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Epidemiological Research in Physical Activity and Sedentary Behaviors

Lead Guest Editor: Wonwoo Byun
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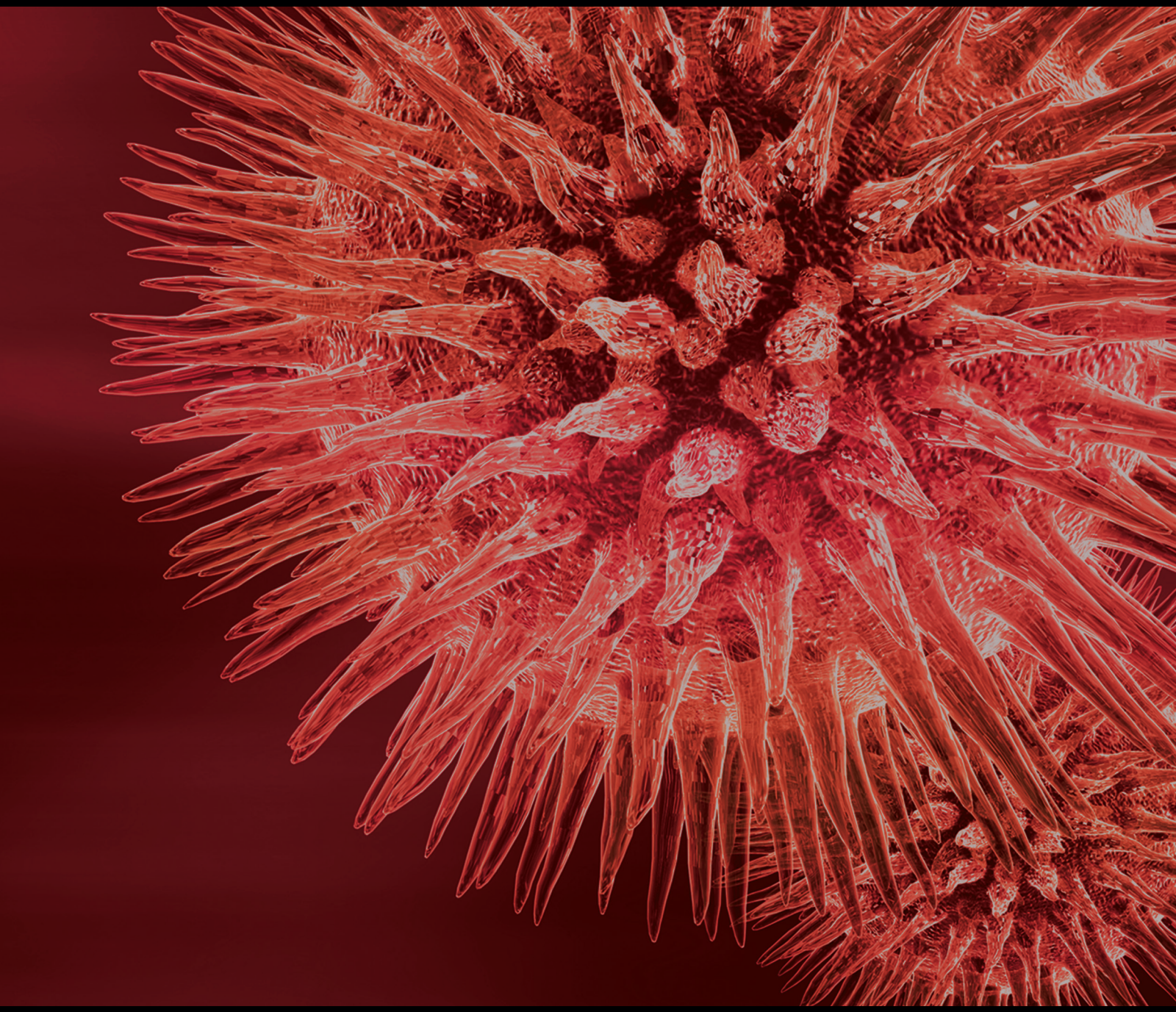

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Contents

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Editorial

Epidemiological Research in Physical Activity and Sedentary Behaviors

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Accumulating data from population-based epidemiological studies is needed to demonstrate positive health outcomes associated with regular physical activity across lifespans. It becomes clearer that physical activity plays a critical role in preventing a number of chronic diseases, such as cardiovascular disease [1], type 2 diabetes [2], obesity [3], osteoporosis [4], and cancer [5], as well as premature mortality [6, 7]. To date, unfortunately, only a small proportion of the population in developed and/or developing countries is physically active enough to gain the associated health benefits. Thus it places physical inactivity (i.e., lack of physical activity) as one of the major public health concerns worldwide.

Further, more recently, there is growing evidence concerning sedentary behavior, independent of physical inactivity, as an emerging health risk behavior in contemporary societies. Recent studies showed that not only the total volume of time spent being sedentary, but also the manner in which sedentary time is accumulated are associated with health outcomes [6, 8]. However, available data are limited and sometimes inconsistent, leaving a gap in understanding the role of sedentary behavior on health in various population groups. As part of continuous efforts to extend our understanding in two of the most influencing lifestyle factors on human health, physical activity, and sedentary behaviors, this special issue focuses on a broad range of topics in epidemiological research on physical activity and sedentary behavior within a behavioral epidemiology framework.

We invited investigators to submit original research articles as well as review articles addressing recent advances in epidemiological studies defining physical activity and/or sedentary behavior as either an exposure or an outcome variable. More specifically, this special issue is dedicated (1) to understanding how physical activity and/or sedentary behavior independently and/or jointly influence the risk of developing adverse health outcomes and longevity in various population groups, (2) to exploring the factors at various levels (e.g., individual, environmental) influencing physical activity and sedentary behavior, (3) to improving physical activity and sedentary behavior assessments in epidemiological research; and (4) to exploring the evidence-based intervention strategies to modify the behaviors at various population groups.

Given the significant burden and the increasing prevalence of chronic disease, the social significance of physical activity and sedentary behavior have never been greater. This special issue has strived to include, in a comprehensive manner, novel research employing methodologies in epidemiology studies such as randomized controlled trials, community-based interventions, observational study, and systematic reviews. With the recognition of difficulties in translating scientific knowledge generated from research into public health practice, we believe that the knowledge provided by this special issue would further contribute to generating high-quality evidence on the health benefits of physical activity and promoting physical activity in practical settings.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Wonwoo Byun
Jung-Min Lee
Yang Bai
Youngdeok Kim

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Research Article

Understanding the Motives of Undertaking Physical Activity with Different Levels of Intensity among Adolescents: Results of the INDARES Study

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Background. The aim of this study was to evaluate the relationship between the motives for undertaking physical activity (PA) and the intensity of PA in Polish adolescents. *Methods.* The study included 1,231 students, 515 boys (age 16.2 ± 0.7 years) and 716 girls (age 16.3 ± 0.6 years). The participants were recruited from secondary schools in 20 conurbations throughout Poland. The International Physical Activity Questionnaire-Long Form and the Motives for Physical Activity Measure-Revised were used. *Results.* In boys, all motives predicted a 10.4% variance in vigorous intensity of PA ($F(5, 509) = 11.822$, $p < .001$). Higher scores on competence and appearance motives for PA were found to be predictors of higher level of vigorous intensity of PA. In girls, all motives explained a 7.4% variance in vigorous intensity of PA ($F(5, 710) = 11.292$, $p < .001$). Higher scores on competence and appearance motives for PA were found to be predictors of higher level of vigorous intensity of PA. *Conclusions.* This study shows that competence and appearance related motives for PA are important motivations for Polish adolescent girls and boys in undertaking vigorous intensity PA.

1. Introduction

Adolescence is a crucial period in one's live. Both healthy and health-endangering habits and patterns are established during these formative years. Such habits and patterns have the potential to influence one's behavior and health status, as they mature into adulthood [1]. This issue specifically concerns habits of physical activity (PA). Regular PA reduces the risk of many diseases in youth [2, 3] and provides positive health benefits [1]. Conversely, being physically inactive directly connected to multiple negative health consequences [4]. Vigorous intensity of PA may be more beneficial than lower intensity activity in the control of one's weight [5]. It is significant to note that the vigorous intensity of PA by adolescents decreases as they age [6, 7].

Studies show a decline in PA levels in 9-18-year-olds and have indicated that the steepest decline is found between ages 15 and 18, with boys being more active than girls [8, 9]. In this context, PA practices depend primarily on one's awareness, abilities, and willingness to be physically active. Individual motivation enables adolescents to initiate and maintain regular PA which closely parallels individual interests and physical capabilities.

Motivation, as a psychological factor, stimulates an organism to act toward a preferred aim and induces, controls, and sustains certain goal-directed behaviors. Adolescents present various kinds of motivation and differ not only in the levels (i.e., how much) but also in the orientation of motivation (i.e., the underlying attitudes or intentions). The types of sports motivation, provided by Deci and Ryan [10] within self-determination theory (SDT), constitute a basic framework of motivation regulations. These types of motivations range from the specific behavior of intrinsic, to the extrinsic or demotivational types, who may be self-determined (autonomous), controlled, or due to lack of motivation. However, there are other mediating factors that need to be considered. In a systematic review on SDT, based on exercise motivation studies from 1960 through 2011, a positive relationship was identified for individuals with self-determination and their adoption and maintenance of PA [11].

Adolescent motivation in undertaking PA is related to several factors. Social-environmental factors, such as the content of the physical education classes (i.e., different activities), and meaningful adult encouragement (i.e., parents, athletes/celebrities as role-models, and cultural values) are significant in motivating adolescents to undertake PA [12, 13]. Moreover, as demonstrated by Wold et al. [14], the reasons of enjoying leisure time PA in adolescents have changed over the past 20 years.

Some analysis of sports motivation in adolescents points to the fact that boys tend to undertake more vigorous forms of sports involving competition [15] and value achievement factors in PA [16, 17]. While girls tend to undertake less intense forms of PA, they, nonetheless, pursue their PA from motivations such as fitness, well-being, and physical appearance [15]. In addition, for girls, health and social motivation are important factors when considering undertaking PA [16–18]. Another study [19] revealed the cause-effect relationship of perceived sports competences and motor skills proficiency with the level of PA and fitness in adolescents. In addition, according to Jaakkola et al. [20], perceived physical competence toward PA in adolescents was the only predictor of later PA engagement.

Limited research has been conducted on the relationship between motivation and the intensity of PA. In a study by Sibley et al. [21], the appearance motive had a negative correlation with fitness test results, unlike fitness and competence motives, that had a significantly positive relationship.

Investigating the relationships between motivation factors and intensity levels of PA in adolescents may help in better understanding the mechanism behind the engagement of adolescents in PA and improve the understanding of the mediating components that are essential to achieve higher engagement in PA. Based on the above findings, a study has been designed with the objective of evaluating the relationship between motives and intensity of PA in Polish adolescents, separately for boys and girls. It was hypothesized that a vigorous intensity of PA is associated with different motives than a moderate or low intensity of PA and that sex plays a crucial role in this relationship.

2. Material and Methods

2.1. Participants and Procedure. The study included data collected in 2015 from 1,231 students, 515 of whom were boys (age M = 16.2, SD = 0.7 years; body mass M = 67.0, SD = 12.4 kg; body height M = 177.3, SD = 7.1 cm) and 716 were girls (age M = 16.3, SD = 0.6 years; body mass M = 57.0, SD = 0.8 kg; body height M = 166.4, SD = 5.9 cm). Body height was measured to the nearest 0.5 centimeters (cm) using a stadiometer and body weight was measured to the nearest 0.1 kilogram (kg) using electronic scales (Tanita Corporation, Japan), with each participant wearing minimal clothing. Measures were taken during physical education classes and recorded by trained research assistants.

For the purpose of the study, the online system International Database for Research and Education Support (INDARES) (www.indares.com) was used [22]. The Polish version was translated from English in compliance with standardized translation guidelines, including back-translation into English. Polish version of the online system INDARES is a suitable diagnostic tool for the examination of sport and PA preferences sphere in adolescents [23]. The participants were recruited from standard urban schools, within Poland, in twenty major conurbations with more than fifty thousand (50,000) residents. The sample unit for the study was a school. Fifty-one secondary schools were randomly selected. Questionnaires were completed in whole-class groups during one regular school lesson in quiet-classroom conditions. The questionnaires were completed in approximately thirty minutes and were administrated by trained research assistants.

2.2. Ethics. Each of the adolescents and their parents received the study information vis-à-vis in-school meetings at which time the study information was provided and consent forms executed. Adolescents were also informed about the anonymous and voluntary nature of their participation, that the study records would be kept confidential, and that their individual contributions would be unidentified in the final report. The study was approved by the Institutional Research Ethic Committee of Palacký University Olomouc (decision no. 24/2012).

2.3. Physical Activity. For the objective of measuring the level of PA the International Physical Activity Questionnaire-Long Form (IPAQ-LF) was used [24]. The purpose of the questionnaire was to find out about the kinds of PA that people undertake as part of their everyday lives. The IPAQ-LF instrument has acceptable measurement properties (Spearman's p clustered around 0.8, criterion validity, assessed against accelerometer measures, had a median p of about 0.30) as for self-reports [25].

The questions ask about the time spent being physically active during the preceding seven (7) consecutive days. Physical activities were ranked as follows: moderate, activities with moderate physical effort making one breath somewhat harder than normal, and vigorous, activities with hard physical effort making one breath much harder than normal. Activities were categorized and may have been treated separately to obtain the specific activity patterns or, alternatively, multiplied

Table 1: Descriptive statistics analyzed variables and differences between boys and girls.

	Overall N = 1231 $M \pm SD$	Boys n = 515 $M \pm SD$	Girls n = 716 $M \pm SD$	p
Anthropometric parameters				
Weight (kg)	61.2 ± 11.7	67.1 ± 12.4	57.0 ± 8.9	< .001
Height (cm)	171.0 ± 8.5	177.4 ± 7.2	166.4 ± 6.0	< .001
BMI (kg/m^2)	20.9 ± 3.1	21.3 ± 3.4	20.6 ±2.8	< .001
Physical activity (MET-Min week^{-1})				
Vigorous intensity	1735.7 ± 2112.6	2053.1 ± 2228.2	1507.4 ± 1995.9	< .001
Moderate intensity	2216.0 ± 2369.9	2549.0 ± 2574.2	1976.5 ± 2182.0	< .001
Low intensity	2428.2 ± 2254.6	2307.5 ± 2238.7	2515.1 ± 2263.6	.111
Total	6379.9 ± 4839.2	6909.7 ± 5104.0	5998.9 ± 4605.6	< .001
Motives for physical activity				
Interest (pts)	35.4 ± 9.5	37.0 ± 8.9	34.3 ± 9.8	< .001
Competence (pts)	34.9 ± 9.6	37.1 ± 9.0	33.3 ± 9.7	< .001
Appearance (pts)	31.6 ± 8.7	30.0 ± 9.2	32.7 ± 8.1	< .001
Fitness (pts)	26.2 ± 6.3	26.7 ± 6.3	25.9 ± 6.2	.020
Social (pts)	20.8 ± 7.4	22.2 ± 7.4	19.8 ± 7.3	< .001
Total (pts)	148.9 ± 32.9	153.0 ± 32.9	146.0 ± 32.6	< .001

by their estimated value in Metabolic Equivalent of Tasks (METs) and totaled in order to gain an overall estimate of PA in a week [26]. According to IPAQ-LF procedure, the MET intensity values used to classify the scores in the questions were vigorous (6 METs), moderate (4 METs), and low, otherwise known as walking (3.3 METs). Time spent in each activity category was derived by multiplying the number of days per week by the minutes spent doing the activity per day, while total weekly PA (MET-Min week^{-1}) was calculated by multiplying the number of minutes spent in each activity category by the specific MET score for each activity. Other questions collected information on the time (i.e., the number of days, average times) spent undertaking PA. The permitted average daily sum of minutes of PA and transportation was set to 600 minutes. Due to these study requirements, 156 participants were excluded. These participants reported an unrealistic estimate of each PA category. Specifically, boys increased the time estimate and the number of days in which they performed vigorous intensity PA.

2.4. Motives for Physical Activity. Participants' motives were assessed with the Motives for Physical Activity Measure-Revised (MPAM-R) [27]. The internal consistency of the scale was high (Cronbach's alpha above 0.87 for each subscale). The scale consists of a total of 30 items assessing five categories of reasons for activity engagement: interest/enjoyment (7 items), competence (7 items), appearance (6 items), fitness (5 items), and social (5 items). A 7-point Likert scale (1, "not at all true for me"; 7, "very true for me") was used to rate the reason for participating in each of the items.

2.5. Statistical Analysis. Descriptive statistics and t-test were used to examine the differences in the analyzed variables for boys and girls. Pearson correlations and multiple regressions were conducted to investigate the relationships of PA with motives for PA in boys and girls. Statistical analysis was carried out using STATISTICA software (StatSoft, Inc., USA).

3. Results

Basic statistical characteristics of the analyzed variables are presented in Table 1, along with the significance of differences between girls and boys. Girls differed significantly from their male peers with regard to body height, weight, and BMI ($p < .001$). Boys declared a higher level of total PA ($p < .001$) and undertook more PA with vigorous ($p < .001$) and moderate intensity ($p < .001$) in comparison to girls. The differences between boys and girls in motives could be found in all motives for PA. Boys scored higher than girls on the following motives, interest, competence, social ($p < .001$), and fitness ($p = .020$), and lower on appearance ($p < .001$).

Pearson's correlation coefficients between motives and PA in girls and boys are summarized in Table 2. In boys, a significant positive correlation was documented between total PA, moderate and vigorous intensity of PA, and all motives for PA ($p < .05$), excluding the relationship between vigorous intensity of PA and social motives. Higher scores on interest and competence were associated with low intensity of PA ($p < .05$). Among girls, a higher level of total PA and higher level of vigorous and low intensity of PA were associated with a higher score on all motives for PA ($p < .05$). However, there was no statistically significant relationship between moderate intensity of PA and examined motives for PA in girls.

To test the hypothesis that PA undertaken with different intensity is related to different motives for PA in adolescent boys and girls, a multiple regression was conducted (Tables 3 and 4).

In boys (Table 3), all motives predicted a 10.4% variance in vigorous intensity of PA ($F(5, 509) = 11.822$, $p < .001$). Higher

Table 2: Pearson's correlation coefficients between motives and PA.

Physical activity	Motives for physical activity					
	Interest	Competence	Appearance	Fitness	Social	Total
			Boys			
Vigorous intensity	.23*	.28*	.20*	.18*	.06	.24*
Moderate intensity	.10*	.13*	.12*	.15*	.09*	.14*
Low intensity	.11*	.11*	.07	.07	.05	.10*
Total	.20*	.23*	.18*	.18*	.09*	.22*
			Girls			
Vigorous intensity	.23*	.25*	.11*	.15*	.13*	.23*
Moderate intensity	.03	.06	.05	.06	.06	.07
Low intensity	.08*	.09*	.08*	.09*	.09*	.11*
Total	.15*	.18*	.11*	.14*	.13*	.19*

Note. * $p < .05$

Table 3: Results of multiple regressions examining the association between motives and PA in boys.

Physical activity	Motives	B	β	T	P
Vigorous intensity		$F(5,509) = 11.822$, $p < .001$, Model $R^2 = .104$			
	(Constant)	-529.160		-1.177	.240
	Interest	31.506	.125	1.557	.120
	Competence	67.977	.274	3.436	< .001
	Appearance	35.612	.147	2.684	.008
	Fitness	-41.823	-.119	-1.708	.088
	Social	-47.726	-.158	-2.923	.004
Moderate intensity		$F(5,509) = 2.648$, $p = .022$, Model $R^2 = .025$			
	(Constant)	807.764		1.491	.136
	Interest	-19.582	-.067	-.803	.422
	Competence	21.702	.076	.910	.363
	Appearance	10.708	.038	.670	.503
	Fitness	39.441	.097	1.337	.182
	Social	12.895	.037	.655	.512
Total		$F(5,509) = 6.820$, $p < .001$, Model $R^2 = .063$			
	(Constant)	1498.001		1.422	.155
	Interest	36.749	.064	.775	.438
	Competence	103.562	.182	2.235	.026
	Appearance	56.490	.102	1.817	.070
	Fitness	-16.495	-.020	-.288	.774
	Social	-47.173	-.068	-1.233	.218

scores on competence ($p < .001$) and appearance ($p = .008$) motives for PA were found to be an indicator of higher level of vigorous intensity of PA. Although the model consisting of different motives in prediction of moderate intensity of PA was significant ($F(5, 509) = 2.648$, $p = .022$) and explained 2.5% of variance, separately none of the motives significantly predicted moderate intensity of PA. The model consisting of different motives and low intensity of PA was not significant ($F(5, 509) = 1.535$, $p = .177$).

In girls (Table 4), all motives explained a 7.4% variance in vigorous intensity of PA ($F(5, 710) = 11.292$, $p < .001$). Higher scores on competence ($p < .001$) and appearance ($p = .038$) motives for PA were found to be predictors of higher levels of vigorous intensity of PA. The models consisting of different motives in predicting moderate and low intensity of PA were found to not be significant ($F(5, 710) = 1.521$, $p = .181$ and $F(5, 710) = 1.925$, $p = .088$, respectively).

Both in girls and boys the model consisting of different motives in predicting total PA was significant ($p < .001$) and explained a 6.3% (in boys) and 4.0% (in girls) variance in total PA. In girls and boys, higher scores on competence were associated with higher levels of total PA ($p < .05$).

