conducted in the year 1989. The prevalence of overweight rose from 2% to 17.1%. The changing life style of the rural dwellers was found to be a contributory factor for the rising rates of obesity and associated metabolic diseases such as diabetes [24].

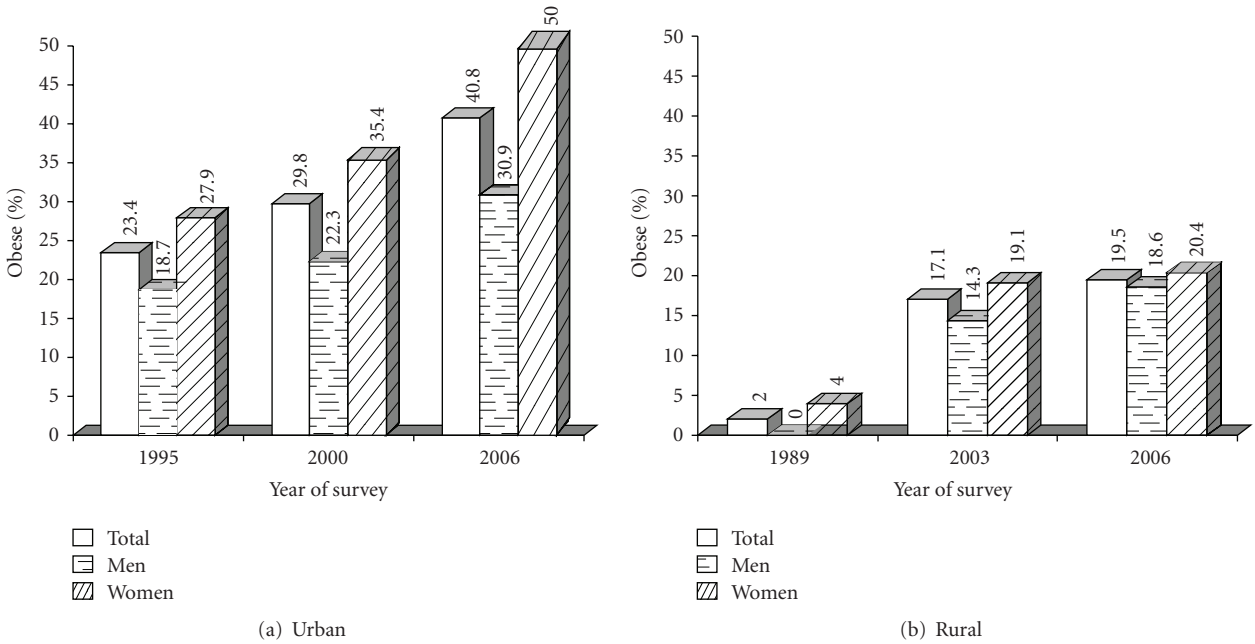

Figure 1: Temporal changes in prevalence (%) of obesity ($\geq$25 kg/m^2) among urban and rural Asian Indians. The results are based on epidemiological data collected in [22–24]. (a) Shows the data for urban population. (b) Shows the data for rural population.

Data from the India National Family Health Survey (NFHS) showed that in the country, the overall prevalence of overweight was low, while undernutrition remained high. Overweight was more prevalent among the urban and high socioeconomic status groups, especially among women [25]. A higher prevalence of obesity seen in the urban areas in developing countries is associated with the change from rural to urban lifestyle causing decreased levels of physical activity and an increase intake of energy dense diet [25].

In some of the developing countries, obesity, especially among women, is regarded as a sign of affluence. Such cultural influence could be related to the higher prevalence among women compared to their male counterparts [26].

In Singapore which is a developed region in Asia, nearly 35% of people aged 18–69 years are overweight, another 14% are obese. This societal problem in Singapore is shown to be associated with its extremely large GDP and economic affluence [12].

2.2. Changing Lifestyle. A significant positive correlation exists between the economic status and the composition of diet consumed [24, 26–30]. Diets consumed have increased energy content from fats and simple sugars. Consumption of saturated fat has increased, especially from animal fat.