4. Discussion

In the forgoing study, the relationship between the individual motives and intensity of PA in Polish adolescents was evaluated. The study hypothesized that PA undertaken with

Table 4: Results of multiple regressions examining the association between motives and PA in girls.

Physical activity	Motives	B	β	T	P
Vigorous intensity		$F(5,710) = 11.292$, $p < .001$, Model $R^2 = .074$			
	(Constant)	-370.360		-1.032	.302
	Interest	15.806	.078	1.048	.295
	Competence	56.390	.275	3.693	< .001
	Appearance	21.676	.088	2.075	.038
	Fitness	-41.392	-.128	-2.151	.032
	Social	-9.161	-.034	-.733	.464
Total		$F(5,710) = 5.874$, $p < .001$, Model $R^2 = .040$			
	(Constant)	2216.195		2.629	.009
	Interest	-17.667	-.038	-.498	.618
	Competence	91.865	.194	2.561	.011
	Appearance	43.610	.077	1.777	.076
	Fitness	-22.825	-.031	-.505	.614
	Social	24.816	.040	.845	.398

different intensity is related to different motives in adolescent boys and girls. It was found that, in boys, higher scores on competence and appearance motives for PA were associated with the higher level of vigorous intensity of PA. Similarly, in girls, higher scores on competence and appearance motives for PA were associated with the higher level of vigorous intensity of PA.

The findings are consistent with a previous study demonstrating that high physical competencies allow for achievement of better results in the competition which was found to be an important PA motivator for boys [28]. It is noteworthy that, in the current study, competence was also an important motive for PA among girls. This result corresponds to the reports indicating that movement competency seems to be a crucial motivating factor in determining an adolescents' ability to start/restart PA participation [29]. The motives associated with the competencies that lead to success in competition may be contrary to the social motivation, which are important to achieve success in sports competition [28]. This may explain the lower importance of social motivation noticed in the presented study findings.

In the current study, in both boys and girls, a higher score on appearance motive for PA was found to be a predictor of the higher level of vigorous PA. This result may be related to the prevalence of body dissatisfaction among adolescents [30]. Likewise, in Laudańska-Krzemińska and Bronikowski's [31] study adolescent girls were extremely critical of their bodies, which led to a lower belief in their possibilities, the will to be someone else, the need to change appearance, and less frequently perceived happiness. In girls, the desire to be thin and feminine leads to increased motivation to be physically active [32], whereas in the case of boys, low body satisfaction often leads to undertaking PA to achieve muscular body shape [33]. This finding may be associated with pressure from the mass media. Sociocultural and biological patterns of masculine and feminine body types may be the reasons that the appearance motive for PA was a predictor of the higher level of vigorous PA in the present study. Similar results have been registered in a previous study [34].

In the present study, social motivation was more important for girls than for boys, which is also in line with the results obtained by Foran et al. [35]. The importance of social motivation for girls was also registered in other studies [16, 17]. Additionally, a study by Ianotti et al. [18] showed that girls had lower social and achievement motivation, but higher health motivation than boys. Litt et al. [17] suggested that it is important to communicate the health benefits of PA as the key motive for affecting the level of PA in adolescents. This corresponds to Kalman et al.'s [16] results, which found that health is a more important value consideration for older adolescent girls, whereas Verkooijen et al. [28] indicated that health and enjoyment were similarly important for both genders. Furthermore, in our study boys reported higher rates of achievement motivation than girls. This is consistent with other studies that found achievement was more important for boys than girls [16, 18].

Our results show that, in comparison to girls, boys demonstrated a higher level of total PA and undertook more PA with vigorous and moderate intensity. A larger number of female respondents presented a low level of PA in comparison to boys. The findings of the current study are in line with the general findings of the epidemiology of PA in adolescents, where boys were more active than girls [36]. Similar results were obtained by Iannotti et al. [18], where female adolescents were less active than males, which further emphasized the role of motivation, and the different reasons for undertaking PA by adolescents. For example, for European girls and boys, achievement motivation was positively related to PA. Moreover, for girls, social motivation was also a strong predictor of PA [18].

In the present study, we found that boys scored higher than girls on the following motives, interest, competence, social, and fitness, and lower on appearance. It should be considered, that adolescents' PA is determined by a complex array of intrapersonal, interpersonal, family, school, and community environmental factors [37, 38]. Thus, the present findings may be related to extraneous factors not evaluated in the current research. For girls, especially, the motives for

undertaking PA in the present study were mainly appearance-oriented. This appearance factor may be linked to the specific choice of the form of PA. Frömel et al. [39] have pointed out that girls most often prefer forms of PA dominated by smooth, aesthetic movements. Camacho-Miñano et al. [40] have recommended making PA enjoyable for girls by increasing the choices and offering a wide range of noncompetitive and innovative activities. Barr-Anderson et al. [41] have also reported that enjoyment was the key PA motivator for girls.

In consideration of the SDT, a review of forty-six studies of the association between the motivations and PA in both children and adolescents indicated that autonomous motivation had a moderate positive association with PA; conversely, controlled forms of motivation had a weak negative association with PA [42]. It appears that autonomous motivation is important mainly for adolescents. Adolescence is a crucial time of increasing autonomy. Accordingly, providing best choices and involving the young people, themselves, in designing PA programs may be worthwhile in establishing and encouraging self-initiated behavior change [43].

Predicated upon this study, and previous studies, possible strategies to improve motives of undertaking PA in adolescents should be driven (for both boys and girls) by primarily focusing on competences and appearance, especially competences that have been shown to be the crucial predictor of continued physical activity in adulthood [20]. Additionally, other areas which might strengthen the motivation should be developed and encouraged through better planning (social network, making arrangements to play with friends and prioritizing PA, effective time management), greater variety of PA (e.g., new and nontraditional activities, more intensive activities), social aspects, parental, teachers and peers' support, restructuring physical education environment, and implementation of health-oriented programs.

Some limitations and strengths of the current study are worth noting. Self-reported measures methods were used. As such, the subjective interpretation of questions may have influenced some of the findings. Future research may benefit from including other factors that may contribute to the explanation of the motives behind undertaking the various levels of PA intensity and related behaviors (e.g., self-efficacy, moral norms, past PA experiences, self-identity, and environmental factors).

Clearly, the strengths of the study include the large sample size of the adolescent female and male participants, recruitment throughout Poland, and the use of standard assessments at each measurement point. The academic acceptance of the applied research tool which allows for comparison of the present study results with findings of other researchers further validates the objective and findings of this study. Finally, the original nature of the present research demonstrates how adolescents are differently motivated toward PA of various intensities.

5. Conclusions

The academic research presented in this study has had as its objective the presentation of empirical data to advance the understanding of the associations between the motives and intensity of PA in Polish adolescents. The findings from the present study confirm that both boy's and girl's competence and appearance motives for PA were predictors of higher levels of vigorous intensity of PA. School physical education programs and PA interventions would be well-served to incorporate this study's findings to form a more complete understanding of the complex motivators of adolescence decision-making as it relates to vigorous PA.

Further analysis as to why competence and appearance were the main predictors of vigorous PA among young people is required. Disturbing is the fact that the study's findings express what little importance young people place on the health and social aspects of PA. Therefore, this study expresses the need to increase the awareness of young people of the physical and emotional benefits of vigorous PA. Moreover, this study points to the need for improved programs for the presentation of the best approaches for implementing and expanding the knowledge of young people on the life-long health advantages of proper PA.

In conclusion, a better understanding of the motives for PA, as well as differences between young boys and girls, can be applied as a framework to improve physical education curriculums.

In turn, this awareness may act to encourage young people to have more active lifestyles. Notwithstanding this present study, more research and analysis will continue to be necessary to add to the knowledge base to more completely understand the complex relationships driving the motivation for PA, and the intensity of PA, in adolescents.

Data Availability

All data arising from this study are contained within the manuscript and supplementary information file.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Supplementary Materials

Supplementary materials contain raw data concerning variables examined in the study. *(Supplementary Materials)*

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Research Article

Objectively Measured Physical Activity and Sedentary Time among Children and Adolescents in Morocco: A Cross-Sectional Study

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Background. Regular physical activity in childhood and adolescent plays an important role in reducing the risk of cardiovascular health diseases, diabetes, and obesity in adulthood. However, little is known about physical activity levels (PA) and sedentary time among children and adolescents in Morocco. *Objective.* To examine gender, type of day, and age grade differences in objectively measured sedentary time, physical activity levels, and physical activity guideline attainment among children and adolescents in Morocco. *Method.* 172 children/adolescents (mean age = 10.92 ± 1.55 years, 49.4% are boys) were recruited for this study and wore a tri-axial accelerometer (GT3X+) for 7 consecutive days. Time spent in sedentary, PA levels, and daily steps were measured and compared according to gender, age grade, and the type of day (weekdays/weekends). *Results.* In weekdays children/adolescents spent more time in sedentary than weekends ($p < 0.001$). Boys were eight times more likely to meet the recommendation for at least 60 min of moderate to vigorous physical activity per day than girls (OR: 8.569; 95% [CI]: 4.23–17.32), $p < 0.001$. *Conclusion.* These findings highlight the need for effective and sustainable strategies and programs aiming to promote physical activity and to reduce sedentary behavior among children and adolescents in Morocco.

1. Introduction

Physical inactivity is the fourth leading cause of death in the world [1]. Lack of physical activity is an important contributing factor in the development of childhood obesity [2]. Overweight children and adolescents are more likely to become obese and to develop noncommunicable diseases (NCDs) during adulthood [2]. A total of ≥60 min of moderate to vigorous physical activity (MVPA) each day is recommended for children aged 6 to 17 years [3]. Reduction in physical inactivity would reduce between 6% and 10% of the major NCDs and increase life expectancy [4].

In high-income countries (HIC), surveillance of children and adolescents physical activities using objective method has been taken for decades [5]. In contrary to Africa, few studies have used objective methods to assess PA among children and estimates of physical activity or sedentary behavior has derived mostly from self-report questionnaires. Indeed, a review of Peltzer reported that only 14.2% of children from 8 countries were physically active (5 days or more in a week with at least 60 min/day) and there are large differences among countries meeting the PA guidelines, 17.7% in Uganda and 9.0% in Zambia through self-report questionnaires [6], 3.9% in Mozambique [7], 1% in South Africa using GT3X accelerometer [8], and 54.8% in Senegal using GT3X+ accelerometer [9].

In Morocco, physical activity in children and adolescents has been measured only with self-report questionnaires [10, 11]. However, activity information derived from self-report is potentially subject to response bias [12] and thus accurate assessment is required to assess current and changing physical activity levels.

As known, physical activity is complex behavior that tends to vary considerably from children or adolescents to another according to different factors. Previous studies assessing objectively measured physical activity among

Table 1: General characteristics of the children/adolescents participants in the study presented by gender (mean ± SD).

	Overall (n=172)	Boys (n=85)	Girls (n=87)	p value
Age (years)	10.92 ± 1.55	10.89 ± 1.50	10.96 ± 1.61	0.793
Weight (kg)	35.00 ± 9.51	34.05 ± 7.06	35.93 ± 11.37	0.195
BMI z-score	-0.16 ± 1.33	-0.18 ± 1.33	-0.14 ± 1.34	0.834

Values are mean ± SD, p values relate to gender difference, and p values derived using t-test.

children and adolescents suggest that boys are more active than girls [13, 14] and physical activity levels decline with age, especially during late primary school years [14]. In Morocco, this study is the first of its kind to use GT3X+ accelerometer to assess physical activity and sedentary time among children and to examine gender, age grade, and type of day differences in physical activity level, sedentary time, and attainment of recommended physical activity guidelines among children and adolescents.

2. Methods

2.1. Ethics Statement. The study was approved by the Ethical Committee of Biomedical Research (CERB). Written informed consent was obtained from the parents of the participants.

2.2. Participants. Participants were a convenience of 175 children/adolescents, who were recruited from urban schools from three cities of Morocco. The study was carried out during school-week, and accelerometry data were collected over seven consecutive days.

To obtain information on children's age, sex, home address, nationality, parental work, and household size, a short parental questionnaire was handed out to assess factors of children's individual socioeconomic status.

2.3. Anthropometry. Anthropometrics measurements were performed by trained operators according to international recommendations [15]. Weight was measured to the nearest 0.1 kg using an electronic portable scale (SECA "Seca Weighing and Measuring Systems, Hamburg", Germany) with the children/adolescents barefoot and wearing light clothes. Height was measured to the nearest 0.1 cm using a stadiometer (ShorrBoard, Portable Height-Length Measuring Board) with the children/adolescents barefoot in a standing position.

2.4. Assessment of Physical Activity. Physical activity was measured using the Actigraph GT3X+ (Pensacola, Florida, USA) a triaxial accelerometer that captures acceleration movements in three axes (Vertical, Horizontal, and Perpendicular) [16].

Children/adolescents were instructed to wear the accelerometer attached to an elasticized belt around the waist, positioned just above the right hip, once they woke up until bed time at night for 7 consecutive days and to remove the accelerometer any time they were to perform activities that involve the use of water such as bathing or swimming, and when going to bed. The accelerometer was initialized to store activity counts every 15 seconds (i.e., for 15-second epochs).

Children/adolescents had to have at least 4 valid days of data (3 week days and 1 weekend day). A valid day is a day with ≥ 600 min of registered data. The cut point used to determine the level of physical activity is the cut point developed by Evenson [17]. The levels of PA were expressed in count per minute (cpm): sedentary (0–100 cpm), light (101–2295 cpm), moderate (2296–4011 cpm), and vigorous (≥4012 cpm). The Actigraph filter was used to separate physical activity level according to the type of day (weekends, weekdays).

The Actigraph data were downloaded using the software provided by the manufacturer (version 6.13.2, Actilife).

2.5. Statistical Analysis. The Kolmogorov Smirnov test was performed to check the distribution of the variables; all variables were normally distributed and were expressed as the mean with standard deviations. t-test was used to examine the difference between weekends and weekdays.

In order to analyze the difference in physical activity levels and sedentary time by age grade, we divided the participants into two subgroups: children [8-11[years and adolescents [11-14] years. Two-way analysis of covariance was used to examine gender and age grade differences in physical activity level and sedentary time variables separately for weekdays and weekends, adjusted for body mass index for age (BMI z-score) and wear time. Effect sizes ($\eta 2$) were also calculated to examine the practical significance of these differences. Logistic regression analyses were conducted to examine independent relationships between attainments of physical activity guidelines and both gender and age grade. All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS, version 21) and results were considered significant at $p < 0.05$.

3. Results

Among the 175 children/adolescents recruited, 3 children/adolescents were excluded from the analysis because of invalid day.

3.1. Description of Children/Adolescents Characteristics. General characteristics of children/adolescents are shown in Table 1.

Children/adolescents were aged between 8 to 14 years (mean age = 10.92 ± 1.55 years). 49.4% were boys. 50 % were aged between 8 and 11 years.

Table 2: Physical activity levels and sedentary time according to the type of day.

	Weekdays	Weekends	p value
Sedentary time (min/day)	559.76 ± 90.75	471.35 ± 127.73	< 0.001
Light intensity physical activity (min/day)	256.20 ± 52.68	266.36 ± 64.70	0.111
Moderate physical activity (min/day)	39.95 ± 18.01	43.26 ± 23.65	0.145
Vigorous physical activity (min/day)	15.30 ± 10.67	16.65 ± 13.02	0.292
MVPA (min/day)	55.25 ± 26.30	59.92 ± 33.76	0.154
Steps per day	10484.82 ± 3554.86	10742.19 ± 4436.79	0.553
Counts (Counts/min)	461.67 ± 159.55	557.11 ± 224.47	< 0.001

Values are mean ± SD, p values relate to the type of day difference, and p values derived using t-test.

The mean BMI z-score was -0.16 ± 1.33. There were no significant differences in children/adolescents characteristics according to gender.

3.2. Description of Physical Activity Levels and Sedentary Time according to the Type of Day. Physical activity levels of children/adolescents according to the type of day are shown in Table 2.

On weekdays, children/adolescents had worn the accelerometer for an average 871.22 ± 75.33 (min/day), with 559.76 ± 90.75 (min/day) of the time in sedentary and average of 55.25 ± 26.30 (min/day) in MVPA (Table 2).

On weekends, children/adolescents had worn the accelerometer for an average 797.64 ± 109.12 (min/day), with an average of 59.92 ± 33.76 (min/day) in MVPA (Table 2).

Children/adolescents spent more time in sedentary during weekdays than weekends ($p < 0.001$). However no differences were seen between weekdays and weekends in MVPA.

During weekdays, children/adolescents accumulate 10484.82 ± 3554.86 steps per day, while in weekends they accumulate 10742.19 ± 4436.79 of steps per day.

Children/adolescents accumulate less count per minute in weekdays than weekends ($p < 0.001$).

Activity data (count/min) in weekdays are depicted in Figure 1. The activity curve (count/min) is illustrative of the typical activity pattern in everyday life of children examined during only weekdays, with characteristic peaks and troughs throughout the day. Activity seems on average lower during school time (8h00 to 12h00 and 14h00 to 16h30) than after school.

Figure 1 represents the average accelerometry count/minute of children and adolescent during weekdays.

3.3. Differences in Physical Activity Levels and Sedentary Time by Gender and Age Grade on Weekdays and Weekends. Table 3 shows the differences in physical activity levels and sedentary time by gender and by age grade on weekdays.

On weekdays, when differences in PA levels and sedentary time were analyzed for gender we observed that boys were more engaged in moderate ($p < 0.001$) and vigorous ($p < 0.001$) activity and took more steps ($p < 0.001$) than girls whereas girls were more engaged in sedentary time than boys ($p = 0.004$).

When PA levels and sedentary time were analyzed for age grade we observed that adolescents spent more time in sedentary ($p = 0.001$) and less time in light activity ($p < 0.001$) than children, whereas no difference according to age grade was observed in MVPA ($p = 0.255$).

Small effect of size of gender was observed in vigorous activity ($\eta 2 = 0.213$).

Table 4 shows the differences in physical activity levels and sedentary time by gender and by age grade on weekends.

During weekends, when differences in PA levels and sedentary time were analyzed for gender we observed that boys were more engaged in moderate ($p < 0.001$) and vigorous ($p < 0.001$) activity and took more steps ($p = 0.001$).

When PA levels and sedentary time were analyzed for age grade, we observed that adolescents spent more time in sedentary ($p = 0.001$) and less time in light activity ($p < 0.001$) than children, whereas no difference according to age grade was observed in MVPA ($p=0.258$).

There are no interactions between gender and age grade with sedentary time ($\eta 2 = 0.001$, $p = 0.669$ on weekdays; $\eta 2 = 0.001$, $p = 0.760$ on weekends) and also with all physical activity levels, for example, with light activity time ($\eta 2 = 0.006$, $p = 0.332$ on weekdays; $\eta 2 = 0.002$, $p = 0.571$ on weekends) and also with steps ($\eta 2 = 0.008$, $p = 0.257$ on weekdays; $\eta 2 < 0.001$, $p = 0.899$ on weekends).

3.4. Attainment of Moderate to Vigorous Physical Activity Guideline by Gender and Age Grade. Table 5 shows the odd ratio of moderate to vigorous physical activity guideline attainment.

38.8 % of the participant attained the recommended MVPA guidelines (≥ 60 min/day) where boys were 8 times more likely to meet this recommendation than girls (OR: 8.569; 95% confidence interval [CI]: 4.23–17.32).

4. Discussion

This is the first study in Morocco to objectively assess sedentary time and physical activity levels according to gender, age grade, and type of day in children and adolescents with GT3X+ accelerometer. The results of this study suggest that children and adolescents spent more time in sedentary during weekdays versus weekends. The amount of time spent in moderate to vigorous activity is higher among boys than girls.

Several studies [13, 18–21] have examined the time spent in different intensities using objective measures of activity. In the present study, the proportion of time spent in sedentary constituted the majority of the day in

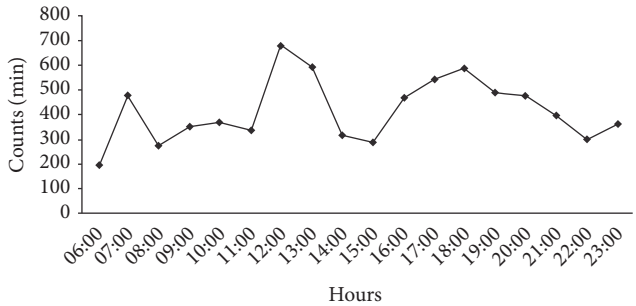

Figure 1: Cumulative mean physical activity counts per minute over the weekdays.

Table 3: Physical activity levels and sedentary time by gender and by age grade on weekdays.

			Sedentary time (min/day)		Light activity (min/day)		Moderate activity (min/day)		Vigorous activity (min/day)		Steps (steps/day)	
			Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Children	Mean		526.4	559.3	277.1	264.7	48.8	35.7	18.8	11.3	11514.4	10005.1
	95% CI	Lower	506.7	540.6	261.6	249.9	43.7	30.8	15.9	8.5	10469.8	9008.03
		Upper	546.1	578.1	292.5	279.4	53.9	40.6	21.7	14.1	12559.1	11002.1
Adolescents	Mean		563.8	588.4	240.5	243.1	45.3	30.1	21.4	9.5	11558.3	8868.9
	95% CI	Lower	544.7	568.9	225.5	227.8	40.3	25.1	18.6	6.6	10547.5	7838.2
		Upper	582.8	607.8	255.5	258.3	50.2	35.1	24.3	12.4	12569.1	9899.7
	Gender	F	8.77		0.41		31.5		44.9		16.6	
		p-value	0.004		0.519		< 0.001		< 0.001		< 0.001	
		$\eta 2$	0.050		0.003		0.160		0.213		0.09	
	Age grade	F	11.47		14.29		3.22		0.09		1.10	
		p-value	0.001		< 0.001		0.075		0.761		0.295	
		$\eta 2$	0.065		0.079		0.019		0.001		0.007	
	Gender	F	0.18		0.94		0.17		2.32		1.29	
	*	p-value	0.669		0.332		0.675		0.129		0.257	
	Age grade	$\eta 2$	0.001		0.006		0.001		0.014		0.008	

Adjusted for BMI z-score and wear time.

these children/adolescents. This makes sense because children/adolescents were sitting in class much of the school days.

Comparisons across the studies for weekdays versus weekends are somewhat difficult because the subject samples and measurement tools differ, as well as the expression of the activity data. Studies have reported differences in activity on weekdays and weekends using objective methods in children and adolescents [18, 19, 22].

Our results revealed that children and adolescents spent more time in sedentary in weekdays versus weekends. Similar trends were reported in different studies [18, 19]. Indeed, a study conducted in four European countries (Denmark, Portugal, Estonia, and Norway) using MTI accelerometer found that time spent in sedentary were higher during weekdays compared with weekends ($p < 0.01$) in a sample of children and adolescents aged between 9 and 15 years [18]. Likewise, another study conducted in China using GT3X+ or GT3X accelerometer reported that children and youth (mean age = 13.4 years) had more sedentary time on weekdays than on weekend days ($p < 0.05$) [19].

Sedentary activity in one study [22] as measured by multisensory accelerometer (Actiheart) reported higher means on weekends than on weekdays in children aged 7.1 years.

The relatively lower amount of time spent in MVPA was also documented [19, 23, 24]. A study [23] comparing MVPA in weekdays versus weekends between Liverpool and Madrid youth (aged between 10 and 14 years) using GT1M accelerometer reported that youth in Liverpool spent an average of 48.6 ± 1.5 (min/day) in MVPA, while Madrid youth accumulated an average of 50.6 ± 1.5 (min/day) of MVPA in weekdays. Time spent in MVPA in weekends was 36.5 ± 1.7 (min/day) in Liverpool's youth and 32.3 ± 1.7 (min/day) in Madrid's youth. This would be comparable to our children/adolescents, where the MVPA during the weekdays averaged 55.2 ± 26.3 (min/day) and during weekends, MVPA averaged 59.9 ± 33.7 (min/day), suggesting that children/adolescents in our study were more active.

In the present study, differences in MVPA between weekdays versus weekends were not observed in 8- to 14-year-old children/adolescents while it showed a difference between boys and girls for PA engagement. These findings

Table 4: Physical activity levels and sedentary time by gender and by age grade on weekends.

			Sedentary time (min/day)		Light activity (min/day)		Moderate activity (min/day)		Vigorous activity (min/day)		Steps (steps/day)	
			Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Children	Mean		438.0	457.0	283.7	290.7	54.8	37.3	20.9	12.4	12265.0	9859.4
	95% CI	Lower	412.9	433.3	264.8	272.8	47.8	30.7	17.2	8.9	10921.4	8587.2
		Upper	463.0	480.7	302.6	308.5	61.8	43.9	24.7	16.1	13608.5	11131.6
Adolescents	Mean		481.7	508.3	247.1	243.4	46.4	34.9	22.3	10.8	11570.6	9333.4
	95% CI	Lower	457.6	483.7	228.9	224.8	39.7	28.1	18.7	7.1	10277.9	8012.5
		Upper	505.7	532.9	265.2	262.0	53.1	41.8	26.0	14.5	12863.4	10654.3
	Gender	F	3.45		0.03		17.8		28.9		12.3	
		p-value	0.065		0.861		< 0.001		< 0.001		0.001	
		$\eta 2$	0.020		< 0.001		0.097		0.149		0.069	
	Age grade	F	14.7		20.14		2.46		0.003		0.84	
		p-value	< 0.001		< 0.001		0.119		0.957		0.360	
		$\eta 2$	0.081		0.108		0.015		< 0.001		0.005	
	Gender	F	0.09		0.32		0.76		0.65		0.16	
	*	p-value	0.760		0.571		0.382		0.420		0.899	
	Age grade	$\eta 2$	0.001		0.002		0.005		0.004		< 0.001	

Adjusted for BMI z-score and wear time.

Table 5: Attainment of moderate to vigorous physical activity guideline by gender and by age grade.

		B ± ES	OR	95% CI		p-value
Gender	Boys	2.14 ± 0.35	8.569	4.239	17.231	< 0.001
	Girls	1				
Age grade	Children	-0.28 ± 0.31	0.750	0.409	1.378	0.354
	Adolescents	1				

are similar to results of some studies, which showed that girls are less active than boys [19–21, 25]. For example, Trost et al. examined age- and sex-related PA using accelerometer in children from grades 1-12. They observed that boys are more physically active than girls at moderate and vigorous intensity. In the present study, boys were more likely to spend time on moderate and vigorous physical activities and less time on sedentary than girls.

Our results also revealed that boys took more steps per day and were more likely to meet the recommendation for at least 60 min of moderate to vigorous physical activity per day than girls, in agreement with previous studies [13, 22, 26, 27]. The differences noted may be due to the weakest participation of girls in organized sport [28]. Biological reasons may also contribute to these differences [29].

In addition, our results indicated that sedentary time increases significantly with age grade while light physical activity decreases significantly with age grade, on both weekdays and weekends.

However, on both weekdays and weekends, no differences were observed in MVPA (min/day) according to age grade. These findings are in contrary to results of some studies, which show that MVPA decreases with age [30, 31]; this could be explained by the narrow age range used in this study.

The WHO [3] recommends that at least 60 minutes of daily accumulated MVPA is necessary for the maintenance of metabolic health [3]. Data in the present study showed that neither children nor adolescents satisfied the criterion of accumulating at least 60 minutes of at least moderate intensity PA. Indeed, only 38.8% of the children and adolescents met the recommendation of ≥ 60 (min/day) of MVPA. It appears that PA of primary school participants on the weekdays was well below the recommended 60 minutes.

In conclusion, in both second- and sixth-grade participants we could find several differences in the PA levels between weekdays and weekend days. This study revealed that Moroccan children and adolescents spent more time in sedentary in weekdays than weekends. Boys engaged more in moderate and vigorous intensity levels than girls. These differences emphasize the need of reducing sedentary during school time for future interventions in Morocco, especially when children grow older and for girls. Further studies need to confirm whether the present findings also apply in rural and suburban populations and in different seasons of the year.

4.1. Strengths and Limitations. This is the first study in Morocco which objectively assessed PA levels by means of accelerometry (GT3X+) in school children/adolescents and investigated whether there are differences between weekdays

and weekend days in two different age groups and according to gender.

However, the present study has several limitations. We assessed the PA levels of a convenience sample of 2nd grade to the 6th grade from three urban regions and surveyed them during school year (winter, spring months), respectively. Therefore, findings are not generalizable to other populations and seasons.

The sample size was relatively small but constitutes the baseline data which are the basis for implementing future monitoring studies with GT3X+ accelerometer in a large population-based surveillance system of youth.

Accelerometry is a good method to gain further insights in children's PA levels. However, the use of accelerometry is associated with several issues: its inability to assess accurately water activities and activities in which the body's centre of gravity is relatively fixed (upper movements) such as cycling [32]. The absence of a universal consensus on data cleaning and processing and accelerometer cut points for determining MVPA [32]. The inclusion criterion of at least 4 valid weekdays and 1 weekend day of 10 valid hours of combined data was chosen to maximize data retention for analysis and enhance the reliability of the presented results.

Data Availability

The data used to support the findings of this study is not freely available because the database is not entirely exploited. Access to these data will be considered by the author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Authors' Contributions

Issad Baddou and Asmaa El Hamdouchi contributed equally to this work.

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Research Article

Sedentary Lifestyle and Nonspecific Low Back Pain in Medical Personnel in North-East Poland

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Introduction. The sedentary lifestyle is defined as prolonged sitting both at work and during leisure time, with energy expenditures of below 600 MET · min/week. The sedentary lifestyle is a well-known predictor of obesity and other components of the metabolic syndrome. The influence of the sedentary lifestyle and associated factors on nsLBP is still being discussed. *Aim*. The aim of this study was to assess the influence of a sedentary lifestyle and its associated metabolic predictors on the prevalence of nsLBP in nurses and paramedics. *Materials and Methods*. The study included 609 participants, aged 30-60 years, who were residents of north-east Poland. Data was collected using a questionnaire (based, in part, on the Nordic Musculoskeletal Questionnaire), and included details of sociodemographic profile, chronic illnesses, and a short version of the International Physical Activity Questionnaire (IPAQ). *Results*. Nearly half (49.59%) of the respondents reported decreased physical activity, and in the group with recurring nsLBP this figure was 67.59%. Univariate logistic regression modelling found that leading a sedentary lifestyle caused a 3.5-fold increase in the incidence of recurring nsLBP ($p<0.001$). Excessive coffee consumption significantly increased the likelihood of recurring LBP (OR=16.44, 95% CI: 8.55-31.61), and cigarette smoking increased the likelihood of both recurrent and chronic LBP. The likelihood of chronic low back pain was significantly increased by components of metabolic syndrome such as high blood pressure (over 9-fold), type 2 diabetes (over 3-fold), and hyperlipidemia (over 2-fold) ($p<0.001$, $p<0.001$, and $p<0.01$, respectively). *Conclusions*. A sedentary lifestyle significantly increased the incidence of recurring low back pain, while increased physical activity had a significant effect on the presence of chronic low back pain. In the sedentary lifestyle group, conditions classified within metabolic syndrome were found to significantly increase the chances of developing nonspecific low back pain.

1. Introduction

Nonspecific low back pain (nsLBP) is a mounting health problem in the 21st century. After headaches, it is the second most common pain reported [1]. NsLBP was ranked in first place for the most common reasons for disability on the YLD (Years Lived with Disability) metric. In recent reports, the increased incidence of nsLBP in young and middle-aged persons is emphasized [2]. The diagnosis of nsLBP is given when no other cause for back pain, apart from spinal degeneration, can be established.

It is suggested that the sedentary lifestyle is one of the predictors for nsLBP [3]. The sedentary lifestyle is defined as prolonged sitting at work, during leisure time and when moving; these activities require energy expenditures of <1.5 METS. An average weekly energy expenditure expressed as MET·min/week for efforts associated with different types of activities (professional work, moving, house chores, and recreation and tourism) does not exceed 600 MET·min/week [4]. Lack of or trace physical activity resulting from the sedentary lifestyle results in the reduction of muscular power and strength [3]. Furthermore, the sedentary lifestyle leads to a reduced ability of the vertebral disc to maintain a normal concentration of water. The level of hydration of the nucleus pulposus influences development of degenerative and overload lesions. It was also found that the sedentary lifestyle may be a risk factor for vertebral disc herniation [5]. People with a sedentary lifestyle may develop flaccid hyperlordosis complex resulting in the development of nsLBP.

Table 1: General characteristic of the study group.

Variables		N	%
Profession	Nurses	324	53.20
	Paramedic	285	46.80
Age (years)	30 – 40	302	49.60
	41 – 60	307	50.40
Sex	Women	362	59.94
	Men	247	40.56
BMI [kg/m^2]	18.5 - 24.99	314	51.56
	25.00 – 29.99/ ≥ 30.00	295	48.44
nsLBP incident in the study group	Recurrent	253	41.54
	Chronic	102	16.75

BMI: body mass index, nsLBP: nonspecific low back pain.

Nurses and paramedics are a group of professionals who are at a high risk of developing pain in the lumbar section of the spine. Working with patients often involves excessive strain on the low back resulting from the need to maintain a forced body position (referred to as postural stress). In finding effective preventative approaches for nsLBP, it seems reasonable to study factors associated not only with working environment, but also lifestyle factors such as daily physical activity, cigarette smoking, excessive coffee consumption, and poor diet. There is a reported association between a lifestyle and the incidence of so-called diseases of affluence. [6, 7].

The importance of overweight or obesity as risk factors for low back pain is also noted [8, 9]. Both overweight and obesity contribute to the mechanical overload of paraspinal tissues or even promotes the development of disc herniations. There have been reports on the influence of other metabolic disorders (hyperlipidaemia, hypertension, and type 2 diabetes) on the occurrence of low back pain [10, 11]. Less numerous reports indicate a relationship between smoking and low back pain [11].

As an increase in low back pain frequency is observed, a research project bringing the knowledge pertaining to the link between sedentary lifestyle and the occurrence of nsLBP appears to be justified.

The aim of this study was to assess the influence of a sedentary lifestyle and its associated metabolic predictors on the prevalence of nonspecific low back in nurses and paramedics.

2. Methods

A group of 609 randomly selected people (medical staff) participated in the study. They lived in north-eastern Poland and their age ranged from 30 to 60 years (the average age was 40.99 ± 6.66 years). In total, 324 nurses (53.2%) and 285 paramedics (46.8%) were included in the study. Among the subjects, there were 302 people aged 30–40 (49.6%) and 307 people aged 41–60 (50.4%). As far as the sex of the participants was concerned, women constituted 59.44% (362 people) and men 40.56% (247 people). As far as the value of the body mass index (BMI) was concerned, it was established that 314 (51.56%) people had correct body mass (BMI = 18.5–24.99 kg/m^2) while 295 (48.44%) subjects were overweight (BMI = 25–29.99 kg/m^2) or obese (BMI ≥ 30 kg/m^2). Detailed characteristics of the study group are shown in Table 1.

The research was carried out using an auditorial survey supervised by researchers, i.e., the authors of the manuscript.

The following types of questionnaires were used:

(1) The questionnaire partially based on standardized Nordic Musculoskeletal Questionnaire includes questions regarding frequency of musculoskeletal pain (1-2 times within past 12 months, ≥ 3 times within 12 months; the pain is present since at least 12 weeks) within low back.

An acute pain episode which had occurred ≥ 3 times in the last 12 months was considered "recurring" low back pain [1, 12]. Chronic back pain is defined as pain that persists for 12 weeks or longer [1].

(2) Author's questionnaire regarding sociodemographic details selected recurrent and chronic diseases (hyperlipidemia, arterial hypertension, and diabetes type 2). This questionnaire was composed of closed questions to choose from (disjunctive question). The respondents entered their height and body mass in the proprietary survey questionnaire. They were used by the researchers to calculate BMI kg/m2.

(3) Short version of International Physical Activity Questionnaire (IPAQ) was included in it the frequency and time of physical activity with high, moderate, and low intensity, lasting continuously for at least 10 minutes. The percentage of sufficiently active subjects was established on the basis of the estimated caloric costs of physical activity, using the assumptions of Paffenbarger et al.

The results were classified according to the following criteria:

(i) Low or trace physical activity (below 600 MET · min/week)

(ii) Moderate physical activity (between 600 and 1500 MET · min/week)

(iii) Increased physical activity (1500-3000 MET · min/ week, 1-2 days a week of intensive activity)

(iv) High physical activity (at least 3000 MET · min/ week or above 1500 MET · min/ week but at least 3 days a week with intense activity [10].

Table 2: The influence of the age and the length of employment on the presence of recurrent and chronic nsLBP.

Predictors	Recurrent nsLBP			Chronic nsLBP		
	OR	95 CI	p	OR	95 CI	p
Age [years]	0.952∗∗	0.929 – 0.976	<0.001	1.072∗	1.037 – 1.168	<0.001
Lenght of employment [years]	0.951∗∗	0.928 – 0.974	<0.001	1.070∗	1.035 – 1.105	<0.001

OR-odds ratio,
∗The risk of nsLBP was significantly increased.
∗∗ The risk of nsLBP was significantly decreased (the univariate logistic regression model).

Trace or low physical activity (below 600 MET · min/week) justified a description of the sedentary lifestyle [12, 13].

(4) Oswestry Disability Index (ODI) includes 10 questions about everyday activities such as pain severity, self-care, ability to lift weights, walking, sitting, standing, sleeping, social life, traveling, and professional work. Each answer was grated according to the following algorithm: (A) 0 points, (B) 1 point, (C) 2 points, (D) 3 points, (E) 4 points, and (F) 5 points. Then points were summed up. The maximum number of points amounted to 50. This questionnaire was composed of closed questions to choose from (disjunctive question) [12, 14].

The following respondents were excluded from the study: those undergoing treatment due to autoimmune disease/cancer, people with a history of osteoporotic fracture, pregnant women, and respondents who had shown symptoms which could presumably constitute the so-called "red flags" that signal specific low back pain (urinary and bowel incontinence, unexplained weight loss during 3 months before the survey, and serious trauma up to 3 months before the survey).

In the course of the research, a database of variables was created, containing statements, opinions, and evaluations of respondents, enabling the use of computational techniques. Statistical analysis began with substantive and logical control of the collected data. In the first stage, the conformity of the tested continuous variables with the Gaussian distribution was verified. The analysis relied on and univariate logistic regression model and the univariate linear regression model. The t-test was used to verify the significance of the linear regression. This was aimed at eliminating the interfering influence of the various independent variables analysed. The statistical significance level was taken to be $p<0.05$. The statistical analysis was conducted using STATA/1.C 12.1 software developed by Stata Corp, LP, Texas, USA.

The study was funded by Medical University of Bialystok. In order to conduct the study, approval was obtained from the Bioethics Commission at the Medical University in Bialystok.

3. Results

Recurring or chronic low back pain was reported by 355 people (58.29% of all subjects), of which 253 people (41.54% of all respondents) complained of recurrent low back pain.

Respondents with the younger age (under 40 years old) and shorter length of employment (under 15 years) were predominating in the group with recurrent low back pain: 146 people (57.71%) and 167 people (66.01%), respectively.

Chronic low back pain was declared by 102 people (16.75% of all respondents). Total number of 302 people met the criteria of sedentary lifestyle (49.59% of all respondents).

The influence of the age and the length of employment on the presence of recurrent and chronic nsLBP is presented in Table 2. In the univariate logistic regression model, with each successive year of life and length of employment, chances for development of recurrent nsLBP decreased by 4.8% and 4.9%, respectively, while with each successive year of life and length of employment chances for development of chronic nsLBP increased by 7.2% and by 7%, respectively.

The frequency of the sedentary lifestyle, types, and concurring predictive factors of nsLBP in the studied group is presented in Table 3.

Sedentary lifestyle increased the risk of recurrence of nsLBP over 3.5 times ($p<0.001$) (Table 4, Figure 1.). On the contrary, chances of chronic nsLBP increased over 10 times in people with high physical activity ($p<0.001$) [Table 4].

The factors associated with lifestyle, such as excessive consumption of coffee (≥ 6 cups per day), increased the risk for nsLBP recurrence by 16 times versus the respondents drinking ≤ 5 cups of coffee a day (OR=16.69; 95% CI: 8.77 – 43.36 ($p<0.001$), whereas smoking increased the chances of recurrent nsLBP by more than 9 times (OR=9.31; 95% CI: 5.34 -16.22; $p <0.001$).

In a group of subjects declaring the sedentary lifestyle, the occurrence of recurrent nsLBP was increased by the following components of the metabolic syndrome: hyperlipidemia more than three 3 times, type 2 diabetes more than 3.5 times, and overweight or obesity more than 2 times ($p<0.05$, $p<0.05$, $p<0.01$, respectively). On the other hand, the risk of chronic nsLBP increased by more than 17.5 times in arterial hypertension, more than 4.5 times in diabetes type 2, more than 4.5 times in hyperlipidemia, and more than 4 times in overweight or obesity. The results were statistically significant ($p<0.001$; $p<0.05$; $p<0.05$; $p<0.05$, respectively) versus the group without these disorders [Table 5].

In the group of respondents with recurrent nsLBP, the sedentary lifestyle was not a factor determining a level of disability, i.e., it did not increase significantly the score based on the Oswestry questionnaire (β = 0.236; p=0.756). However, in the respondents with chronic nsLBP, it significantly reduced the score based on Oswestry and reduced the level of disability (β = -6.422; $p<0.001$. In contrast, the comorbidities found in the group of respondents with the sedentary lifestyle with recurrent nsLBP significantly increased the final score by 6.243 points on average for overweight or obesity and 2.415

Table 3: The study population presented in the context of physical activity in the week before filling the questionnaire and concomitant/potential predictive factors of nsLBP.

Variables	Total respondent group (N)	Respondents with recurrent nsLBP N(%)	Respondents with chronic nsLBP N(%)
Sedentary lifestyle	302	171 (67.59)	13 (12.75)
Moderate physical activity	106	8 (3.16)	17 (16.67)
Increased physical activity	57	3 (1.19)	5 (4.90)
High physical activity	144	71 (28.06)	67 (65.69)
Overweight or obesity	298	140 (55.34)	61 (59.8)
Smoking tobacco	370	214(84.58)	71 (69.61)
Excessive coffee consumption	311	41(16.21)	5 (4.9)
Hyperlipidemia	45	31 (68.89)	14 (13.73)
Arterial hypertension	34	3 (8.82)	21 (20.59)
Diabetes type 2	58	36 (62.07)	20 (19.61)

Table 4: Occurrence of non-specific low back pain, depending on the levels of physical activity.