In China, the average energy density of food has increased over 10 years both in the urban and rural populations. Consumption of fast food and sweetened carbonated drinks have increased many folds which is considered to have caused the increase in prevalence of obesity [31]. In addition, reduced physical activity at work due to mechanization, improved motorized transport and preferences for viewing television and video games to outdoor games during leisure time, have resulted in positive energy balance in most of the Asian countries [27]. The increased use of automobiles has tilted the energy balance from a physically active, energy scarcity state to a sedentary lifestyle marked by an energy surplus state [32]. In Asia, automobiles are rapidly replacing bicycles as the primary mode of transport. Motor vehicle ownership has increased in China and India. Epidemiological data from India have shown a similar profile among the urban and the urbanizing rural population in the last two decades [23, 24].

Generally the prevalence of overweight and obesity is associated with higher socioeconomic status (SES) both among the children and adults [22, 29]. The pattern of association between SES and obesity, in low-income countries (with a GNP per capita up to US $735) like India and China is observed to be complex [33]. Food scarcity, patterns of high energy expenditure found among the poor and greater capacity of the elite group to obtain surplus food are considered to be related to the protection of the lower SES groups in developing populations against obesity. However, a study conducted in Mumbai, India [34] had shown no relationship between SES and obesity. More research in this area may be required to explain the lack of such an association.

2.3. Studies in Youth. In parallel with the increase in adult obesity, obesity in children is also increasing. Certain ethnic groups such as American Asians, native Americans and Hispanics have the highest risk of childhood obesity. In 2002, it was reported that rate of childhood obesity had increased 2.3- to 3.3- fold in about 25 years in the USA (BMI $\geq$ 95th percentile) [35]. In Japan, increase in the incidence

of type 2 diabetes was parallel with the levels of obesity between 1975 to 1995 (BMI $\geq 30\,\text{kg/m}^2$) [36]. Childhood obesity has reached more than 25% in many developing countries.

Studies in India (Overweight $\geq 25\,\text{kg/m}^2$, Obesity $\geq 30\,\text{kg/m}^2$using Cole's criteria [37, 38], Singapore [39], China [16], Malaysia [40] (BMI ≥95th percentile in both) and other Asian countries [27] had shown a rising prevalence of obesity among children. Wang et al. [41] showed that the rate of obesity among children aged 7–17 years in big cities in China was more than 20%. Li et al. [42] reported a parallel increase of obesity with dietary fat and high energy consumption in Chinese children. The study revealed that overweight children spent less time on moderate/vigorous physical activities. It also revealed parental obesity to be the most pronounced risk factor for childhood obesity among these children.

The etiological factors for childhood obesity include genetic, metabolic, and behavioural components [6, 10, 27]. An imbalanced energy intake versus energy expenditure due to consumption of energy dense food and increase in sedentary habits has mainly contributed to increase in childhood obesity, both in developed and developing countries [2]. Some evidence suggests that lack of physical activity rather than high- fat intake is a major determinant of obesity [2]. Studies from developed western countries, USA and parts of Western Europe and UK, have estimated that average per capita energy consumption, especially fat consumption has declined in the last 2 decades [27]. On the other hand, it has also been reported that the average consumption of dietary sugars by American population has considerably increased in the recent years and this is regarded as one of the contributory factors for the increased obesity rate. The National Health and Nutrition Examination Survey (NHANES) showed that the mean intake of added sugars increased significantly from 2001–2004 [43]. However evidences to project the positive association between sugar consumption and obesity are inconsistent [43]. The rise in obesity has also been correlated well with lack of energy expenditure owing to physical inactivity, which could contribute significantly toward the increasing rate of overweight and obesity [27]. A study in urban school children in India has supported this observation [38].

In Western studies, occurrence of cardiometabolic risk variables and its clustering were reported only in obese children [44, 45]. On the contrary, a study in Asian Indian urban children and adolescents (12–19 years) showed that nearly 65% of normal weight subjects also had at least one risk factor [46]. The cardiometabolic risk factors studied were blood pressure, fasting plasma glucose, HDL-cholesterol, triglycerides, waist circumference and insulin resistance. The percentage of abnormalities increased to 85% in overweight children. Clustering of abnormalities occurred more commonly in them and insulin resistance showed a strong association with the clustering (Table 2).

The comorbid conditions associated with this scenario are, abnormal glucose tolerance including type 2 diabetes, hyperlipidaemia, hypertension, early menarche, polycystic ovarian syndrome, increased risk of obesity in adulthood, increased risk of other hormonal disorders and psychosocial issues.