The level of physical activity	Recurrent nsLBP		Chronic nsLBP	
	OR (95 %CI)	p	OR (95% CI)	p
Sedentery lifestyle	3.582 (2.549 – 5.033)∗	<0.001	0.110 (0.060 – 0.202)∗∗	<0.001
Moderate	0.086 (0.041 – 0.181)∗∗	<0.001	0.939 (0.532 – 1.659)	0.829
Increased	0.067 (0.021 – 0.217)∗∗	<0.001	0.451 (0.176 – 1.159)	0.098
High	1.512 (1.038 – 2.203)∗	0.031	10.690 (6.646 – 17.195)∗	<0.001

OR- odds ratio,
∗the risk of nsLBP was significantly increased; ∗∗ the risk of nsLBP was significantly decreased (the univariate logistic regression model).

Table 5: The influence of the particular components of the metabolic syndrome on prevalence of recurrent nonspecific lower back pain in patients declaring sedentary lifestyle.

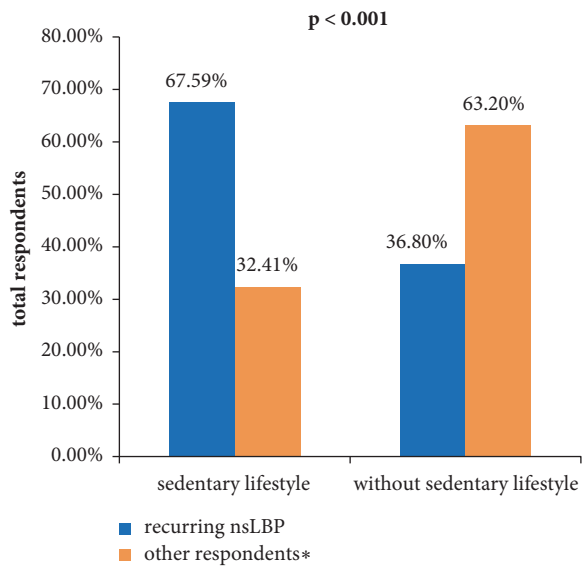
Metabolic syndrome component	Recurring nsLBP		Chronic nsLBP	
	OR (95 %CI)	p	OR (95 %CI)	p
Smoking	9.305 (5.339 – 16.219)∗	<0.001	0.821 (0.262 – 2.576)	0.735
Excessive coffee consumption (≥ 6 cups for day)	16.688 (8.771 – 43.363)∗	<0.001	0.299 (0.038 – 2.343)	0.250
Overweight or obesity	2.182 (1.368 – 3.481)∗	0,001	4.020 (1.084 – 14.913)∗	0.038
Hiperlipidemia	3.277 (1.069 – 10.050)∗	0.038	4.800 (1.207 – 19.082)∗	0.026
Diabetes type 2	3.505 (1.150 – 10.680)∗	0.027	4.517 (1.141 – 17.875)∗	0.032
Arterial hypertension	0.160 (0.034 – 0.756)∗∗	0.021	17.905 (4.432 – 72.340)∗	<0.001

OR: odds ratio; 95 %CI: confidence interval for OR.
∗The risk of nsLBP was significantly increased; ∗∗ the risk of nsLBP was significantly decreased (the univariate logistic regression model).

points on average for hyperlipidaemia (p<0.001; p=0.026, respectively). In the group of respondents with the sedentary lifestyle with chronic nsLBP they significantly increased the final score by 8.168 points on average for overweight or obesity and 4.263 points on average for type 2 diabetes (p<0.001; p=0.003, respectively) [Table 6].

4. Discussion

Numerous studies and analyses focused on the excessive strain of the spine and its consequences to health. It was demonstrated that even 2/3 of people below 40 years of age suffered from at least one episode of low back pain and over



∗respondents with chronic nsLBP , episodic nsLBP and respondents without nsLBP

Figure 1: The frequency of recurring low back pain in the groups of respondents, depending on their lifestyle.

Table 6: The impact of particular types of metabolic syndrome component on higher values on a point scale based on the Oswestry questionnaire in a group of respondents with recurrent or chronic nsLBP declaring sedentary lifestyle.

Metabolic syndrome component	Recurrent nsLBP				Chronic nsLBP			
	Non- standard-izedbeta coefficient	SE∗∗∗	t	p	Non-standardized beta coefficient	SE∗∗∗	t	p
Smoking	0.379	0.987	0.384	0.701	1.23	1.264	0.914	0.701
Excessive coffee consumption (≥ 6 cups for day)	-1.502∗∗	0.744	-2.018	0.045	1.711	2.699	0.634	0.527
Overweight or obesity	6.243∗	0.599	10.425	<0.001	8.168∗	0.867	9.424	<0.001
Hyperlipidemia	2.415∗	1.076	2.244	0.026	0.479∗	1.696	0.282	0.778
Diabetes type 2	0.488	1.020	0.479	0.633	4.263∗	1.408	3.029	0.003
Hypertension	-2.893	3.288	-0.880	0.380	-1.489	1.436	-1.036	0.303

SE: standard error.
∗ The average score obtained on the Oswestry questionnaire was significantly increased, test t.
∗∗ The average score obtained on the Oswestry questionnaire was significantly decreased, in the univariate linear regression model, test t.

60% of them experience a recurrence of pain within the same year [2, 12, 15].

The results of our studies indicate that nonspecific low back pain also represents a significant health problem in the group of professionally active medical personnel, i.e., nurses and paramedics. Over 40% of the respondents complained of recurrent nsLBP, with a significant ($p<0.001$) prevalence of medical personnel of younger age and length of employment. Martinelli et al. explain this situation with the fact of incorrect use of muscles by the medical personnel during their daily activities at the initial stage of their professional work [16]. The results of our research indicate that, with each year of length of employment, the frequency of recurrent nsLPB decreases significantly (OR=0.95; 95% CI: 0.93-0.97, $p<0.001$), while the frequency of chronic nsLBP increases significantly (OR = 1.07; 95% CI: 1.03-1.10, $p<0.001$).

Mannion et al. reached similar conclusions in their prospective study. They report that, for nurses, the frequency of recurrent nsLBP episodes decreased with longer length of employment. They also suggest that this observation may be associated with the fact that medical personnel develops protective adaptation to the increased load [17]. These findings support the appropriateness of preventative programmes dedicated to medical professionals, including educational measures for preventing recurring and chronic low back pain.

The reported data indicate a relationship between nsLBP with the sedentary lifestyle and factors associated with the lifestyle [18, 19]. Our studies demonstrated that the sedentary lifestyle was led by nearly half (49.59%) of all subjects and as many as 67.59% in the group with recurrent nsLBP. In the simple logistic regression model, the sedentary lifestyle

increased the chance for development of recurrent nsLBP by over 3.5 times (OR = 3.58; 95% CI: 2.55–5.03, $p < 0.001$). Hussain et al. in their studies involving 5050 adult Australia inhabitants noted that watching TV for more than 2 hours a day was a predictive factor for low back pain [20]. Similar conclusions were also reached by Falavigna et al. on the basis of their research conducted in a group of medical and physiotherapy students [21].

In our study, the sedentary lifestyle reduced the chances for the development of chronic nsLBP, while a high level of activity significantly increased the chances for the occurrence of recurrent and chronic nsLBP (OR = 1.51; 95% CI: 1.04–2.20 and OR = 10.69; 95% CI: 6.64–17.19, respectively). These results confirm the hypothesis that a relationship between the level of activity and nsLBP can be a U-shaped curve; that is, both inactivity and excessive activity (unhealthy activity) cause an increased risk of back pain [22]. Therefore, this is yet another important conclusion from our study, contradicting a well-spread conviction that the more physical activity the better and indicating a need for appropriate educational activities in this area.

Particularly interesting results of our studies concern the effect of excessive caffeine consumption on recurrent low back pain. Drinking of ≥6 cups of coffee a day increased the chance for the development of recurrent nsLBP by over 16 times versus respondents who did not consume excessive amounts of caffeine (OR=16.69; 95% CI: 8.77–43.36). It should be emphasized that this relationship has not yet been described in the literature. The mechanism underlying that phenomenon has not been fully explained. It is assumed that excessive consumption of coffee may result in flushing magnesium from the body and in lower absorption of calcium, leading to excessive, painful contractions of spine extensor muscles, and lumbar muscles [23].

The results of our study support the thesis that smoking is an important risk factor for recurrent low back pain. In the studied group, smoking increased a chance for recurrent nsLBP by over 9 times (OR=9.31; 95% CI: 5.34–16.22, $p < 0.001$) versus other people. Studies included in the meta-analysis conducted by Shemory et al. implied that smoking increased a chance for low back pain by over 4 times [11]. Similar conclusions were reached by Karahan et al. for the group of medical personnel and by Smith et al. for nurses [24, 25]. An existence of this relationship was not reported in the research conducted, among others, by Wong et al. [26].

Individual reports are published indicating a relationship between increased total cholesterol serum levels and an increased risk of disc herniation [27]. Suggestions and indirect evidence indicate a certain role played by atherosclerosis in subchondral bone vessels in the pathogenesis of osteoarthritis [28]. In accordance with the results of our studies, hyperlipidaemia increased a chance for development of recurrent and chronic nsLBP by over 3 and 4 times, respectively (OR=3.28; 95% CI: 1.07–10.05 and OR=4.80; 95% CI: 1.21-19.08, respectively).

The results of our study indicate that, in the group with the sedentary lifestyle, concurrent type 2 diabetes increased a chance for recurrent nsLBP by over 3.5 times (OR=3.50; 95% CI: 1.15–10.68) versus people not suffering from diabetes ($p=0.027$). This observation is consistent with the results obtained by Ha et al. [10]. It is suggested that type 2 diabetes may lead to earlier degeneration of vertebral discs [29].

According to the results of our studies, hypertension significantly increased a chance for development of chronic pain in the lumbosacral spine by over 17.5 times (OR=17.905; 95% CI: 4.43–72.34). This relationship is consistent with the results of very scarce research on this subject [30, 31].

We demonstrated that over half of the respondents with nsLBP were overweight or obese, with a higher percentage found for respondents with chronic nsLBP (59.8%). In respondents declaring the sedentary lifestyle, overweight or obesity significantly increased chances for occurrence of recurrent and chronic nsLBP (OR=2.18; 95% CI: 1.37–3.48 and OR=4.02; 95% CI: 1.08 –14.91; $p=0.03$, respectively) versus the group without overweight or obesity ($p<0.001$ and $p=0.03$, respectively). Results of previous studies conducted by other authors are ambiguous. Croft et al. demonstrated that higher body weight was a predictive factor for pain in the lumbosacral spine in a group of women [32]. Contrary to these results, other researchers [33, 34] did not demonstrate a significant relationship between overweight and obesity and low back pain in a group of nursing personnel.

It is generally thought that low back pain may be a factor determining the occurrence of disability, which, apparently, should result in decreased physical activity. However, a meta-analysis conducted by Lin et al. did not show such a relationship. On the contrary, the researchers demonstrated that people complaining of chronic nsLBP declared a high level of physical activity [35]. Also, our own research did not find a significant relationship between the level of physical activity and the level of disability in subjects with recurrent and chronic nsLBP. Hussain et al. reached opposite conclusions, proving the existence of a relationship between the sedentary lifestyle and the level of disability [20].

The data in the literature indicate that diseases concurrent with nsLBP may be factors determining the level of disability, and accepted predictive factors for disability associated with nsLBP are overweight and obesity [36]. These observations are consistent with the results of our research. Concurrent overweight or obesity significantly increased the final score in the Oswestry questionnaire, i.e., the level of disability in groups of respondents with recurrent and with chronic low back pain ($p<0.001$; $p<0.001$, respectively). Also, the presence of hyperlipidaemia or type 2 diabetes in the group of respondents with recurrent and chronic nsLBP significantly determined the level of disability ($p<0.02$ and $p<0.003$, respectively). Tsuboi et al., studying 316 healthcare employees with nsLBP, demonstrated a significant relationship between the functional disability and a concurrent metabolic syndrome [37]. However, this relationship requires confirmation in further studies.

5. Conclusions

(1) A large proportion (over 40%) of recurring nonspecific low back pain is an important health concern in the nursing and paramedical professions.

(2) A sedentary lifestyle significantly increased the incidence of recurrent low back pain, while increased physical activity had a significant effect on the occurrence of chronic low back pain.

(3) Within the group of individuals leading a sedentary lifestyle, a significant effect of metabolic syndrome components as well as excessive coffee consumption was found on the increased probability of nonspecific low back pain. This finding would support earlier suggestions of recognising these diseases as "novel" predictive factors of nonspecific low back pain.

(4) The results of our study support the appropriateness of preventative programs targeting so-called "diseases of affluence" within medical professionals, including educational measures for preventing recurring and chronic low back pain (with a special emphasis on the importance of recreational physical activity, smoking cessation, maintaining a healthy body mass and instruction in the biomechanical hygiene of the spine).

Data Availability

Data are available any time from the first author, Dr. Anna Citko.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Physical Activity and Health-Related Fitness of Adolescents within the Juvenile Justice System

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Background. The purpose of this study was to examine the physical activity patterns and health-related fitness levels of adolescents within the Juvenile Justice System. *Methods*. Participants included 68 adolescents (Mean age = 17.1 ± 1.0 years) in two secure Juvenile Justice correctional facilities in the Western USA. Moderate-to-vigorous physical activity (MVPA) was monitored for one week using the ActiGraph GT9X accelerometer. Health-related fitness was measured using the FITNESSGRAM test battery. *Results*. Adolescents averaged 43.3±21.6 minutes of MVPA per weekday compared to 42.7±27.5 per weekend day. During school hours, adolescents accumulated 17.1±9.0 minutes of MVPA compared to 5.9±3.4 minutes before school and 21.0±13.6 minutes after school. Adolescents averaged 18.9±11.0 push-ups, 44.5±26.4 curl-ups, 34.7±24.8 PACER laps, and 22.1%±10.0% body fat. *Conclusions*. Adolescents within the Juvenile Justice System are falling short of the recommended 60 minutes of MVPA per day and 30 minutes of MVPA during school and also need to improve their health-related fitness, especially cardiorespiratory endurance.

1. Introduction

The benefits of physical activity are vital to the physical, psychosocial, and cognitive health of adolescents [1, 2]. A population that may benefit from increases in physical activity and health-related fitness is adolescents within the Juvenile Justice System. In the USA, Juvenile Courts handle an estimated 1.7 million cases each year with more than 110,000 incarcerated in Juvenile Facilities [3, 4]. It is anticipated that more than 70,000 juvenile offenders are in residential placements for adolescents [5], as there are nearly 600 detention facilities in the USA [6, 7]. Juvenile Justice facilities house adolescents with criminal or rehabilitation needs and adolescents can be committed to a facility for a matter of days to more than a year [8]. Given the relatively high prevalence of adolescents within Juvenile Justice facilities in the USA and high length of stay variability, the physical condition of these youth is a public health concern [9, 10]. Implementing interventions within Juvenile Justice System may be an effective way to attenuate health risk via physical activity behavior modification. Indeed, the benefits of daily physical activity participation are numerous as past studies have found relationships between physical activity and physical, psychological, social, and cognitive health indicators in adolescents [11–16].

In addition to the behavior of physical activity, specific components of health-related fitness are important to improve health and wellbeing in youth. Health-related fitness consists of five domains including body composition, cardiorespiratory endurance (aerobic fitness), muscular strength and endurance, and flexibility; however, body composition and cardiorespiratory endurance are the two domains that tend to have the strongest relationships with health outcomes in the pediatric population [17]. Because of the established relationships between body composition, cardiorespiratory endurance, and various health markers, improving these components health-related fitness has become a priority to improve wellbeing and attenuate risk of developing chronic disease [18, 19].

The United States Department of Health and Human Services [20] and the World Health Organization [21] both recommend 60 minutes of moderate-to-vigorous physical activity (MVPA) daily for adolescents (10-19 years old).

Achieving 60 minutes of MVPA has shown to be related to the amount of physical activity associated with positive health indicators [11]. Despite the known benefits of MVPA, previous research indicates that adolescents are falling short of both of these recommendations [22–24], which subsequently affects body composition and cardiorespiratory endurance. Furthermore, physical activity and specific components of health-related fitness tend to decline with age [25, 26].

In adult prisoners, there tends to be higher prevalence of unfavorable body composition and cardiorespiratory endurance levels, correlating with length of stay [27, 28]. This suggests that prisoners who have longer sentences tend to have poorer fitness levels compared to prisoners with shorter sentences [27, 28]. Fortunately, physical activity programming has been found to improve psychological wellbeing in male prisoners [29] in addition to improving cardiorespiratory endurance and muscular strength and endurance [30]. In youth, much research in pediatric behavior change, specifically pediatric physical activity programming, has focused on the school environment. However, to our knowledge, little is known regarding the physical activity behavior and the health-related fitness components of body composition, cardiorespiratory endurance, and muscular strength and endurance in incarcerated adolescents within the US Juvenile Justice System. Knowing this information can help devise effective programming. Therefore, the purpose of the study was to explore the physical activity and specific components health-related fitness of adolescents from two secure Juvenile Justice facilities from the state of Utah in the USA.

2. Method

2.1. Participants. Participants included 68 adolescents (Mean age = 17.1 ± 1.0 years; 60 males, 8 females) incarcerated in two secure Juvenile Justice correctional facilities in the Southwest US Adolescents who were 48% ethnic minority (33% Hispanic, 7% African American, 4% Pacific Islander, 4% American Indian) from one metropolitan area. Adolescents were incarcerated in secure facilities for sentences ranging from 9 months to 2 or more years. A typical weekday had adolescents spending their mornings in their individual or small group units followed by a traditional school schedule before returning to their individual housing units. Gymnasium and field space were available for physical activity although physical activity was not required. Some adolescents if they needed the school credit did have access to physical education (<30%). All procedures were approved by both the University Institutional Review Board and the State Health Research Board. Parents provided written consent and youth provided written assent. Participation was voluntary and the youth could decide to stop participating at any time.

2.2. Instruments

2.2.1. Physical Activity. Physical activity was monitored for one week using the ActiGraph (Pensacola, FL) GT9X Link accelerometer. Accelerometer data were recorded in 5-second epochs at 100 Hertz and then processed using Evenson et al. [31] MVPA cut points which have a strong criterion-referenced energy expenditure agreement with indirect calorimetry [32].

2.2.2. Health-Related Fitness. Health-related fitness was assessed using the FITNESSGRAM test battery including push-ups and curl-ups for muscular strength and endurance, the Progressive Aerobic Cardiovascular Endurance Run (PACER) for cardiorespiratory endurance, and two-site skin fold for body composition.

The PACER was administered during an agreed upon time outside of school classes. The PACER was conducted per recommendations [33] across a 20-m distance within an allotted time frame. The final score was recorded in laps.

FITNESSGRAM's push-up test was administered using an audio compact disk providing a cadence of 20 push-ups per minute. The PACER was run by small groups (e.g. 6-12) of students at one time. The 90° push-up is a reliable measure of upper body strength and endurance in children [28]. Push-up scores were recorded as the total number of correctly performed repetitions.

FITNESSGRAM's Dynamic Curl-Up is a test for abdominal muscular endurance. The Dynamic Curl-Up consisted of having the adolescents curl up and down sliding their fingers across a distance of 4.5 inches at a specific cadence provided by a recorded compact disk. Curl-up scores were recorded as total number of correctly performed repetitions [34]. Push-up and curl-up testing were completed in small groups.

Body composition was determined using two-site skinfold assessment with a Lange Skinfold Caliper (Seko, USA). All youth were measured at the right tricep and right medial calf using recommended procedures [34]. The trained Principal Investigator administered the skinfold assessment. Skinfolds were taken in duplicate and averaged across two trials. If two measurements were off by more than 2mm, a third measurement was taken at the respective site. The Slaughter et al. [34] formula was used to estimate body fat percentage. Body composition testing was done individually in a semiprivate area.

2.3. Procedures. Accelerometers were distributed each morning by facility staff and youth wore them on their right hip above the iliac crest all day (approximately 6am-10pm). Facility attire included sweat pants which some students suggested made using the accelerometer clip challenging due flimsy nature of the waist band which led to the monitors occasionally falling off; however, wear time did not show this to be an issue getting complete data. Total MVPA was calculated for both weekday and weekend days as well as during school hours using the Actilife segment feature. Data were downloaded using Actilife Software. Wear time was classified using the Choi et al. [35] algorithm. To adjust for wear time, percent of time spent in sedentary, light physical activity, and MVPA was also reported. A valid day had at least 10 hours of data. To be included in the study participants had to have at least 3 weekdays and one weekend day of valid data.

Table 1: Participant characteristics, school segment sedentary times, and school segment physical activity data for the total sample.