2.4. Adiposity in Asians: General Adiposity. Asian populations generally have a lower body mass index (BMI) than many other ethnic groups, but the association between BMI and glucose intolerance is as strong as in any other population [47]. The risk of diabetes (odds ratio) was significant for urban Indian populations with a BMI of $\geq 23\,\text{kg/m}^2$ [48]. This has been confirmed by studies from other parts of India [49], by studies in migrant Indians and in other Asian populations [50]. According to the WHO recommendations, a BMI of 18.5–22 kg/m^2 is considered healthy for Asian populations [51].

Insulin resistance is one of the major etiological factors for diabetes and the risk association between obesity and diabetes is mediated through insulin resistance.

2.5. Abdominal Adiposity (Central Obesity). The risks for diabetes and for CVD are associated with a lower BMI among Asian populations. Many Asian populations, especially south Asians, have a higher total and central adiposity for a given body weight when compared with matched white populations. A higher prevalence of metabolic syndrome in south Asians is mostly attributed to the higher prevalence of central adiposity.

The IDF criteria for metabolic syndrome recommends use of ethnic specific threshold for waist circumference which includes ≥ 90 cm in men, and ≥ 80 cm in women of Asian origin [52]. The Japanese population is an exception.

The International Day for the Evaluation of Abdominal Obesity (IDEA) study examined the average waist circumference of 30,000 individuals in three Asian regions and compared them with figures from a similar number of people in Northwest Europe. Data from three Asian regions, namely south Asia (India, Pakistan), East Asia (China, Korea, Taiwan) and south east Asia (Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam) showed that obesity and abdominal obesity were highly prevalent in these countries, especially in south Asia [53]. As per the IDF criteria [52] of waist circumference ≥ 90 cm for men and ≥ 80 cm for women, prevalence of abdominal obesity in men and women were 58% and 78% in south Asia, 38%, and 51% in East Asia and 38% and 51% in South East Asia compared to respective prevalences of 58% and 67% in the Europeans using cutoff values of ≥ 94 cm for men and ≥ 80 cm for women, respectively. South Asians had the highest prevalence of abdominal obesity and women had higher rates than men. A higher prevalence of diabetes and CVD in Asian populations, especially in women could be attributed to the higher waist circumference [53].

The data from the Health Survey for England [54] highlights the differences in central obesity among south Asian populations and the general population in UK (total population of UK) (Table 3). Mean BMI of Chinese, Bangladeshi, Indian and Pakistani men was lower than in the general population (27.1 kg/m^2). Chinese women had markedly lower and Indian women had similar BMI compared with the general population. Pakistani and Bangladeshi men and

Table 2: Effects of body weight on prevalence and clustering of cardiovascular risk factors in teenagers in India. The risk factors considered were: blood pressure, fasting plasma glucose, HDL-cholesterol, triglycerides and waist circumference [46].

Body Weight	n	Prevalence of risk factors			
		None (%)	Any one (%)	Any two (%)	Two or more (%)
Total	2640	32.2	44.7	20.6	2.4
Normal weight	2245	35.2	44.8	18.7	1.3
Overweight	394	15.0*	44.4	31.7*	8.9*

* $P < .002$ versus normal weight.

Table 3: Comparison of body mass index, waist hip ratio and waist circumference in Asian populations and the general population aged 16 years and above in the UK (Health Survey England 2004 [54]).

	Indian		Pakistani		Bangladeshi		Chinese		General population of UK (whole population of UK)	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
BMI (kg/m^2)										
Mean	25.8	26.2	25.9	27.1	24.7	25.7	24.1	23.2	27.1	26.8
SEM	0.23	0.22	0.25	0.30	0.18	0.33	0.23	0.28	0.10	0.12
Overweight and obesity ($\geq$25 kg/m^2) %	53	55	55	62	44	51	37	25	67	57
WHR										
Mean	0.92	0.82	0.92	0.84	0.91	0.85	0.87	0.81	0.92	0.82
SEM	0.005	0.004	0.006	0.006	0.007	0.005	0.007	0.005	0.001	0.001
Raised WHR (%)*	38	30	36	39	32	50	17	22	33	30
Waist circumference (cm)										
Mean	93.0	83.9	95.0	87.7	88.7	85.7	86.8	77.6	96.5	86.4
SEM	0.82	0.74	0.87	0.93	1.00	1.09	1.02	0.75	0.22	0.21
Raised Waist Circumference** (%)	20	38	30	48	12	43	8	16	31	41

* $\geq$0.95 for men and $\geq$0.85 for women, ** $\geq$102 cm for men and $\geq$88 cm for women.

women had raised waist to hip ratio and waist circumferences and Chinese men and women had lower values than the general population [54].