		Mean or Percent	Standard Deviation
Participant Characteristics	Age (years)	17.1	1.0
	White	52%	
	Hispanic	33%	
	African American	7%	
	Pacific Islander	4%	
	American Indian	4%	
Before School Behavioral Data	Sedentary time	87.3%	6.3%
	Light Physical Activity	9.4%	5.0%
	Moderate-to-Vigorous Physical Activity	3.3%	1.7%
During School Behavioral Data	Sedentary time	88.2%	5.4%
	Light Physical Activity	8.8%	5.5%
	Moderate-to-Vigorous Physical Activity	3.0%	2.8%
After School Behavioral Data	Sedentary time	87.1%	8.9%
	Light Physical Activity	9.2%	6.2%
	Moderate-to-Vigorous Physical Activity	3.7%	2.9%

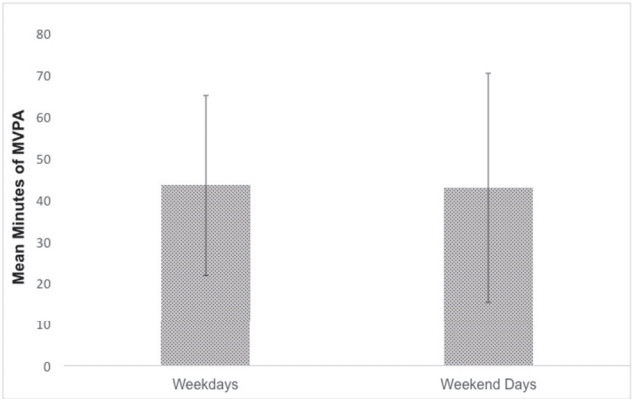

Figure 1: Minutes of MVPA on weekdays and weekend days.

2.4. Statistical Analysis. Descriptive statistics were calculated for time in MVPA on weekdays and the weekend. Means and standard deviations were calculated for PACER, curl-up, push-up, and two-site skinfold. Percentage of youth in the Healthy Fitness Zone (HFZ) for each component was also calculated.

3. Results

Table 1 presents the participant characteristics as well as percent sedentary times, light physical activity, and MVPA for the period before, during, and after school hours. Figure 1 shows youth MVPA on weekdays and weekends. Adolescents averaged 43.3±21.6 minutes of MVPA per weekday compared to 42.7±27.5 per weekend day. For absolute minutes per day of MVPA, during school hours, adolescents accumulated 17.1±9.0 minutes of MVPA compared to 5.9±3.4 minutes before school hours and 21.0±13.6 minutes after school hours. Figure 2 shows the percentage of youth in the HFZ for each component of the FITNESSGRAM. Adolescents averaged 18.9±11.0 repetitions for push-ups (49% Healthy Fitness Zone; HFZ), 44.5±26.4 repetitions for curl-ups (64% HFZ), 34.7±24.8 PACER laps (32% HFZ), and 22.1%±10.0% percent body fat (54% HFZ).

4. Discussion

The purpose of the study was to explore the physical activity and several components of health-related fitness of adolescents in two secure Juvenile Justice facilities. Adolescents within the Juvenile Justice System are falling short of the recommended 60 minutes of MVPA per day and 30 minutes of MVPA during school hours and are also in need of improving their health-related fitness, especially cardiorespiratory endurance, where only 1 in 3 youth was in the HFZ.

Adolescents in custody accumulate slightly less daily physical activity (MVPA) when compared to adolescents who are not in custody [17, 36–40]. We had anticipated juvenile defenders being more active because of the regimented schedules and available facilities to be physically active. The largest deficit appears to be in the amount during school hours where adolescents in the current study are accumulating just over half the recommended levels. The

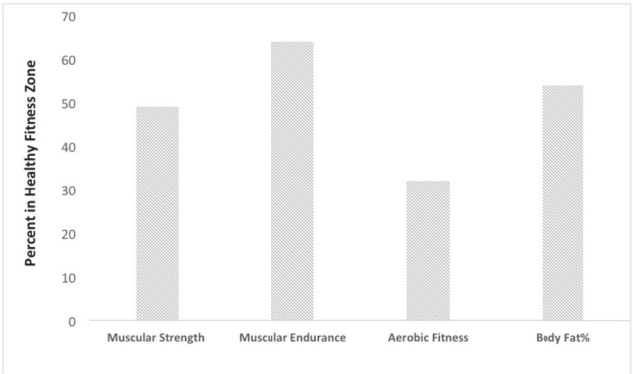

Figure 2: Percent of adolescents in the Healthy Fitness Zone for FITNESSGRAM test battery. *Note.* For muscular strength, Healthy Fitness Zone is ≥ 18 push-up repetitions for males and ≥ 7 push-up repetitions for females; for muscular endurance, Healthy Fitness Zone is ≥ 24 curl-up repetitions for males and ≥ 18 curl-up repetitions for females; for aerobic capacity, Healthy Fitness Zone is ≥ 44.3 mL/kg/min for males and ≥ 38.8 mL/kg/min for females; for % body fat, Healthy Fitness Zone is ≤ 22.3% in males and ≤ 31.3% in females.

one area where this population appear to be accumulating more physical activity than other groups is on the weekend where adolescents maintained their physical activity. Previous studies have identified a significant decrease in physical activity on weekends [37, 38]. Even without typical school time physical activity opportunities on weekends in these facilities, adolescents did have opportunities to participate in some recreational activities including basketball, football, and softball, which we hypothesized would contribute to higher weekly physical activity.

Clearly, interventions are needed in this population targeting PA and fitness. Beets and colleagues [41] suggest that physical activity can be increased by expanding, extending, and enhancing opportunities to be active. Correctional/detention facilities should require physical education (PE) as PE often contributes 25% of a student's daily physical activity [37] and 20% of their physical activity accumulated at school [42]. This alone has the potential to help adolescents meet daily recommendations. Keys to physical education implementation in this population might include providing choice and individualizing instruction as well as using curricular approaches such as the health club model or teaching personal and social responsibility [43]. Classroom physical activity interventions have also had some success in increasing both physical activity [44] and behavior [45]. Providing activity breaks or active academics might help increase physical activity but also the behavior and focus of these adolescents in their classrooms. Morning physical activity programs [46] may improve both health and behavior. This could be as simple as a walking club [46]. Adolescents have downtime in the morning around breakfast, so it seems that morning activities could be easily implemented. After school [47] and intramural [48] programming could also be beneficial. On weekends in these facilities, both pick-up and intramural games like softball and basketball were often played which allowed for higher levels of physical activity. Adolescents who did not choose to participate could engage in an unstructured activity of their choice or spend time in their individual units. Multicomponent physical activity programs called CSPAP (Comprehensive School Physical Activity Program) [49] have also shown improvements in physical activity [50], cardiorespiratory endurance [23], and cardiometabolic outcomes [51] as well as classroom behavior [12]. CSPAPs use all available resources during, before, and after school hours for children and adolescents to be active and meet the 60 minutes of physical activity per day guideline. CSPAPs usually involve five components including quality physical education, providing additional physical activity opportunities before, during, and after school hours, and facilitating community, staff, and family engagement. For these types of programs to be effective, additional training is likely required for both school teachers and facility security staff. Although not something we specifically looked at in this study, these types of interventions of Juvenile Justice facilities may also help protect youth from cardiovascular health issues that are often seen in youth with adverse childhood experiences [52].

To our knowledge this is the first study to examine objective measures of physical activity and fitness of adolescents in custody. However, this study is not without limitations. The generalizability of the study is limited due to the facilities being only from one state. The study also had a relatively small sample size, although many secure Juvenile Facilities have small numbers. Furthermore, the physical activity and school structure may be different across other facilities. Future research should also contextualize what activities youth participated in and how often. Additionally, a vast majority of adolescents in secure facilities are male. For example, at the time of this study, only 8 girls statewide were in secure facilities whereas approximately 100-150 males were in secure facilities at given time. Finally, FITNESSGRAM testing was completed the week prior to physical activity measurement to ensure that the PACER test did not influence daily physical activity patterns although the testing could have made students aware of their fitness levels, which may have influenced physical activity.

5. Conclusions

Adolescents in custody, like most adolescents, could benefit from additional physical activity and fitness opportunities. These facilities may need to redefine the training and roles of school and facility personnel in order to increase opportunities. Partnering on programming with local organizations or universities [53] may help fulfil the training or expertise needs to start these programs.

Disclosure

This paper was previously presented at the American College of Sports Medicine annual meeting.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Research Article

Association between Resting Heart Rate and Health-Related Physical Fitness in Brazilian Adolescents

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The aim of this study was to identify the relationship between health-related physical fitness components (aerobic fitness, muscle strength, flexibility, and body fat) and resting heart rate (RHR) in Brazilian adolescents. The study included 695 schoolchildren (14–19 years) from public schools of the city of São José, Brazil. RHR was evaluated using an automated oscillometric sphygmomanometer. Aerobic fitness was assessed by the modified Canadian Aerobic Fitness Test; muscle strength was measured by handgrip dynamometer; flexibility was assessed by the sit-and-reach test; and body fat was assessed indirectly by sum of two skinfold thicknesses (triceps and subscapular). Sociodemographic variables, habitual physical activity, sexual maturation, and body mass index were the covariates. Cardiorespiratory fitness (β = -0.11; 95%CI: -0.14, -0.08) and handgrip strength (β = -0.10; 95%CI: -0.18, -0.01) were inversely associated with RHR in boys. For girls, cardiorespiratory fitness (β = -0.09; 95%CI: -0.12, -0.06) was inversely associated with RHR. In both sexes, body fat (β = 0.50; 95%CI: 0.25, 0.75 for boys; β = 0.17; 95%CI: 0.36, 2.72 for girls) was directly associated with RHR. The RHR is measured more easily than the physical fitness tests, so it is recommended to assess adolescent's heath in large surveillance systems.

1. Introduction

Heart rate (HR) reflects the number of contractions of the ventricles per unit time and fluctuates substantially with variations in systemic demand for oxygen. Resting heart rate (RHR) monitoring is a simple and noninvasive clinical method related to health prognoses [1]. RHR elevation in adolescents is directly associated with indicators of cardiovascular diseases, such as increased blood pressure levels [2], elevated blood glucose [1], higher total cholesterol concentrations [3], and elevated triglycerides [3].

Considering the evidence regarding the negative health effects associated with elevated RHR in adolescents [1–3], it is relevant to study this issue and to identify factors related to high RHR, such as health-related physical fitness components. It is important to verify the relationship between health-related physical fitness components and RHR, since it is possible to identify modifiable factors in the adolescent population by means of low-cost, easily administered instruments and to propose strategies with the objective of preventing health problems associated with high RHR [1–3].

Most of the findings related to RHR come from investigations aimed at investigating the relationship between RHR and risk factors for cardiovascular diseases, such as blood pressure and inflammatory markers [1, 2]. These risk factors for cardiovascular diseases are influenced by adequate levels of health-related physical fitness components [4, 5]. The literature has reported that adolescents with better performance in physical fitness tests have lower odds of high blood pressure, hypercholesterolemia, and cardiovascular dysfunction [6, 7]. Thus, to investigate the relationship between RHR and health-related physical fitness components will clarify whether the changes in RHR may also be due to the results in physical fitness tests.

The health-related physical fitness components have biologically plausible links to changes in RHR. Higher or improved cardiorespiratory fitness is associated with more efficient myocardial function and lower RHR [8]. Lower results on aerobic fitness tests were associated with lower left ventricular mass, which affects lower resting systolic volume and higher RHR [8]. In addition, higher or improved muscle strength and flexibility levels were associated with neural and muscular adaptations which results in greater parasympathetic nervous system activity reflected in healthy RHR [9, 10]. Excess body fat is associated with the release of inflammatory adipokines into the bloodstream, which are associated with increased sympathetic nervous system activity that results in greater RHR [11]. However, most of this evidence comes from studies with the adult population, which makes it uncertain whether these associations are confirmed with adolescents.

The aim of this study was to investigate the association between health-related physical fitness components (cardiorespiratory fitness, handgrip strength, flexibility, and body composition) with RHR in Brazilian adolescents. Our hypothesis was that better results in health-related physical fitness tests will be associated with lower RHR.

2. Materials and Methods

This cross-sectional epidemiological study was carried out in the second half of 2014 in the city of São José, Southern Brazil. The municipality has a Human Development Index (HDI) of 0.809 and Gini index of 0.44 [12].

The sampling process was completed in two stages: being stratified by public high schools (according to density) and clustered by classes considering school shift and grade. To determine the sample size, we followed the procedures suggested by Luiz and Magnanini [13] for a finite population. According to data from the Secretariat of Education of the State of Santa Catarina, we obtained 5,182 students (14–19 years old) who were enrolled in the 2014 school year at 11 eligible public schools of São José and distributed into 170 high school classes (74.8% of students were on the day shift). A confidence level of 1.96 (95% confidence interval), a tolerable error of five percentage points, a prevalence of 50%, and a 1.5 design effect were adopted. We included an additional 20% to compensate for possible losses and refusals and another 20% to control for potential confounders in the association analyses [14]. Under these parameters, the required sample size was 751 students. However, as all students in the selected classes were included, this process resulted in sample larger than estimated, resulting in the collection of data from 1,132 students. Of this amount, 695 students had information regarding RHR and other variables investigated in this study. This sample size had enough statistical power (> 80%) to verify the relationship between RHR and health-related physical fitness components when investigated as continuous variables. In the analyses in which the variables were stratified by sex and treated categorically, the statistical power was less than 80% for the body composition, flexibility, and handgrip strength.

The study was approved by the Ethics Research Committee with Human Beings of the Federal University of Santa Catarina, Brazil. Only subjects who returned the informed consent form signed by parents (<18 years) or by themselves (≥18 years), together with the consent form signed by participants, participated in the study.

Data collection took place in the school environment in the second half of 2014, during the months of August to November. The research team was comprised of undergraduate and graduate students previously familiar with and trained to apply the questionnaire and physical assessments. The questionnaire was answered in the classroom, and data were self-reported by students.

RHR was evaluated using the automated oscillometric sphygmomanometer model Omron HEM 742 (Kyoto, Japan), with validation for adolescents [15]. Participants were informed about the procedures and instructed to remain at rest for at least five minutes, in a quiet and calm environment, with empty bladder, without having exercised for at least 90 minutes before evaluation, not having smoked and not having consumed alcohol, coffee, or tea at least 30 minutes prior to data collection. During RHR collection, participants remained with their backs on a chair, arms flexed at an angle of 90° according to procedures adopted by the American Heart Society [16]. Measurements were performed twice at intervals of fifteen minutes. For this research, the average beats per minute (bpm) rate of the two measurements was used. RHR was measured on the same day of the aerobic fitness test; however, it was performed before the aerobic fitness test. For purpose of analysis, RHR was treated as a continuous measure.

Aerobic fitness was measured using the modified Canadian Aerobic Fitness Test (mCAFT) [17], validated in comparison to indirect calorimetry in Canadian men and women aged 15–69 years [18], and with sufficient discriminatory power to detect high blood pressure levels in young Brazilians [19]. Adolescents had to complete one or more stages of three minutes each (going up and down two steps with increasing intensity) at predetermined rates according to sex and age. The test was terminated when the subject reached 85% of age-predicted maximal heart rate and the end of a 3-minute stage [17], with heart rate measured using a Polar® frequency meter model H7 Bluetooth (Kempele, Finland). In order to estimate VO_2peak the equation *17.2 + (1.29 x Oxygen Expenditure) - (0.09 x weight in kg) - (0.18 x age in years)* was used.[17] In addition, VO_2peak values were classified according to the distribution tertile for boys (1st tertile ≤ 39.63 $mL.kg^{-1}.min^{-1}$, 2nd tertile = 39.64 – 45.20 $mL.kg^{-1}.min^{-1}$, and 3rd tertile ≥ 45.21 $mL.kg^{-1}.min^{-1}$) and girls (1st tertile ≤ 32.69 $mL.kg^{-1}.min^{-1}$; 2nd tertile = 32.70 – 37.56 $mL.kg^{-1}.min^{-1}$; and 3rd tertile ≥ 37.57 $mL.kg^{-1}.min^{-1}$). We chose this classification because there are no criterion-referenced cut-points for this physical test for the Brazilian population.

Handgrip strength was measured using Saehan® manual dynamometer (Seoul, South Korea). During evaluation, participants remained standing with arms outstretched at the side of the body, with the hand and dynamometer not touching the body. The device was individually sized between the distal phalanges and the palm of the hand, and the adolescent was asked to take maximum inspiration and expiration, followed

by a maximal effort to squeeze the dynamometer [17]. The test was performed on both hands alternately, twice, and the best result of each hand was recorded in kilograms (kg) and summed, obtaining the total force. In addition, handgrip strength values were classified according to the distribution tertile for boys (1st tertile ≤ 64.00 kg, 2nd tertile = 64.01 – 79.00 kg, and 3rd tertile ≥ 79.01 kg) and girls (1st tertile ≤ 40.00 kg; 2nd tertile = 40.01 – 49.00 kg; and 3rd tertile ≥ 49.01 kg). We chose this classification because there are no criterion-referenced cut-points for this physical test for the Brazilian population.

Flexibility was measured using the Wells bench for the sit-and-reach test [20]. The test was performed twice and the highest value reached in the test was used [17]. In addition, sit-and-reach test values were classified according to the distribution tertile for boys (1st tertile ≤ 25.19 cm, 2nd tertile = 25.19 – 32.48 cm, and 3rd tertile ≥ 32.49 cm) and girls (1st tertile ≤ 26.16 cm; 2nd tertile = 26.17 – 32.54 cm; and 3rd tertile ≥ 32.55 cm). We chose this classification because there are no criterion-referenced cut-points for this physical test for the Brazilian population.

Body fat was evaluated using the sum of two skinfold thicknesses. The triceps and subscapular skinfold thickness values were collected using the Cescorf® skinfold caliper (Porto Alegre, Brazil), a Brazilian model with design and mechanics similar to the English Harpenden® skinfold caliper (Burgess Hill, United Kingdom), with a presumed constant pressure for any opening of its jaws around 10g/mm^2, measuring unity of 0.1 mm and contact area (surface) of 90mm^2. The measurements were taken according to recommendations of the International Society for the Advancement of Kinanthropometry (ISAK) [21]. Anthropometric measurements were performed by a single evaluator with level one ISAK certification. For the present study, the sum of the two skinfolds thickness values was used. In addition, the sum of the two skinfolds thickness values was classified according to the distribution tertile for boys (1st tertile ≤ 16.5 mm, 2nd tertile = 16.6 – 22.3 mm, and 3rd tertile ≥ 22.4 mm) and girls (1st tertile ≤ 26.6 mm; 2nd tertile = 26.7 – 36.9 mm; and 3rd tertile ≥ 37.0 mm). We chose this classification because there are no criterion-referenced cut-points for this physical test for the Brazilian population.

Sociodemographic, physical activity, sexual maturation, and BMI variables were included in the analyses as control variables. Sociodemographic variables were sex (male/female) and age, collected in complete years and later categorized in 14/15, 16/17, and 18/19 years. Physical activity was evaluated by the following question of the Brazilian version of the Youth Risk Behavior Surveillance (YRBSS) questionnaire, used in the United States, translated and validated for Brazil [22]: "During the last seven days, in how many were you physically active for at least 60 minutes a day? (moderate and/or vigorous physical activity)." This question had responses categorized as "inactive/insufficiently active" (zero to four days) and "active" (five days or more) [23].

Sexual maturation was self-assessed by adolescents, using maturational development boards proposed by Marshall and Tanner [24]. These boards contained photographs of the five stages of maturational development, with adolescents being asked to look closely at each photograph and to mark in the questionnaire which photograph most resembled their genital organ size for boys and breast size for girls. Students were individually oriented by same-sex evaluators about the objective and importance of this evaluation. There was a low frequency of adolescents who were in the prepubertal stage (2%), so they were excluded from the analysis. Thus, from this variable, adolescents were classified in "Pubertal" and "Post-pubertal" categories.

Weight and height measures were collected to calculate the BMI. Height was measured with a Sanny® stadiometer with tripod (São Paulo, Brazil) and body mass with G-tech® digital scale (Zhongshan, China). BMI z-scores were computed using age- and sex-specific reference data from World Health Organization [25].

Descriptive and inferential statistical procedures were used, and data normality was verified through mean and median comparison, skewness, kurtosis, and graphs. For the description of continuous variables, mean and standard deviation were used. Student's *t*-test was used to identify differences between variables according to sexes. For categorical variables we used Chi-square test. In order to investigate the relationship between RHR and health-related physical fitness indicators (aerobic fitness, muscular strength, flexibility, and body fat), models were created for each indicator, in which possible associations were analyzed through simple and multiple linear regression, and results were presented as regression coefficients (β), 95% confidence intervals (95% CI), and determination coefficients (R^2). In the adjusted analysis between RHR and models with each health-related physical fitness indicator, sociodemographic variables (sex and age), physical activity, sexual maturation, and BMI were inserted as control variables. Residuals from the final multiple linear regression models were assessed by heteroscedasticity and normality. In addition, the interaction between covariates (age, physical activity, sexual maturation, and BMI) and physical fitness variables was verified. As there was no interaction between variables, analysis of covariance (ANCOVA) was used stratified by sex in order to verify if there were differences in RHR according to the categories (in tertiles) of health-related physical fitness components. In all analyses we calculated the effect size as recommended by the literature [26, 27]. Significance level of $p < 0.05$ was adopted. Statistical analyses were performed using Stata 13.0 software (STATA Corp., College Station, Texas, USA), considering the sample weight and design effect for school.

3. Results

A total of 695 students aged 14 to 19 years were included in this analysis. The sample characteristics are shown in Table 1.

In boys, we found that, in the crude linear regression analysis, aerobic fitness and handgrip strength were inversely associated with RHR (Table 2). In the analysis adjusted by age, physical activity, sexual maturation, and body mass index, the aerobic fitness and handgrip strength remained inversely associated with RHR, indicating that the increment of one unit in peak oxygen uptake (mL.kg^{-1}.min^{-1}) results in a

Table 1: Characteristics of the sample.