Visceral fat increases the risk of diabetes and hyperlipidemia by favouring insulin resistance. By measuring visceral and subcutaneous abdominal fat areas in nondiabetic southern Indians, we showed that insulin resistance was also associated with subcutaneous fat indicating that subcutaneous fat was not innocuous [55].

2.6. Body Fat Percentage. It has also been noted that for a given BMI, Asians have higher body fat percentage compared with Caucasians [56, 57]. Higher insulin resistance and an increased risk of diabetes may be partially attributed to this feature. The differences in anthropometric characteristics are evident even in Asian children who are shown to have higher body fat percentage at lower levels of body weight [58, 59] and also a tendency for abdominal obesity [46].

2.7. Obesity and Insulin Resistance—Role of Adipose Tissue. Currently, overnutrition is common even in the developing countries. Changing lifestyle has tilted the energy balance towards excess storage of body fat in the adipose tissue, causing escalating rates of overweight and obesity. There is also a strong genetic component for obesity. Obesity is associated with increased number and/or size of fat cells which overproduce hormones such as leptin, and cytokines like Tumour necrosis factor α (TNFα), some of which cause cellular resistance to insulin [60]. Synthesis of adiponectin which enhances insulin sensitivity is suppressed. The activity of hormone-sensitive lipase is increased causing increased flux of nonesterified fatty acids (NEFAs], which in turn causes insulin resistance in the liver and muscle. Increased levels of NEFA lead to excess synthesis of triglycerides and cholesterol and cause other derangements in lipid metabolism.

Compensatory hyperinsulinaemia maintains normoglycaemia but may cause retention of sodium and water through stimulation of sympathetic nervous system and cause increase in blood pressure [60].

Excess secretion of TNF-α and other cytokines, is associated with a proinflammatory state which also partially contributes to insulin resistance.

2.8. Genetics of Obesity. Obesity is a typical example of multifactorial disease that arises through the interaction of multiple genetic and environmental factors. Even though the genesis of obesity is associated with a strong genetic

influence [27], a strong obesogenic environment is typically required for its phenotypic expression [61]. Recent genome-wide studies have shown multiple loci on chromosomes which affect the obesity-related phenotypes [61]. Familial prevalence of obesity has been reported in different populations [62, 63]. A community-based study done in Chennai, South India, showed a high rate of heritability for abdominal obesity [63]. More studies on the gene-gene and gene-environment interactions are required to clearly understand the etiology of obesity.

2.9. Prevention of Obesity—The Ultimate Solution. The number of adults and children who are obese has reached epidemic proportions in many countries. For prevention of obesity, overweight and its related health risks, population-based strategies to improve social and physical environmental contexts of healthy eating and physical activity are essential [64]. Lifestyle changes that lead to weight reduction have been demonstrated to reduce the incidence of diabetes and hypertension [65]. Such primary prevention studies using healthy foods, sustained physical activity, and initiatives to educate the community regarding the benefits of these will help to tackle the global problem of obesity and its associated disorders. Guidelines have been laid down by the WHO for formulating national policies to meet these challenges [66].

Some countries including Pakistan, Singapore, India, and China have initiated national programmes related to obesity and nutrition. National programmes have also been initiated for prevention of noncommunicable diseases. Singapore's "Fit and Trim" programme in school children has led to a remarkable drop in prevalence of obesity from 16.6% in 1992 to 14.6% in 2000 among children aged 11 to 12 years, and from 15.5% to 13.1% among children aged 15 to 16 years [67].

The ministry of Health, Malaysia and Academy of Medicine, Malaysia (2003) have laid down guidelines for reduction of overweight and obesity in children and adolescents [40]. These include: reduction in energy intake by use of conventional food, improving physical activity and thus the energy expenditure, behaviour modification associated with eating habits and activity pattern, and involvement of the family in the process of change. Guidelines are also provided to the parents for healthy feeding of the children and for improving their physical activity levels [40].

In certain cases pharmacological treatment may be required in addition to diet, exercise, and behaviour modification [68]. To date, there is little published scientific evidence reporting the long-term safety and efficacy of currently available anti-obesity drugs [69].

Developing Asian countries, lack proper urban planning. Therefore there is a lack of open space. The density of population is high in cities and towns. Measures to improve facilities to enhance physical activities in schools and communities have to be taken by the governments. Immediate impact cannot be seen in the developing countries, as they are in a phase of enjoying the benefits of increasing economy. Public education campaigns, warning on the ill effects of obesity and its related metabolic disorders can produce slow, but gradual impacts. Prevention of obesity is likely to be most effective when implemented in the childhood itself.

Adverse environmental factors overwhelm behavioural and educational techniques designed to reduce energy intake and augment physical activity. The pressing need to address the public health crisis demands increased funding for research into various factors contributing to the epidemic of obesity. These include detailed studies on dietary components, activity, behavioural, and environmental aspects. Studies on safe and effective pharmacological approaches for prevention and treatment of obesity are also warranted. For a population-based approach, family-based and school-based programmes will prove more effective [35]. Many Asian countries such as India have to solve the coexistence of undernutrition and overnutrition. Serious governmental actions are required to reduce the health related problems and the huge economic healthcare cost.

There are several areas in which future research should be undertaken. Nationally representative and longitudinal studies are required to monitor secular trends, to study the usefulness of the current cutoff values for predicting long-term health outcomes and also to examine the health and psychosocial outcomes of childhood obesity [70]. Moreover obesity prevention will require better understanding of the causative factors for obesity which influence behaviour and the social and cultural environment [70].

Conflict of Interest

The authors declared that there is no conflict of interests.

Acknowledgment

The authors gratefully acknowledge Dr. Krithika Rajesh and Mr. Ram Jagannathan for helping in literature search. They also thank Mrs. Vijaya L for secretarial assistance.

References

[1] World Health Organization, "Obesity and Overweight, Fact Sheet No. 311," September 2006.

[2] World Health Organization, "Report of a joint WHO/FAO Expert. Consultation. Diet, nutrition and the prevention of chronic diseases," WHO technical report series No. 916, http://whqlibdoc.who.int/trs/who_TRS_916.pdf.

[3] World Health Organization, "Preventing chronic disease: a vital investment," WHO global report, World Health Organization, Geneva, Switzerland, 2005.

[4] P. M. Kearney, M. Whelton, K. Reynolds, P. Muntner, P. K. Whelton, and J. He, "Global burden of hypertension: analysis of worldwide data," *The Lancet*, vol. 365, no. 9455, pp. 217–223, 2005.

[5] International Diabetes Federation, *Diabetes Atlas*, 4th edition, 2009.

[6] K.-H. Yoon, J.-H. Lee, J.-W. Kim et al., "Epidemic obesity and type 2 diabetes in Asia," *The Lancet*, vol. 368, no. 9548, pp. 1681–1688, 2006.

[7] K. M. Flegal, M. D. Carroll, C. L. Ogden, and L. R. Curtin, "Prevalence and trends in obesity among US adults, 1999–2008," *Journal of the American Medical Association*, vol. 303, no. 3, pp. 235–241, 2010.

[8] P. L. Griffiths and M. E. Bentley, "The nutrition transition is underway in India," *Journal of Nutrition*, vol. 131, no. 10, pp. 2692–2700, 2001.

[9] S. M. Sidik and L. Rampal, "The prevalence and factors associated with obesity among adult women in Selangor, Malaysia," *Asia Pacific Family Medicine*, vol. 8, no. 1, pp. 1–6, 2009.

[10] A. M. Prentice, "The emerging epidemic of obesity in developing countries," *International Journal of Epidemiology*, vol. 35, no. 1, pp. 93–99, 2006.

[11] Y.-C. Lin, L.-L. Yen, S.-Y. Chen et al., "Prevalence of overweight and obesity and its associated factors: findings from National Nutrition and Health Survey in Taiwan, 1993-1996," *Preventive Medicine*, vol. 37, no. 3, pp. 233–241, 2003.

[12] M. Deurenberg-Yap, S. K. Chew, V. F. P. Lin, B. Y. Tan, W. A. van Staveren, and P. Deurenberg, "Relationships between indices of obesity and its comorbidities in multi-ethnic Singapore," *International Journal of Obesity*, vol. 25, no. 10, pp. 1554–1562, 2001.

[13] G. T. C. Ko, M. M. F. Wu, J. Tang, H. P. S. Wai, C. H. S. Chan, and R. Chen, "Body mass index profile in Hong Kong Chinese adults," *Annals of the Academy of Medicine Singapore*, vol. 30, no. 4, pp. 393–396, 2001.

[14] D. M. Kim, C. W. Ahn, and S. Y. Nam, "National prevalence of obesity: prevalence of obesity in Korea," *Obesity Reviews*, vol. 6, no. 2, pp. 117–121, 2005.