	Male (n = 337) Mean (SD)	Female (n= 358) Mean (SD)	p	Cohen's D
RHR (bpm)	76.1 (13.6)	81.1 (10.9)	<0.01∗	0.40
Age (years)	16.2 (0.1)	16.0 (0.1)	<0.01∗	0.18
Weight (kg)	65.7 (0.5)	58.5 (0.5)	<0.01∗	0.60
Height (cm)	172.7 (0.3)	161.3 (0.2)	<0.01∗	1.69
BMI (kg/m^2)	22.0 (3.6)	22.4 (4.0)	0.04∗	0.11
Triceps skinfold (mm)	10.8 (5.1)	18.7 (6.9)	<0.01∗	1.30
Subscapular skinfold (mm)	10.8 (4.8)	15.5 (7.2)	<0.01∗	0.76
Sum of skinfolds (mm)	21.5 (9.5)	34.3 (13.5)	<0.01∗	1.09
Aerobic fitness (mL.kg^{-1}.min^{-1})	42.7 (5.4)	35.3 (3.7)	<0.01∗	1.60
Handgrip strength (kg)	71.8 (17.3)	45.4 (10.4)	<0.01∗	1.85
Sit-and-reach test (cm)	28.7 (7.6)	29.5 (7.6)	0.08	0.11
	n (%)	**n (%)**	**p**	**Cramer's V**
Physical activity				
Active	99 (57.9)	72 (42.1)	<0.01∗	0.01
Less active	238 (45.4)	286 (54.6)		
Sexual Maturation				
Pubescent	244 (52.7)	219 (47.3)	<0.01∗	<0.01
Post-Pubescent	93 (40.1)	139 (59.9)		

RHR: resting heart rate; SD: Standard Deviation; ∗p<0.05; Cohen's D: effect size for comparison between groups; Cramer's V: effect size for chi-square test.

decrease of 0.11 bpm in RHR and that the increase of 1.0 kg results in a decrease of 0.10 bpm in RHR, respectively. In addition, the sum of skinfolds was directly related to the RHR, indicating that the increment of one mm in the sum of skinfolds results in an increase of 0.5 bpm in RHR. These results had a medium effect size (Cohen's f^2 = 0.27) for the variable aerobic fitness and small (Cohen's f^2 = 0.03) for handgrip strength and sum of skinfolds (Cohen's f^2 = 0.05) (Table 2).

In girls, we found that, in the crude linear regression analysis, aerobic fitness and handgrip strength were inversely associated with RHR (Table 2). In the multivariate analysis the aerobic fitness and the body composition were associated with RHR, indicating that the increment of one unit in peak oxygen uptake (mL.kg^{-1}.min^{-1}) results in a decrease of 0.09 bpm in RHR and that the increase of 1.0 mm in the sum of skinfolds results in an increase of 0.17 bpm in RHR. These results had a small effect size (Cohen's f^2 = 0.14) for aerobic fitness and small effect size (Cohen's f^2 = 0.06) for sum of skinfolds (Table 2).

In boys (Figure 1) higher RHR was observed in adolescents who had handgrip strength levels classified in the first tertile (lower levels) of the sample distribution when compared to those in the third tertile (higher levels). Higher RHR values were also observed in the adolescents who had VO_2 peak values classified in the first tertile (lower levels) when compared to those in the second and third tertiles (higher levels).

In girls (Figure 2) higher RHR values were observed in the adolescents who had VO_2peak values classified in the first tertile (lower levels) when compared to those in the second and third tertiles (higher levels).

4. Discussion

The main finding of this study was that aerobic fitness was associated with RHR in both sexes, indicating that lower aerobic fitness values were associated with higher RHR values. One explanation for this is that the improvement of cardiorespiratory fitness is associated with increased left ventricular diameter/thickness and increased final systolic volume (due to elevated plasma volume and decreased peripheral resistance), leading to increased stroke volume [8, 28]. The increase in stroke volume leads to a decrease in the number of beats required to maintain cardiac output, decreasing the metabolic load of the heart, contributing to lower RHR [8, 28]. Another explanation is that high levels of aerobic fitness decreases parasympathetic nervous system activity, which reduces the RHR [29]. Other authors found that the improvement of cardiorespiratory fitness in adolescence reflects better cardiovascular health indicators, such as healthy blood pressure levels, favorable lipid profile, and lower risk of morbidity and mortality in adult life [30, 31]. In this way, promoting the improvement of the cardiorespiratory fitness of children and adolescents is to promote healthier people throughout life.

For boys, we also found inverse association between handgrip strength and RHR values. A cohort study followed 38,000 men for 30 years (from adolescence to adulthood) and found that men with high muscle strength in adolescence had a decreased risk of later cardiovascular disease events (HR:

Table 2: Relationship between resting heart rate and health-related physical fitness components in adolescents.

Variable	Crude Analysis				Adjusted Analysis [b]				Cohen's f^2
	ß[a]	(95%CI)	*p*	R^2	ß[a]	(95%CI)	*p*	R^2	(df = 5)
Male									
Aerobic fitness	-0.09	(-0.11; -0.07)	<0.01*	0.15	-0.11	(-0.14; -0.08)	<0.01*	0.21	0.27
Handgrip strength	-0.13	(-0.20; -0.06)	<0.01*	0.02	-0.10	(-0.18; -0.01)	0.28*	0.03	0.03
Sit-and-reach test	-0.15	(-0.31; 0.15)	0.07	0.01	-0.15	(-0.34; 0.03)	0.10	0.03	0.03
Sum of skinfolds	0.11	(-0.22; 0.24)	0.10	0.01	0.50	(0.25; 0.75)	<0.01*	0.05	0.05
Female									
Aerobic fitness	-0.05	(-0.08;-0.03)	<0.01*	0.04	-0.09	(-0.12; -0.06)	<0.01*	0.12	0.14
Handgrip strength	-0.10	(-0.20; -0.01)	0.02*	0.01	-0.04	(-0.15; 0.05)	0.36	0.04	0.04
Sit-and-reach test	-0.04	(-0.17; 0.08)	0.47	0.01	-0.05	(-0.19; 0.09)	0.48	0.03	0.03
Sum of skinfolds	-0.05	(-0.12; 0.01)	0.14	0.01	0.17	(0.36; 2.72)	<0.01*	0.06	0.06

a: regression coefficient; b: adjusted analysis by sex, age, physical activity, sexual maturation, and body mass index; R^2: determination coefficient; CI: confidence interval; Cohen's f^2:effect size for multiple linear regression; df: degree freedom.

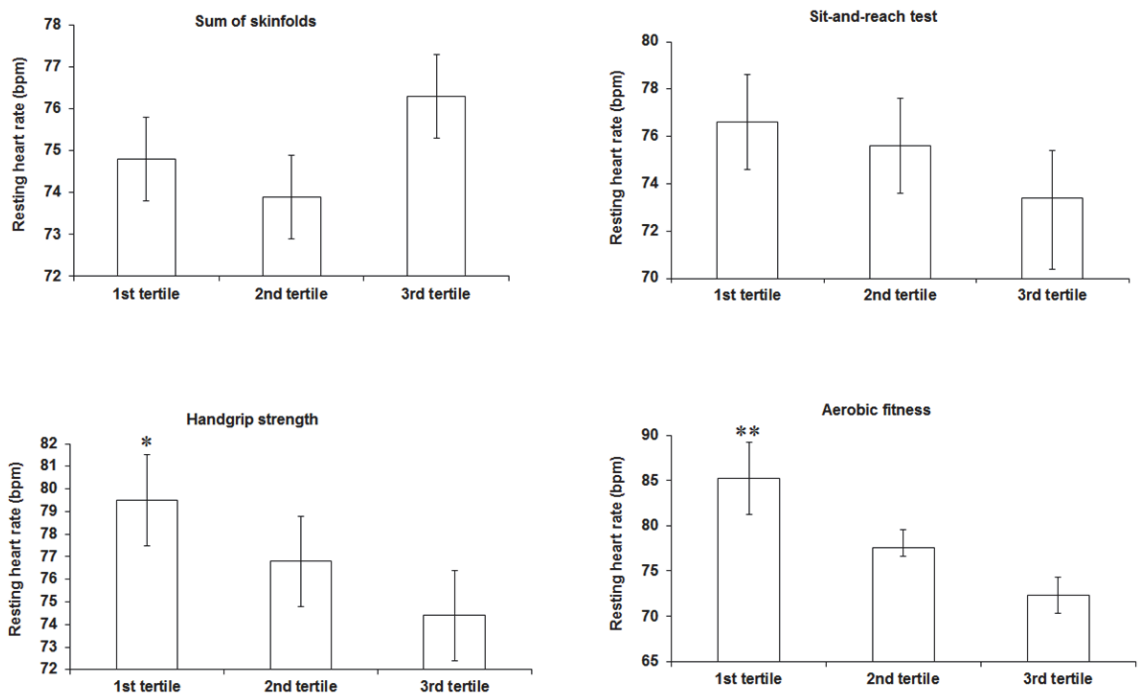

Figure 1: Comparison of resting heart rate (mean and 95% confidence intervals) according to the categories of health-related physical fitness components among males. Analysis of covariance with age, physical activity, and sexual maturation as covariates. ∗ higher values when compared to the third tertile; ∗∗ higher values when compared to the second and third tertile.

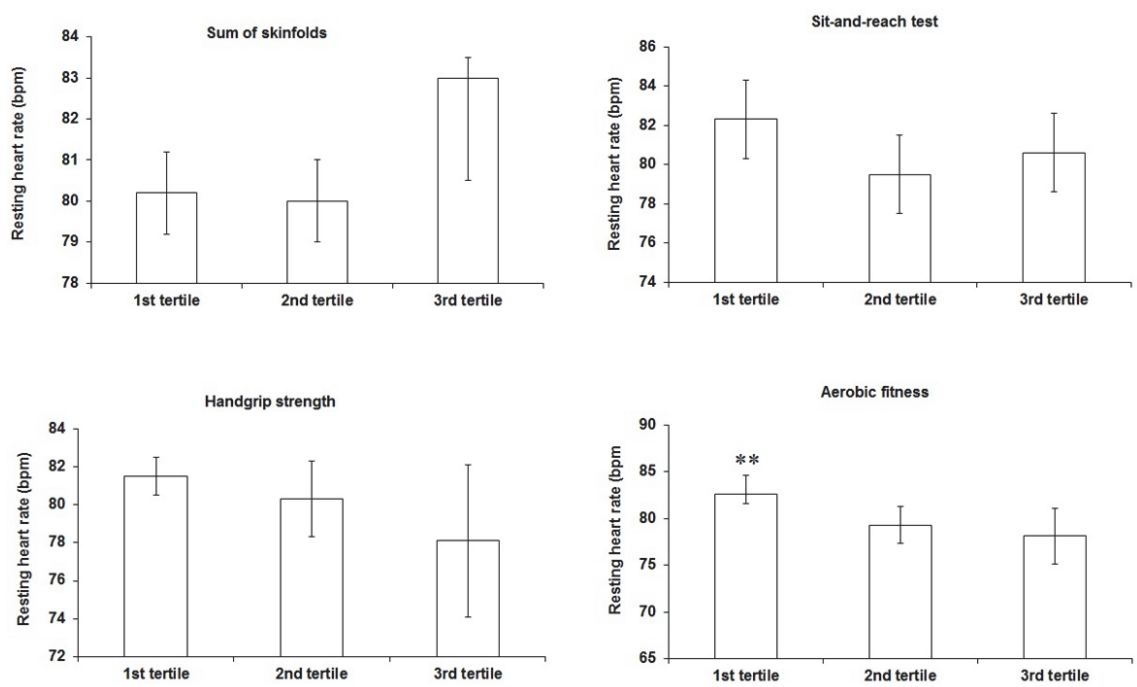

Figure 2: Comparison of resting heart rate (mean and 95% confidence intervals) according to the categories of health-related physical fitness components among females. Analysis of covariance with age, physical activity, and sexual maturation as covariates. ∗∗ higher values when compared to the second and third tertile.

0.88; 95% CI: 0.77-0.99). However, low muscle strength was associated with increased risk of cardiovascular disease mortality during middle age (HR: 1.31; 95% CI: 1.02-1.67) [32]. As the RHR is an indicator of cardiovascular health [2], we can hypothesize that adequate levels of muscle strength in men can be an indicator of adequate levels of RHR. The biological plausibility of the association between muscle strength and RHR is the fact that the development of muscular strength is directly related to the intensity and duration of the counterresistance effort [33]. The increase in the cardiometabolic demands concomitant with the counterresistance effort (necessary to improve muscle strength) leads to an imbalance between the tonic activity of the sympathetic accelerator neurons and parasympathetic depressors in favor of the greater vagal domain, resulting in lower RHR [8, 33, 34].

For girls an association between handgrip strength and RHR was not found. In the crude analysis we found an inverse association between these variables, but when the model was adjusted, especially with the inclusion of BMI, this association was not maintained. A systematic review reported there are few studies with women that aimed to identify the association between muscular strength and cardiovascular health indicators [35]. These few studies have reported a significant association between muscle strength and indicators of body fat or metabolic syndrome [35]. Research completed with Australian adolescents found an association between handgrip strength and cardiovascular indicators; however, when the BMI was included in the analysis model this association disappeared [36]. This Australian study did not stratify the sample by sex. Rioux et al. [37] aimed to investigate the association between handgrip strength and cardiometabolic health in a large Canadian sample of children and youth. The authors found that for girls high handgrip strength was significantly associated with lower odds of cardiometabolic risk factors independent of age, BMI z-score, and cardiorespiratory fitness. For boys handgrip strength was not associated with lower odds of cardiometabolic risk factors [37]. Thus, there are inconsistent findings in the literature. Based on a recent systematic review, our study is timely, as the authors of this review concluded that there is a lack of comprehensive understanding of factors, such as sex, that could impact cardiometabolic risk factors in youth and children [38]. We also emphasize that as there are few studies that aimed to associate muscle strength with RHR in adolescents, we cannot establish whether our results agree or disagree with the literature. Possible justification for nonassociation between muscle strength and RHR in girls would be related to lower absolute strength values in girls compared to boys, which results in lower compression of blood vessels by the muscle during contraction, which may result in reduced adaptations related to cardiac hypertrophy and reduction in RHR [39]. In addition, the lack of association between muscle strength and RHR in girls may also have occurred because of the hormonal changes that affect adolescents. The hormonal changes in girls due to puberty result in lower performances in strength tests, which may have made the girls sample homogeneous in relation to handgrip strength, making it difficult to find differences between the groups investigated [33, 40].

As we found in the present study, other studies [3, 41] have identified a direct relationship between increased body fat and increased RHR. Some hypotheses indicate that an increase in body fat results in increased sympathetic nervous system activity [11, 42]. In addition, adipose tissue secretes angiotensinogen, which provokes angiotensin II formation and further activation of sympathetic nervous system activity. This increased activity of the sympathetic nervous system results in greater RHR [11, 42]. In addition, it is possible that the association between body fat and RHR may have been mediated by the level of physical activity and/or aerobic fitness, considering that both factors are related to body fat and RHR [1, 7].

We found no association between flexibility and RHR. Although it is a topic that needs further research, the literature reports that adequate levels of flexibility have beneficial effects on cardiovascular health, such as blood pressure and heart rate variability [9]. Recent evidence in adults suggests that improving the flexibility of a single muscle group or different muscle groups may reduce blood pressure and RHR [9, 43]. One potential mechanism for this situation may be related to the improvements in sympathetic control of vasomotor tone which can be caused by improving muscle flexibility [44]. Indeed, it has been suggested that the decrease in sympathovagal balance can be associated with increased trunk flexibility [45]. Therefore, any notable improvement in RHR with improved flexibility may be related to a decrease in vasomotor tone (i.e., reduced vagal inhibition) [9]. The literature did not investigate these effects in adolescents and so we cannot say that this would be expected in them. Proportional differences in the length of the upper and lower limbs of schoolchildren may have contributed to the absence of the association between flexibility and RHR, since such asymmetry may imply underestimation or overestimation of the results and affect the validity of the test used [46].

For all results of this study, the effect size was small or medium, reflecting little meaningful interpretations in a practical sense [26, 27]. In other words, what we want to report is that these results should be interpreted with caution. In boys, cardiorespiratory fitness and handgrip strength will need to increase 9.0 $mL.kg^{-1}.min^{-1}$ and 10 kg, respectively, to result in a decrease of one bpm in RHR. For body fat in boys it will need to decrease 2.0 mm in sum of skinfolds to result in a decrease of one bpm in RHR. In girls, cardiorespiratory fitness will need to increase 10.0 $mL.kg^{-1}.min^{-1}$ to result in a decrease of one bpm in RHR. Body fat in girls will need to decrease 5.0 mm in sum of skinfolds to result in a decrease of one bpm in RHR. The most important result of the present study is that associations were found between health-related physical fitness components an d RHR. This demonstrates that acting on the improvement of these components in the pediatric population may be useful in preventing cardiovascular complications in adolescence.

The use of RHR as a prognosis for health problems has been evidenced in the literature [1–3, 19, 41]. However, some previous studies did not consider in the analyses the possible confounding effect of aspects directly related to RHR, such as indicators of physical fitness or levels of physical activity [1, 2, 41]. In the present study, we considered these variables in the

statistical analyses and found an inverse association between RHR and aerobic fitness (boys and girls) and muscular strength (boys) and direct association with body fat (boys and girls). Such associations had a weak magnitude of association. However, the results found reinforce the use of RHR as a useful measure to be used in adolescents and can be used in large monitoring systems because they are easier to apply than physical fitness tests.

This study has some notable limitations. The cross-sectional design of this study may be considered a limitation, since it prevents the establishment of causality and temporality among variables. The low sampling power for the comparisons between the tertiles of the health-related physical fitness components and RHR is another limitation of the research. Physical fitness tests depend on the adolescent's motivation to perform it, and, for this reason, it can be a measure with limitations. Another limitation was that although schoolchildren had their RHR values measured after five minutes of absolute rest (and were told not to exercise for at least 90 minutes prior to assessment), it is possible that some of those evaluated may have performed moderate to vigorous intensity physical activity prior to 90 minutes from the assessment of RHR, which may have implied a possible bias of the verified results. This occurs because physiological alterations resulting from activities of moderate to vigorous intensity may imply RHR values above the basal value for prolonged periods [47]. However, a strength of this study was its methodological rigor in the training of the team and the use of direct physical measures using validated instruments for data collection, providing greater assurance of the accuracy of the findings.

In conclusion, the present study demonstrated that cardiorespiratory fitness and handgrip strength were inversely associated with RHR in boys. For girls, cardiorespiratory fitness was inversely associated with RHR. In both sexes body fat was directly associated with RHR. These associations were independent of age, physical activity level, stage of sexual maturation, and BMI of adolescents. RHR measurement is a viable alternative for use in large health monitoring systems because they are easier to employ than physical fitness tests.

Data Availability

All article data can be accessed by contacting the corresponding author.

Conflicts of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Research Article

Students' Motivation for Sport Activity and Participation in University Sports: A Mixed-Methods Study

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Background. Physical activity among students is essential for complimenting sedentary behavior and for individuals' future health. This study investigates reasons for sport engagement among students and addresses the utilization of university sports programs (USP) by employing a mixed-methods approach. *Methods*. The NuPhA-Study consists of a quantitative online survey (n=689) followed by qualitative interviews (n=20). In the survey, we assessed reasons for sport activity using a 24-item battery and USP utilization. Quantitative results were further explored using qualitative data to check for completeness of the predefined items (content validity) and to identify opportunities to improve participating in USP. *Results*. A factor analysis grouped the 24 items into five factors (life balance/fitness/body image/contact with others/fun). Our qualitative study explained these in more detail and revealed missing aspects. 47.6% of students participated in USP. Potential improvements for USP include program maintenance during the semester break and temporal harmonization with the classes. *Discussion*. The qualitative component identified additional reasons for sport activity that were not addressed by the item battery, which provides critical implications for developing item batteries for future research. Our results may help to generate a more target-group-oriented approach to increase physical activity among students, which will reduce sedentary behavior and future disease burden.

1. Introduction

Adolescence and emerging adulthood is a time of physical, social, psychological, and structural changes, which may influence barriers to and motivations for physical activity [1]. University students represent a specific subgroup in this period as they are particularly affected by changing (structural) life circumstances with the start of their studies. Students' daily lives are characterized by sedentary behavior (e.g., attending university classes); however, physical activity in this age group is important, because future patterns of adult health are established already at this stage of life [2]. In addition, obesity resulting from a lack of physical activity in this age group can have adverse health consequences later in life [3].

A variety of studies have been conducted to identify reasons for participating in physical activity and potential barriers to being physically active in adolescence and young adulthood [4–8]. Motivation for physical activity is often measured by asking about its benefits; there is no consistent way of categorizing items, and often an "intrinsic motivation" category has been used [7, 9–11]. The essential benefits identified in former studies have been "health" [6, 11, 12] and "fun" [5, 8, 12].

These former studies were mainly quantitative and followed a similar procedure (i.e., using a predefined, self-reported questionnaire). Results were discussed without reflecting them back to the target group, which is often necessary to gain a deeper insight to the following questions: (1) What are the aspects underlying the individual response categories? (2) What motivates these responses? and (3) Are there other, more specific aspects associated with the response categories that were neglected? So far, these questions have not been answered. By using a mixed-methods approach

consisting of a quantitative survey and qualitative reflection, we contribute to a deeper understanding of motivation for physical activity among university students [13].

Moreover, besides gathering information on general motivators for physical activity, further details on sport programs that are offered to university students are also needed. To enhance the benefits of a university sports program, it is important to target the program to the needs of the students. However, there is a lack of target-group-specific recommendations for the future development of university sports, for instance, in Germany. While quantitative results may help to identify how many students participate in university sports, a qualitative analysis is useful in exploring participants' needs and providing concrete suggestions for program improvement.

Consequently, we bridged existing knowledge gaps by using data from a mixed-methods study conducted among university students. We aimed to (1) quantify the importance of predetermined potential reasons for sport activity, (2) reflect the target groups' quantitative results by using qualitative interviews to garner a deeper understanding of the reasons and to identify neglected reasons to analyze content validity, (3) quantify the utilization of the university sports program, and (4) collect information on its potential improvement.

2. Materials and Methods

The analyses were based on the Nutrition and Physical Activity Study (NuPhA), a mixed-methods study (explanatory sequential design) including a cross-sectional survey (n=689) and guided face-to-face interviews (n=20) with university students in Germany. We chose this design to gather quantitative information on students' motivations for sport activity and their utilization of the university sports program as a first step. Then, we conducted the qualitative interviews to get a deeper understanding on motivations and utilization as well as to elaborate possible explanations for the quantitative results. The qualitative study part was also used to test the content validity—and therewith the completeness—of the item battery used in the quantitative part. In the past, applying a mixed-methods approach has been shown to be useful since the methods and their results inform each other [14].

This study obtained ethics approval by the Medical Ethics Committee of the Medical Faculty Mannheim, Heidelberg University (2013-634N-MA). All participants provided informed consent before taking part in the study.

2.1. Quantitative Study. We conducted an online survey among university students from all over Germany from October 31, 2014, to January 15, 2015. Students were recruited via fliers, mailing lists, social networks, and lecturers. Completing the questionnaire took approximately 30 minutes. Prior to the first question, participants received information on the study aims and data security. Forty gift cards (20 worth €25 and 20 worth €50) were raffled off.

2.1.1. Variables. Motivation: motivation to be physically active was measured via 24 items (e.g., *I do sports because it relaxes me*), which were answered using five choices (*disagree, tend to disagree, undecided, tend to agree,* and *agree*). The items are based on an established battery by Brown et al. [4]. Since this item battery also included barriers for physical activity, which were analyzed independently in our study following Andajani-Sutjahjo et al. [15], we excluded the items on barriers and added items on motivation from other validated instruments [5–8, 10–12] to cover an even broader range of items. The completeness of the final item battery was tested—as described above—in the qualitative study part (content validity; [14]). Motivation questions were only answered by the students who reported to be physically active (91.9% of the total sample).

Additional individual characteristics: individual characteristics that were included in the analyses were sex, residence change due to start of studies (*yes/no*), and number of semesters studied.

2.1.2. Analyses. First, we performed descriptive analyses of the 24 items on motivation for sport activity and calculated Cronbach's alpha. We conducted a factor analysis with oblimin rotation to summarize the 24 items. All analyses were performed using IBM SPSS Statistics 22 (IBM Corporation, Armonk, USA).

2.1.3. Sample Characteristics. Students (n=689, aged 16–29 years, Table 1) from all over Germany participated in the study (69.5% women; mean age = 22.7 years). 82.0% of the students reported a change in physical activity compared to school. While 36.5% stated that they are more physically active today, 45.4% indicated being less physically active. Most were physically active (91.9%); however, 79.8% stated that they would love to be more physically active (women = 81.8%, men = 75.2%, p = .047).

2.2. Qualitative Study. From March till December 2016, 20 interviews were conducted face-to-face by the last author (JH, a female scientist who is trained in interviewing) without the presence of a third person. The students were recruited via fliers and social networks till theoretical saturation was reached. The average duration of the interviews was 41:45 minutes (range = 28–59 minutes). Prior to the first question, participants received information on study aims and data security. All participants received a gift card for participating (worth €20). We used a semistructured interview guide with open-ended questions. Interviews were audiotaped (Olympus DS-2500) and transcribed verbatim.

2.2.1. Analyses. Qualitative content analysis following Mayring [16] was performed to identify themes, patterns, and contradictions by comparing the 20 interviews. Categories were identified based on the quantitative study. Regarding motivation, our analyses revealed five main categories, which were further divided into 18 subcategories. Regarding university sports, we had four main categories. The data were independently coded by two researchers (JH and HD). The comparison revealed high agreement (82%). For coding the data, we used MAXQDA 12 (VERBI Software GmbH; Berlin, Germany).

Table 1: Characteristics of university students participating in the quantitative component of the NuPhA-Study (Germany).

			Male		Female		
	n	%	n	%	n	%	p-value
Social demographics							
Sex	689						
Male	210	30.5					
Female	497	69.5					
Age	689						0.081
up to 20	167	24.2	40	19.0	127	26.5	
21 - 22	170	24.7	48	22.9	122	25.5	
23 - 24	188	27.3	64	30.5	124	25.9	
25 and older	164	23.8	58	27.6	106	22.1	
Mean (SD)	22.69	(2.73)					
Immigrant background	689						0.513
No	593	86.1	178	84.8	415	86.6	
Yes	96	13.9	32	15.2	64	13.4	
Family status	689						0.537
Married	28	4.1	9	4.3	19	4.0	
Committed relationship	360	52.2	103	49.0	257	53.7	
Single	301	43.7	98	46.7	203	42.4	
Residence	689						0.700
Alone	137	19.9	47	22.4	90	18.8	
With a partner	136	19.7	40	19.0	96	20.0	
Shared flat	246	35.7	75	35.7	171	35.7	
Dormitory or elsewhere	170	24.7	48	22.9	122	25.5	
Money per month	678						0.045
Until 550	174	25.7	46	22.2	128	27.2	
551 - 690	139	20.5	34	16.4	105	22.3	
691 - 885	180	26.5	58	28.0	122	25.9	
886 +	185	27.3	69	33.3	116	24.6	
Study-related characteristics							
Study discipline	689						0.018
Social Sciences	86	12.5	20	9.5	66	13.8	
Medicine/Health Care	369	53.6	104	49.5	265	55.3	
Sport Sciences	43	6.3	19	9.0	24	5.0	
Law	46	6.7	21	10.0	25	5.2	
Other disciplines	145	21.0	46	21.9	99	20.7	
Semester	671						0.361
1 - 3	234	34.9	64	31.2	170	36.5	
4 - 5	127	18.9	42	20.5	85	18.2	
6 - 9	187	27.9	55	26.8	132	28.3	
10 +	123	18.3	44	21.5	79	17.0	
Mean (SD)	5.89	(3.51)					

SD = standard deviation.
P-values are based on Chi^2-tests.

2.2.2. Sample Characteristics. Students were aged 20–26 years (mean age = 22.8 years). Nine were completing a bachelor's degree (semesters three to six), six were completing a master's degree (semesters two to six), and six were completing a state exam (semesters seven to ten). Eleven participants (55%) stated that they were participating in sports more often compared to their sport activity during school years. Nineteen of the 20 students were physically active; however, 15 said that they would love to do more sports.

3. Results

With regard to the quantitative study, the five most critical motives for being physically active were "because it makes me

feel good" (completely agree: 73.3%), "because it is healthy" (56.7%), "because it is fun" (55.8%), "to stay fit" (54.1%), and "to achieve balance in daily life" (51.0%). Reliability was good (Cronbach's alpha = 0.853). Factor analysis of the 24 items revealed five factors (*life balance, fitness, body image, contact to others, fun*; KMO=0.871; Bartlett<0.001, Table 2).

In the qualitative study, further information about these five factors and the reasons behind the answers regarding motivations for physical activity have been addressed. *Life balance* included various aspects of "balance in daily life": an important reason seems to be "to keep a clear head" (S03). This was mentioned in ten of the 20 interviews (S03, S08, S09, S10, S11, S12, S13, S14, S15, and S20). By being physically active, the students try to "reduce stress and calm down" (S08) and "relax a bit and take (their) mind off of everyday problems" (S10). According to them, it feels good to "stop contemplating" (S12), to "switch off" (S13), and to "let the mind wander" (S14). Furthermore, sports are seen as "a source of relaxation" (S20) and a measure to "reduce stress" (S15). Another aspect that was mentioned repeatedly was sports' ability to compensate for the time spent sitting down while studying (S07, S08, and S19).

Fitness not only described building endurance (S06, S07, S14, and S19), but also muscle, especially in the back area (S01, S11, and S20). In this context, sports were also mentioned as "preventing back pain" (S18) and counteracting tenseness because of sitting down for extended periods (S01, S18, S19, and S20). Other associations were general health aspects and the need to stay fit overall (S02, S06, S07, S13, and S16).

Body image included thoughts on body shape, the wish to be slim, and the feeling of physical well-being after playing sports. Body weight seems to be important to both young men and women. The students do not want to "gain a lot of weight" (S07), which is why they try to "counterbalance any deficits in the diet" (S06) by playing sports. Participants also mentioned that their body metabolism has changed over time, which is why they cannot eat whatever they want now (S07) and need to watch their weight (S18). However, it seems to be important not only to have a slim physique, but also to be athletic and to sculpt one's body (S20). One's personal "body sensation" (S09) seems to be part of the body image as well, which means that participants "feel better" (S30) about themselves after playing sports and if they miss it because there is no time, they do not feel fit and awake (S08).

Contact with others described diverse benefits: (a) the development of a feeling of community in sports (S01, S04, S09, S15, S16, and S17), with "group experiences" (S04) as a reason to be physically active, as well as "sharing a sense of achievement with other people" (S15); (b) getting to know new people (S03, S08, S14, and S15) and developing friendships (S08 and S14); (c) spending time together with other people (S06, S12, S14, S15, and S18) and "keeping in touch with friends" (S12); and (d) a positive kind of peer pressure that serves as a motivation to be physically active (S15 and S17).

Fun was minimizing barriers to be physically active (S13, S16, and S20). "If it was not fun, (...) then it would definitely be a hassle to go there" (S03). Enjoying physical activity was associated with competition and team sports (S14 and S15) and a sense of self-affirmation seemed to be the source of pleasure for some participants (S06, S17, S19, and S20).

3.1. University Sports. In the quantitative study, 47.6% of students stated that they participated in university sports. Because of this, students in the qualitative part of the study were asked about how they would evaluate the program in general, how satisfied they were with it, how often they used it, what may prevent someone from participating, and what could be improved.

The qualitative data showed that, in general, students evaluated their university's sports program positively: "It's fine the way it is. I don't think there's anything that should be changed" (S06). The participants especially liked that many courses were free-of-charge or had very low participation fees (S01, S06, S08, S13, S16, S18, S19, and S20).

The variety of courses available was also seen as an advantage (S10, S11, S14, and S17): "The program offers every kind of activity imaginable, from climbing to kayaking and even field trips" (S14). However, some students expressed mixed feelings: "While there is a wide range of courses available, for me personally, there isn't much that interests me" (S20). Common criticisms were the sizes of the facilities and the number of attendees (S02, S03, S15; S18, and S19): "It's just not a lot fun to share the room with one hundred other people" (S03).

Not all students were taking advantage of the university sports program—some praised the variety of available courses, but still did not attend any of them (S01, S13, S09, and S20). Others, however, gladly took advantage of them (S02, S07, and S17). Participating in the program for the very first time may be difficult for some, as one student explained: "My first experience was rather unpleasant; so, I had to force myself to attend in the beginning. I didn't do very well and was out of breath quickly, which wasn't much fun. But in the end, I started doing more sports because of it" (S07).

The main reasons that prevented students from taking advantage of the program were a lack of time and it not being compatible with their schedules (S07, S08, S10, S11, S14, S16, and S20). Access to the facilities (S04 and S05) seemed to be less of a hindrance.

Possible improvements according to study participants were a broader range of courses available during semester breaks (S03) and further adapting them to the usual lecture times so that students could play sports immediately after finishing their courses for the day (S07). The United States was mentioned as an example of a nation where "sports are an integral part of university life" (S12). In addition, some students expressed the need for more beginner courses to accommodate first-time participants (S19), expanding the sports program (S06), and increasing promotion (S10).

4. Discussion

To our knowledge, this study is among the first to combine quantitative and qualitative methods to analyze university students' motivation for sports engagement. Our study underlines the importance of combining quantitative and qualitative research approaches, since our qualitative analysis

Table 2: Factor analysis of 24 items on reasons for being physically active in German university students (NuPhA Study).

I do sports...	Factor loadings	Strongly disagree (%)	Disagree (%)	Neither agree or disagree (%)	Agree (%)	Strongly agree (%)	Mean (SD) / Median (IQR)
Factor 1: Life balance							
...because it helps reducing anxiety, stress and worries	.823	6.5	7.6	9.9	35.3	40.7	3.95 (1.19) / 4 (1)
...because I need to balance out my everyday life	.791	3.9	4.7	5.5	34.8	51.0	4.23 (1.04) / 5 (1)
...because it distracts me from problems	.721	9.4	18.9	18.9	28.7	24.1	3.39 (1.29) / 4 (2)
...to blow off steam	.700	9.0	14.3	15.2	34.4	27.0	3.57 (1.28) / 4 (2)
...because it relaxes me	.626	3.6	6.6	12.6	40.6	36.5	4.00 (1.09) / 4 (1)
Factor 2: Fitness							
...to keep fit	.833	0.8	1.7	2.4	41.0	54.1	4.47 (0.69) / 5 (1)
...because it is healthy	.755	1.1	2.2	5.1	34.9	56.7	4.45 (0.77) / 5 (1)
...to improve my performance	.737	1.4	2.1	6.6	42.2	47.6	4.34 (0.79) / 4 (1)
...because it strengthens my muscles	.687	0.9	3.2	6.6	41.6	47.6	4.33 (0.79) / 4 (1)
...because it makes me feel good	.542	0.6	1.1	2.8	22.2	73.3	4.66 (0.66) / 5 (1)
Factor 3: Body Image							
...because it makes me look slim	.855	15.1	14.6	19.5	34.9	16.0	3.20 (1.31) / 4 (2)
...because it helps me to prevent weight gain	.840	17.4	12.3	13.9	37.8	18.6	3.26 (1.38) / 4 (2)
...because I have weight problems	.735	43.9	19.1	13.9	15.0	8.1	2.22 (1.36) / 2 (2)
...because I do something for my physique	.642	5.5	8.2	12.3	41.6	32.3	3.86 (1.13) / 4 (2)
...because I can maintain my sporty appearance afterwards	.541	9.5	13.4	22.6	33.2	21.3	3.43 (1.23) / 4 (1)
....because I look better afterwards	.516	4.3	9.5	17.9	36.6	31.7	3.83 (1.11) / 4 (2)
...because it improves my self-perception	.379	4.1	6.8	16.9	43.3	28.9	3.86 (1.04) / 4 (2)
Factor 4: Contact to others							
...because it strengthens my friendships	.879	24.7	21.7	25.5	21.1	7.0	2.64 (1.25) / 3 (2)
...because it helps me maintaining my contacts	.847	26.4	21.4	23.3	21.4	7.6	2.62 (1.29) / 3 (3)
...because sport gives me the possibility to do something in company of others	.812	16.6	19.2	20.9	31.5	11.7	3.01 (1.29) / 3 (2)
...because my friends also exercise	.808	17.8	21.7	19.5	26.0	14.9	2.98 (1.34) / 3 (2)

Table 2: Continued.

I do sports...	Factor loadings	Strongly disagree (%)	Disagree (%)	Neither agree or disagree (%)	Agree (%)	Strongly agree (%)	Mean (SD) / Median (IQR)
Factor 5: Fun							
...because it is my hobby	.544	3.8	9.2	12.9	26.7	47.5	4.06 (1.15) / 4 (2)
...to measure my strength with others	.541	39.6	24.3	18.3	12.6	5.2	2.20 (1.24) / 2 (2)
...because it is fun	.491	1.0	4.8	7.9	30.6	55.8	4.37 (0.88) / 5 (1)

Factor analysis with oblimin rotation; Kaiser-Meyer-Olkin=0.871, Bartlett<0.001; n=602; only students being physically active answered the question on the reasons.
SD = standard deviation; IQR = interquartile range.

identified additional reasons for sport participation that were not addressed by the quantitative instrument. However, such a procedure can be helpful to analyze content validity. In addition, we assessed the perception and the utilization of university sports, which is a key form of physical activity in this target group.

The importance of fun, health, and well-being have been stated as key reasons for physical activity in previous studies [5, 6, 8, 11, 12]. Besides analyzing individual items, we used a quantitative factor analysis to group participants' reasons for sports engagement [4]. Our quantitative data revealed 5 factors, which were explained in more detail during our qualitative analysis. For instance, the factor *life balance* was additionally interpreted as "time for recovery," which was not addressed by the quantitative items. The *fitness* factor included trying to prevent back pain resulting from a sedentary way of life. Concerning the factor *contact with others*, qualitative interviews revealed that playing sports involves a group experience and a shared sense of achievement. Further, students indicated that sports are a source of *fun* and pleasure and can provide self-affirmation. In sum, the qualitative study provided critical suggestions for the further development of quantitative items. Our findings underline the importance of including the target group in the process of developing assessment methods such as questionnaires.

The university sports program was positively evaluated by most of the students. Lack of time was mentioned as the most important barrier for nonparticipation in university sports. This is in line with previous research [12, 15, 17–23]. An aspect that was often criticized by students in our qualitative interviews was overcrowded courses. Students also mentioned that the maintenance of the sports program during semester break and the harmonization of class schedule with the start of sport courses would be beneficial.

4.1. Strengths and Limitations. Our study is among the first in combining quantitative and qualitative data und thus comes to profound results. Nonetheless, there are some limitations that should be considered while interpreting our results. First, we used convenience sampling, a type of nonprobability sampling. Therefore, there could be participation bias. Second, participants answered some questions retrospectively; therefore, there may be recall bias. However, this bias was not a problem in our pretests. Third, because of the cross-sectional design of the survey, it is not possible to identify causal relationships. Since our overall aim was to explore motivation and barriers for physical activity, this shortcoming played a trivial role.

5. Conclusion

Our study is a lesson in the importance of combining quantitative and qualitative methods. Only if those who are directly affected—in this case, students exposed to sedentary behavior—are involved in the development of survey tools can the reasons for participating in sports be comprehensively and exhaustively assessed. Our findings provide key implications for other researchers working in this field. Nearly half of the students participated in university sports, which underlines their importance. By following the recommendations for improvement made by the students (i.e., maintenance of the sports program during semester breaks and the harmonization of class schedule with the start of sport courses), stakeholders can enable even more students to participate in university sports and to benefit from the program. This would be a crucial step towards an increase in physical activity in this target group and thus a relevant contribution to their current and future health.

Data Availability

The data analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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Research Article

Development of Step-Count Cut Points for School-Day Vigorous Physical Activity

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Background. No study has established step-count cut points for varying amounts of accelerometer-assessed vigorous physical activity (VPA) accrued during the school day in children. The purpose of this study was to establish step-count cut points for discriminating children meeting VPA in 5 minutes, 10 minutes, 15 minutes, and 20 minutes per 7-hour school day. *Methods*. Participants were a convenience sample of 1,053 children (mean age = 8.4 (1.8) years) recruited from 5 schools from the Mountain West region of the USA. Data within students were observed across multiple semesters totaling 2,119 separate observations. Step counts and time in VPA were assessed using ActiGraph wGT3X-BT triaxial accelerometers that were worn during the entirety of a 7-hour school day for one school week. Average censored step counts and minutes in VPA were calculated across 3 to 5 days. Receiver operating characteristic (ROC) curves were employed to derive step counts via calculation of the maximum Youden J statistic. *Results*. Area-under-the-curve (AUC) scores ranged from AUC = 0.81 (95% CI: 0.78–0.83; $p < 0.001$) for meeting at least 5 minutes of VPA to AUC = 0.94 (95% CI: 0.88–1.00, $p < 0.001$) for meeting at least 20 minutes of VPA. Approximately 3,460 steps best discriminated children meeting at least 5 minutes of VPA (sensitivity = 74.0%, specificity = 74.0%, and accuracy = 74.1%) and approximately 5,628 steps best discriminated children meeting at least 20 minutes per day of VPA (sensitivity = 85.7%, specificity = 95.1%, and accuracy = 95.1%). *Conclusion*. Step counts can discriminate with reasonable accuracy children that meet at least 5 minutes of school-day VPA and with strong accuracy children that meet 20 minutes of school-day VPA.

1. Introduction

Higher levels of vigorous physical activity (VPA) have been more strongly linked to lower mortality in adults and improved health-related fitness in youth compared to moderate physical activity [1, 2]. By convention, physical activity recommendations and research in physical activity surveillance and intervention efficacy use moderate-to-vigorous physical activity (MVPA) as the primary metric for assessment [3]; however research supports there being stronger independent correlations between VPA and health in the pediatric population [4, 5]. Unfortunately, age related declines in VPA appear to be greater compared to declines in moderate physical activity [6]. Although the "moderate" physical activity component of MVPA may relate to improved health outcomes in high-risk youth (e.g., those with obesity), adults, and the geriatric population [7, 8], in lower-risk children, moderate physical activity has shown in many studies to be only a modest predictor of health-related fitness and cardiometabolic health outcomes [4]. This is not to deny moderate physical activity's role in emotional wellbeing, cognitive functioning, and other benefits [9, 10], but this is to communicate that it is through increasing VPA that there is a sufficient physiological response needed to improve cardiorespiratory endurance and to yield large energy expenditures needed to maintain or improve body composition [11, 12].