[15] W. Aekplakorn, Y. Chaiyapong, B. Neal et al., "Prevalence and determinants of overweight and obesity in Thai adults: results of the Second National Health Examination Survey," *Journal of the Medical Association of Thailand*, vol. 87, no. 6, pp. 685–693, 2004.

[16] Y. Wu, "Overweight and obesity in China," *British Medical Journal*, vol. 333, no. 7564, pp. 362–363, 2006.

[17] G. M. Villavieja, R. D. Lana, and C. M. Cerdena, "1998 updating of nutritional status of Filipino children at the provincial level," *Philippine Journal of Nutrition*, vol. 48, pp. 1–14, 2001.

[18] C. S. Yajnik, "Nutrient-mediated teratogenesis and fuel-mediated teratogenesis: two pathways of intrauterine programming of diabetes," *International Journal of Gynecology and Obstetrics*, vol. 104, pp. S27–S31, 2009.

[19] M. de Onis, C. Monteiro, J. Akre, and G. Clugston, "The worldwide magnitude of protein-energy malnutrition: an overview from the WHO global database on child growth," *Bulletin of the World Health Organization*, vol. 71, no. 6, pp. 703–712, 1993.

[20] B. M. Popkin, M. K. Richards, and C. A. Montiero, "Stunting is associated with overweight in children of four nations that are undergoing the nutrition transition," *Journal of Nutrition*, vol. 126, no. 12, pp. 3009–3016, 1996.

[21] A. L. Sawaya and S. Roberts, "Stunting and future risk of obesity: principal physiological mechanisms," *Cadernos de Saúde Pública*, vol. 19, pp. S21–S28, 2003.

[22] A. Ramachandran, S. Mary, A. Yamuna, N. Murugesan, and C. Snehalatha, "High prevalence of diabetes and cardiovascular risk factors associated with urbanization in india," *Diabetes Care*, vol. 31, no. 5, pp. 893–898, 2008.

[23] A. Ramachandran, C. Snehalatha, and V. Vijay, "Temporal changes in prevalence of type 2 diabetes and impaired glucose tolerance in urban southern India," *Diabetes Research and Clinical Practice*, vol. 58, no. 1, pp. 55–60, 2002.

[24] A. Ramachandran, C. Snehalatha, A. D. S. Baskar et al., "Temporal changes in prevalence of diabetes and impaired glucose tolerance associated with lifestyle transition occurring in the rural population in India," *Diabetologia*, vol. 47, no. 5, pp. 860–865, 2004.

[25] International Obesity Task Force Secretariat, "The global challenge of obesity and the International Obesity Task Force," http://www.iuns.org/features/obesity/obesity.htm.

[26] D. A. Lawlor and N. Chaturvedi, "Treatment and prevention of obesity—are there critical periods for intervention?" *International Journal of Epidemiology*, vol. 35, no. 1, pp. 3–9, 2006.

[27] J. Parizkova, M.-K. Chin, M. Chia, and J. Yang, "An international perspective on obesity, health and physical activity: current trends and challenges in China and Asia," *Journal of Exercise Science and Fitness*, vol. 5, no. 1, pp. 7–23, 2007.

[28] C. Gopalan, "Current food and nutrition situation in south Asian and south-east Asian countries," *Biomedical and Environmental Sciences*, vol. 9, no. 2-3, pp. 102–116, 1996.

[29] K. Vijayalakshmi, G. Amarender Reddy, T. Prasanna Krishna, and K. Krishnaswamy, "Obesity in adolescents of different socio-economic groups: prevalence in Andhra Pradesh, India," *Asia Pacific Journal of Clinical Nutrition*, vol. 11, supplement, pp. S740–S743, 2002.

[30] B. M. Popkin, "Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases," *American Journal of Clinical Nutrition*, vol. 84, no. 2, pp. 289–298, 2006.

[31] T. O. Cheng, "Fast food and obesity in China," *Journal of the American College of Cardiology*, vol. 42, no. 4, p. 773, 2003.

[32] J. C. N. Chan, V. Malik, W. Jia et al., "Diabetes in Asia: epidemiology, risk factors, and pathophysiology," *Journal of the American Medical Association*, vol. 301, no. 20, pp. 2129–2140, 2009.

[33] C. A. Monteiro, E. C. Moura, W. L. Conde, and B. M. Popkin, "Socioeconomic status and obesity in adult populations of developing countries: a review," *Bulletin of the World Health Organization*, vol. 82, no. 12, pp. 940–946, 2004.

[34] N. V. Dhurandhar and P. R. Kulkarni, "Prevalence of obesity in Bombay," *International Journal of Obesity*, vol. 16, no. 5, pp. 367–375, 1992.

[35] C. B. Ebbeling, D. B. Pawlak, and D. S. Ludwig, "Childhood obesity: public-health crisis, common sense cure," *The Lancet*, vol. 360, no. 9331, pp. 473–482, 2002.

[36] Y. Matsushita, N. Yoshiike, F. Kaneda, K. Yoshita, and H. Takimoto, "Trends in childhood obesity in Japan over the last 25 years from the national nutrition survey," *Obesity Research*, vol. 12, no. 2, pp. 205–214, 2004.

[37] T. J. Cole, M. C. Bellizzi, K. M. Flegal, and W. H. Dietz, "Establishing a standard definition for child overweight and obesity worldwide: international survey," *British Medical Journal*, vol. 320, no. 7244, pp. 1240–1243, 2000.

[38] A. Ramachandran, C. Snehalatha, R. Vinitha et al., "Prevalence of overweight in urban Indian adolescent school children," *Diabetes Research and Clinical Practice*, vol. 57, no. 3, pp. 185–190, 2002.

[39] M. Chia, J. Wang, T. K. Sock-Miang, J. J. Quek, and K. Kumar, "Relationship between hours of computer use, physical activity and physical fitness among children and adolescents," *European Journal of Physical Education*, vol. 7, no. 2, pp. 136–155, 2002.

[40] S. M. Sidik and R. Ahmad, "Childhood obesity: contributing factors, consequences and intervention," *Malaysian Journal of Nutrition*, vol. 10, no. 1, pp. 13–22, 2004.

[41] L. Wang, L. Kong, F. Wu, Y. Bai, and R. Burton, "Preventing chronic diseases in China," *The Lancet*, vol. 366, no. 9499, pp. 1821–1824, 2005.

[42] Y. Li, F. Zhai, X. Yang et al., "Determinants of childhood overweight and obesity in China," *British Journal of Nutrition*, vol. 97, no. 1, pp. 210–215, 2007.

[43] R. K. Johnson, L. J. Appel, M. Brands et al., "Dietary sugars intake and cardiovascular health a scientific statement from the American Heart Association," *Circulation*, vol. 120, no. 11, pp. 1011–1020, 2009.

[44] R. Weiss, J. Dziura, T. S. Burgert et al., "Obesity and the metabolic syndrome in children and adolescents," *The New England Journal of Medicine*, vol. 350, no. 23, pp. 2362–2374, 2004.

[45] M. L. Cruz and M. I. Goran, "The metabolic syndrome in children and adolescents," *Current Diabetes Reports*, vol. 4, no. 1, pp. 53–62, 2004.

[46] A. Ramachandran, C. Snehalatha, A. Yamuna, N. Murugesan, and K. M. V. Narayan, "Insulin resistance and clustering of cardiometabolic risk factors in urban teenagers in Southern India," *Diabetes Care*, vol. 30, no. 7, pp. 1828–1833, 2007.

[47] A. Ramachandran, C. Snehalatha, A. Kapur et al., "High prevalence of diabetes and impaired glucose tolerance in India: National Urban Diabetes Survey," *Diabetologia*, vol. 44, no. 9, pp. 1094–1101, 2001.

[48] C. Snehalatha, V. Viswanathan, and A. Ramachandran, "Cut-off values for normal anthropometric variables in Asian Indian adults," *Diabetes Care*, vol. 26, no. 5, pp. 1380–1384, 2003.

[49] A. Misra, R. M. Pandey, J. R. Devi, R. Sharma, N. K. Vikram, and N. Khanna, "High prevalence of diabetes, obesity and dyslipidaemia in urban slum population in northern India," *International Journal of Obesity*, vol. 25, no. 11, pp. 1722–1729, 2001.

[50] M. Chandalia, N. Abate, A. Garg, J. Stray-Gundersen, and S. M. Grundy, "Relationship between generalized and upper body obesity to insulin resistance in Asian Indian men," *Journal of Clinical Endocrinology and Metabolism*, vol. 84, no. 7, pp. 2329–2335, 1999.

[51] Report of WHO Consultation, "Obesity: preventing and managing the global epidemic," *World Health Organization—Technical Report Series*, no. 894, pp. 1–253, 2000.

[52] K. G. M. M. Alberti, P. Zimmet, and J. Shaw, "Metabolic syndrome—a new world-wide definition. A consensus statement from the International Diabetes Federation," *Diabetic Medicine*, vol. 23, no. 5, pp. 469–480, 2006.

[53] "Medscape Conference Coverage, based on selected sessions at the: European Society of Cardiology 2006 World Congress," http://www.medscape.com/viewarticle/544229%3Frss.

[54] V. Hirani and E. Stamatakis, "Anthropometric measures, overweight, and obesity," in *The Scottish Health Survey*, vol. 6, pp. 163–203, 2004.

[55] C. Snehalatha, A. Ramachandran, K. Satyavani, M. Y. Vallabi, and V. Viswanathan, "Computed axial tomographic scan measurement of abdominal fat distribution and its correlation with anthropometry and insulin secretion in healthy Asian Indians," *Metabolism*, vol. 46, no. 10, pp. 1220–1224, 1997.

[56] A. Ramachandran and C. Snehalatha, "Current scenario of diabetes in India," *Journal of Diabetes*, vol. 1, pp. 18–28, 2009.

[57] A. Raji, E. W. Seely, R. A. Arky, and D. C. Simonson, "Body fat distribution and insulin resistance in healthy Asian Indians and Caucasians," *Journal of Clinical Endocrinology and Metabolism*, vol. 86, no. 11, pp. 5366–5371, 2001.

[58] C. S. Yajnik, H. G. Lubree, S. S. Rege et al., "Adiposity and hyperinsulinemia in Indians are present at birth," *Journal of Clinical Endocrinology and Metabolism*, vol. 87, no. 12, pp. 5575–5580, 2002.

[59] T. Gill, "Young people with diabetes and obesity in Asia: a growing epidemic," *Diabetes Voice*, vol. 52, pp. 20–22, 2007.

[60] F. Thévenod, "Pathophysiology of diabetes mellitus type 2: roles of obesity, insulin resistance and β-cell dysfunction," *Frontiers in Diabetes*, vol. 19, pp. 1–18, 2008.

[61] R. J. F. Loos and C. Bouchard, "Obesity—is it a genetic disorder?" *Journal of Internal Medicine*, vol. 254, no. 5, pp. 401–425, 2003.

[62] R. C. Whitaker, J. A. Wright, M. S. Pepe, K. D. Seidel, and W. H. Dietz, "Predicting obesity in young adulthood from childhood and parental obesity," *The New England Journal of Medicine*, vol. 337, no. 13, pp. 869–873, 1997.

[63] G. Davey, A. Ramachandran, C. Snehalatha, G. A. Hitman, and P. M. McKeigue, "Familial aggregation of central obesity in Southern Indians," *International Journal of Obesity*, vol. 24, no. 11, pp. 1523–1527, 2000.

[64] S. K. Kumanyika, E. Obarzanek, N. Stettler et al., "Population-based prevention of obesity: the need for comprehensive promotion of healthful eating, physical activity, and energy balance: a scientific statement from American Heart Association Council on Epidemiology and Prevention, Interdisciplinary Committee for prevention (formerly the expert panel on population and prevention science)," *Circulation*, vol. 118, no. 4, pp. 428–464, 2008.

[65] R. E. Pratley and G. Matfin, "Pre-diabetes: clinical relevance and therapeutic approach," *British Journal of Diabetes and Vascular Disease*, vol. 7, no. 3, pp. 120–129, 2007.

[66] *The World Health Report 2006: Working Together for Health*, World Health Organization, Geneva, Switzerland, 2006.

[67] C. M. Toh, J. Cutter, and S. K. Chew, "School based intervention has reduced obesity in Singapore," *British Medical Journal*, vol. 324, no. 7334, p. 427, 2002.

[68] G. Glazer, "Long-term pharmacotherapy of obesity 2000: a review of efficacy and safety," *Archives of Internal Medicine*, vol. 161, no. 15, pp. 1814–1824, 2001.

[69] R. S. Padwal and S. R. Majumdar, "Drug treatments for obesity: orlistat, sibutramine, and rimonabant," *The Lancet*, vol. 369, no. 9555, pp. 71–77, 2007.

[70] Y. Wang and T. Lobstein, "Worldwide trends in childhood overweight and obesity," *International Journal of Pediatric Obesity*, vol. 1, no. 1, pp. 11–25, 2006.