Because children spend a majority of their waking hours in school, physical activity surveillance and physical activity promotion in primary and secondary school settings have been an increasingly popular line of research [13, 14]. VPA may be especially important during school hours because of

the long bouts of sedentary behavior that often accompany academic classes and limited time windows during the school day for PA engagement. Unfortunately, because of the expense of accelerometers and the time and resources needed to process and download accelerometer count data, physical activity assessment using large samples of children may not be feasible for many researchers and practitioners. Although the use of accelerometers is preferable in most contexts because of its ability to characterize intensity using validated count cut points, pedometer step counts offer an alternative method to assess physical activity [15]. Pedometers are inexpensive devices that record step counts and can provide meaningful information regarding children's ambulatory physical activity [16]. Pedometers can also be administered to large samples of children concurrently, with significantly less cost, time, and resources needed compared to accelerometers. Despite this, the major limitation of using step counts (pedometers) for physical activity assessment is the inability to characterize physical activity intensity [17]. Thus, determining step counts relating to various levels of physical activity will be useful for researchers, physical educators, and health practitioners when assessing large samples of children within school settings. There has been published research establishing step counts associated with MVPA [18–20]; however no study to date has established step-count cut points discriminating children meeting various levels of VPA during school hours. Therefore, the purpose of this study was to develop step-count cut points discriminating 5 minutes of VPA, 10 minutes of VPA, 15 minutes of VPA, and 20 minutes of VPA during a 7-hour school day in children from the first through 6th grades.

2. Methods

2.1. Participants. Participants were a convenience sample of 1,053 children (mean age = 8.4 (1.8) years; 525 girls, 528 boys) recruited from 5 schools from the Mountain West region of the USA. Participants were recruited from the first through 6th grades. Physical activity data within students were observed across multiple semesters totaling 2,247 separate observations. Because of missing or invalid data, the final sample consisted of 2,119 separate observations (94.3% of original sample; 8.5 (1.9) years; 1,041 girls, 1,078 boys). The final sample distribution per grade level included 533 first-grade observations, 521 second-grade observations, 443 third-grade observations, 343 fourth-grade observations, 172 fifth-grade observations, and 107 sixth-grade observations. Data were collected across three school years between 2014 and 2017. All participants were enrolled in schools receiving a Comprehensive School Physical Activity Program that was funded by the US Department of Education. The 5 schools from which all participants were recruited were considered of low income and "Title 1" and thus were receiving supplemental government financial assistance.

2.2. Procedures. School-day steps and time in VPA were assessed using ActiGraph wGT3X-BT triaxial accelerometers (Pensacola, FL, USA). The step-count function in ActiGraph models has shown evidence for moderately high degree of criterion validity with accelerometer counts (r = 0.82) and convergent validity with Omron pedometer step counts (r = 0.89) in children [21]. Low force steps were censored because ActiGraph accelerometer step counts are more sensitive to low force acceleration compared to research-grade pedometers [19]. Therefore, accelerometer censored step counts may more strongly agree with pedometer steps. Step counts were disregarded if the associated accelerometer counts were less than 500 counts/minute. The low-frequency extension was not used. Each participant in the original sample (N = 2,247) was instructed to wear the accelerometer for 5 school days (Monday through Friday) between the hours of 8 am and 3 pm with no included non-wear time. Accelerometers were worn on the right hip at the level of the iliac crest, aligned with the kneecaps. Classroom teachers, physical educators, and members of the research team ensured that the devices were worn during the entirety of the school day. A valid day for accelerometers was determined to be at least 7 valid hours out of total wear time for at least 3 days of the school week. Approximately 2,119 observations met these criteria (94.3% of the original sample) and therefore were subsequently included in the data analysis.

Accelerometer data were recorded in 15-second epochs at 100 Hertz and subsequently processed using the Evenson et al. [22] cut points. Evenson et al. [22] cut points are often used to classify physical activity intensity in children and adolescents because of established strong criterion-referenced energy expenditure agreement with indirect calorimetry [23]. The epochs during the school day were classified as sedentary, light, moderate, or vigorous physical activity. The ActiLife 6.11.5 software program (Pensacola, FL, USA) was used to initialize, download, process, and store accelerometer data.

Data were collected across 3 academic school years between 2014 and 2017 (5 semesters total). Data were collected both in the fall and spring semesters across the 5 schools. Schools involved in this study were part of the same school district and therefore had similar bell schedules and all were characterized by a 7-hour school day. Accelerometer step count and count data used in the subsequent analysis included the school-day averages across one school week (3–5 days).

2.3. Statistical Analysis. Differences between the sexes on school-day step counts, MVPA, and VPA were examined using independent t-tests. The average time in school-day VPA was stratified into a binary classification scheme for 5 minutes of school-day VPA, 10 minutes of school-day VPA, 15 minutes of school-day VPA, and 20 minutes of school-day VPA. Receiver operating characteristic (ROC) curves were developed to determine the number of school-day step counts needed to discriminate students who did and who did not achieve various VPA levels during school hours. Separate ROC curves were developed for each VPA cut point. To keep sample sizes large, ROC curves were not developed for more specific age or age-sex groups. Overall diagnostic power was determined using the area under the curve (AUC). The sex differences between AUC scores were examined using STATA's "roccomp" command. AUC scores of ≥0.90 were considered excellent, 0.80–0.89 good, 0.70–0.79 fair, and <0.70 poor [24]. Step-count cut points for each ROC curve

Table 1: Descriptive statistics for separate weekly data observations (means (standard deviations)).

	Total sample (N = 2,119)	Girls (n = 1,041)	Boys (n = 1,078)
Age (years)	8.5 (1.9)	8.3 (1.8)	8.6 (2.0)
School-day steps	3,319 (1328)	3,211 (1243)	**3,767 (1433)**
School-day MVPA (minutes)	31.7 (14.3)	29.9 (12.9)	33.1 (15.9)
School-day VPA (minutes)	4.7 (4.4)	4.2 (4.3)	4.9 (4.5)

Note. MVPA stands for moderate-to-vigorous physical activity; VPA stands for vigorous physical activity; bold indicates statistically significant differences between sexes, $p < 0.05$.

Table 2: Receiver operating characteristic curve step-count cut points across various levels of school-day vigorous physical activity.

VPA cut point	Step-count cut point	Sensitivity	Specificity	Maximum Youden's J Statistic	Accuracy
5 minutes of VPA	3,460	74.0%	74.0%	0.48	74.1%
10 minutes of VPA	4,133	81.0%	77.5%	0.56	77.8%
15 minutes of VPA	4,133	97.0%	74.8%	0.71	75.2%
20 minutes of VPA	5,628	85.7%	95.1%	0.81	95.1%

Note. VPA stands for vigorous physical activity.

were determined using the maximum Youden J statistic, which was calculated using STATA's "senspec" command and is the point on the ROC curve that maximizes the sum of sensitivity and specificity ($J\max = \max((\text{sensitivity} + \text{specificity}) - 1)$). Sensitivity was the probability that a student achieved a VPA cut point based on step counts (T^+) given that he or she actually did achieve the VPA cut point via accelerometer counts (D^+) or $P(T^+ \mid D^+)$. Sensitivity is synonymous with the probability of achieving a true positive. Specificity was the probability that a student did not achieve a VPA cut point (T^-) based on step counts, given that he or she did not achieve the VPA cut point via accelerometer counts, $P(T^- \mid D^-)$, or a true negative [25]. Maximizing sensitivity and specificity scores associates with the datum closest to (0, 1) on the ROC curve and is a step-count cut point that is likely to yield high classification accuracy compared to other cut points. For each derived step-count cut point, classification accuracy (i.e., the percentage of children correctly classified having met or not met a respective VPA cut point) was calculated. The aforementioned methodology was similar to that used in Burns et al. (2016) [18]. Alpha level was set at $p \leq 0.05$ and all analyses were carried out using STATA v14.0 statistical software package (College Station, TX, USA).

3. Results

The descriptive statistics for the total sample and within sex groups are displayed in Table 1. Boys displayed a higher number of school-day steps (mean difference = 556 steps, $p < 0.001$, Cohen's $d = 0.39$). However, there were no differences between the sexes in minutes of school-day MVPA or VPA. There were 726 weekly observations (34.2% of total sample) that met at least 5 minutes per school-day VPA, 157 weekly observations (7.4% of total sample) meeting at least 10 minutes of school-day VPA, 33 weekly observations (1.6% of total sample) meeting at least 15 minutes of school-day VPA, and 10 weekly observations (0.5% of total sample) meeting 20 minutes of school-day VPA.

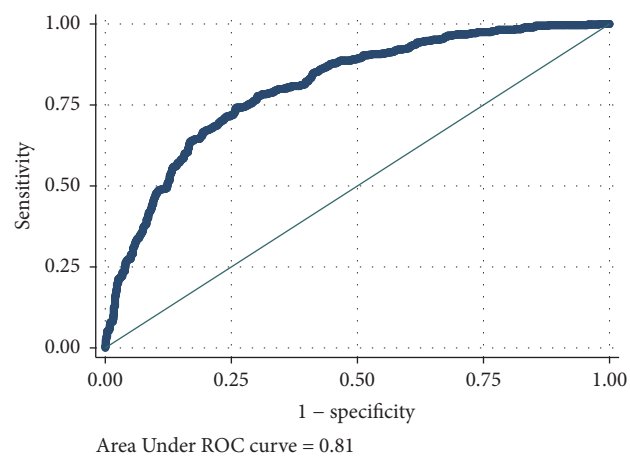

Figure 1: Receiver operating characteristic curve for step counts discriminating 5 minutes of school-day vigorous physical activity.

Table 2 reports the results of the ROC analyses for each VPA cut point ranging from 5 minutes of school-day VPA to 20 minutes of school-day VPA. AUC scores ranged from good to excellent. The AUCs were AUC = 0.81 (95% CI: 0.78–0.83; $p < 0.001$) for meeting at least 5 minutes of VPA, AUC = 0.86 (95% CI: 0.83–0.89; $p < 0.001$) for meeting at least 10 minutes of VPA, AUC = 0.93 (95% CI: 0.89–0.96; $p < 0.001$) for meeting at least 15 minutes of VPA, and AUC = 0.94 (95% CI: 0.88–1.00, $p < 0.001$) for meeting at least 20 minutes of VPA. There were no statistical differences between sexes on the AUCs for any VPA cut point. Figures 1–4 display the ROC curves for each VPA cut point. Step counts discriminated with reasonable accuracy students who achieved 5 minutes of VPA (3,460 steps; sensitivity = 74.0%; specificity = 74.0%; 74.1% accuracy), 10 minutes of VPA (4,133 steps; sensitivity = 81.0%; specificity = 77.5%; 77.8% accuracy), and 15 minutes of VPA (4,133 steps; sensitivity = 97.0%; specificity = 74.8%; 75.2% accuracy) and with strong accuracy those students who

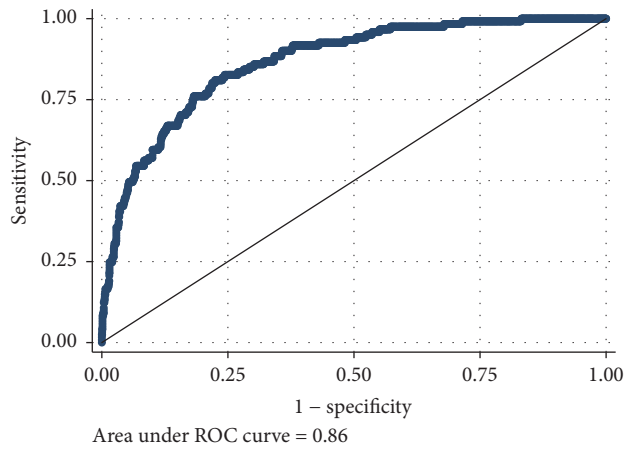

Figure 2: Receiver operating characteristic curve sex discordance for step counts discriminating 10 minutes of school-day vigorous physical activity.

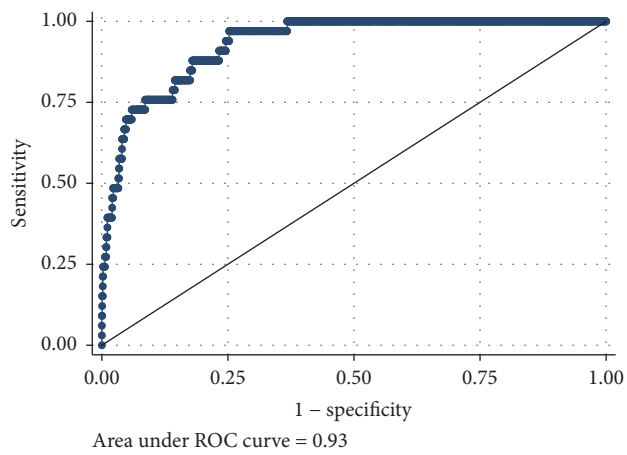

Figure 3: Receiver operating characteristic curve for step counts discriminating 15 minutes of school-day vigorous physical activity.

achieved 20 minutes of VPA (5,628 steps; sensitivity = 85.7%; specificity = 95.1%; 95.1% accuracy).

4. Discussion

The purpose of this study was to develop step-count cut points that discriminate children meeting various levels of school-day VPA. The results showed that step counts were able to discriminate with reasonable accuracy children meeting 5 minutes of school-day VPA through 15 minutes of school-day VPA and with strong accuracy children meeting 20 minutes of school-day VPA. These cut points were derived across a 7-hour school day. Because past research has shown the importance of increasing VPA in the pediatric population, the derived cut points can be used for physical activity surveillance in school settings for clinical and research purposes in the absence of accelerometers, because of either unavailability or logistical limitations. Implications for health-related fitness, how the derived VPA cut points compare to prior established MVPA step-count cut points,

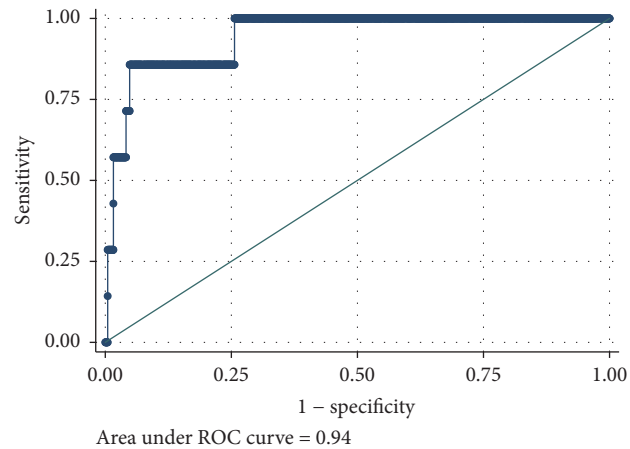

Figure 4: Receiver operating characteristic curve sex discordance for step counts discriminating 20 minutes of school-day vigorous physical activity.

and possible applications in school settings are discussed further.

Pedometers have strong practical utility in the pediatric population because they are reliable and inexpensive and the output is simple to understand [26]. Understanding step-count cut points for varying amounts of accelerometer-assessed VPA fills in the knowledge gap of pedometer's inability to characterize physical activity intensity. The results of this study can facilitate researchers and health professionals to evaluate the physical activity intensity levels during the school day and can determine activities that accumulate VPA levels, which can elicit greater benefits in cardiorespiratory fitness and body composition [26]. In pediatric population, VPA has been shown to significantly improve cardiorespiratory endurance [27]. VPA was also effective at lowering the resting blood pressure in overweight and obese adolescents [28]. Interventions aimed at increasing VPA yielded significant improvements in $VO_{2\ Peak}$ and excess postexercise oxygen consumption [29]. Additionally, submaximal heart rate, resting pulmonary function, and ventilatory response to exercise were also improved following bouts of VPA [30, 31]. Tjønna et al. [32] reported greater improvements in blood glucose in a high intensity exercise group compared to a control group in a sample of overweight adolescents. These established beneficial effects of VPA indicate that VPA is an effective option to improve the health-related physical fitness of children. Additionally, increasing VPA may be a time-efficient strategy that can meet the children's inherent preference for physical activity [28]. The step-count cut points for VPA established from the study strengthen pedometer (step counts) utility on promoting children's health. Studies using objectively assessed physical activities have demonstrated that VPA was more closely associated with body composition compared to physical activity of lower intensities [33, 34]. Wittmeier and colleagues [35] revealed that children (aged 8–11 years) who performed less than 5 min/day of VPA were 4.0 times more likely to have greater than 20% body fat and 5.2 times more likely to be classified as overweight compared

to children performing greater than 15 min/day of VPA. Carson et al. [28] examined longitudinal associations between different physical activity intensities and cardiometabolic risk factors in a sample of Canadian youth (aged 9–15 years) over a period of two years. The results showed that VPA was negatively associated with body composition while the participants significantly reduced their BMI z-scores and their waist circumference level in a dose-response manner. Finally, intervention studies have demonstrated that obese adolescents who spent the most weekly time engaged in VPA tended to be those who decreased the most in body fat [36]. Indeed, physical activity or exercise of a vigorous intensity (≥6 METs) incurs greater energy expenditures compared to moderate intensity (3–5.9 METs) performed for the same duration [37]. Despite the aforementioned evidence, physical activity volume is often not controlled for when comparing VPA to physical activity of lower intensities; therefore, it is unknown whether the greater benefits of VPA would hold if physical activity volume (e.g., MET-minutes per week, estimated energy expenditure) were constant. Future research needs to control for the potential confounding of physical activity volume when exploring health effect discordance among levels of physical activity intensity in children.

The practical utility of the derived cut points from this study may be strong in school settings. Tudor-Locke et al. [38] found that children average approximately 13,000 (boys) and 12,000 (girls) of accelerometer step counts per day, with censored steps reducing these amounts by approximately 2,600 steps. Adams et al. [19] showed that children needed to accumulate approximately 9,000 pedometer-scaled steps in order to meet the 60-minute-per-day MVPA guideline. The children in the current sample averaged approximately one-third (3,319 steps) of these recommended total day steps when it is recommended that children accrue at least one-half of total day physical activity during school hours [39]. Despite this low sample average for school-day step counts, the data yielded strong evidence to discriminate children meeting various levels of VPA. Given past research showing the discordance in health outcomes in children achieving 5 minutes per day of VPA and 15 minutes per day of VPA (35), accruing 4,000–5,000 steps (one-half of the daily recommended guideline) discriminates children meeting higher VPA cut points and aligns with current recommendation from the Institutes of Medicine recommending that children should accumulate one-half of physical activity guidelines during school. These derived cut points are lower than those found in other work establishing pedometer cut points for school-day MVPA (approximately 5,505 steps). This phenomenon may have been due to the inclusion of both moderate physical activity and VPA in the derived cut points in previous studies [18]. Both cut points (derived for MVPA and VPA) should be considered valid depending on the physical activity intensity that a researcher or practitioner aims to assess during the school day.

Accumulating one-half of pediatric physical activity guidelines during school hours seems to align well with quantitative empirical research establishing pedometer step counts for total day and school-day physical activity. Because the derived step-count cut points for higher amounts of VPA is greater than 4,000 and 5,000 steps for 15 minutes of VPA and 20 minutes of VPA, respectively, the message of accruing this number of steps counts should be a public health message for schools. Given the empirical research suggesting that 9,000 censored steps are an accurate cut point for total day MVPA in children [19], establishing one-half of this amount during school should be an easily understood goal for youth. The current study developed the step-count cut points using VPA as the criterion because of the sporadic high intensity movements young children often participate in during active play [40].

Despite the findings of the current study, analyses were not conducted within specific age and sex groups. Because of this, the results are potentially confounded by body size, specifically height, contributing to discordances in stride length across age and sex groups. Confounding may be present because stride length is inversely related to steps taken within a given time frame. Taller students may take fewer steps over a respective physical activity duration compared to shorter children. Future research developing cut points in developing youth should take into account a child's or adolescent's stride length to derive potentially more valid cut points.

There are other limitations to this study that must be considered before the results can be generalized. The sample consisted of first-grade through 6th-grade children recruited from schools located in the Mountain West region of the USA; therefore, the results are questionable if generalized to younger or older age groups or to populations within different geographical regions. Second, step counts were recorded using the ActiGraph accelerometer; the results may have differed if a separate pedometer monitor was used to record step counts concurrently with the accelerometer counts. Third, as stated previously, there may have been different results if the analyses were conducted on separate age groups to partially account for physical development, especially height as this may affect participant stride length. Fourth, data were collected across a 7-hour school day; therefore step-count cut points may differ if a longer or shorter bell schedule was used. Fifth, physical activity volume was not controlled for (e.g., MET-minutes per week, estimated energy expenditure) and moderate physical activity and light physical activity were not assessed, which undoubtedly contributes to step-count totals during the school day. Additionally, few students met the 15-minute-per-day and 20-minute-per-day VPA cut points; the validity of the results would be stronger if a greater proportion of the total sample were in these strata. Finally, data were collected across different semesters; therefore weather may have confounded the results due to its potential influence on outside play during recess or physical education.

5. Conclusions

In conclusion, step counts discriminate with reasonable accuracy children meeting VPA ranging from 5 to 15 minutes per 7-hour school day and with strong accuracy children meeting 20 minutes of school-day VPA per 7-hour school day. This is the first study to associate step counts with varying amounts of VPA accrued during the school day and may have

several applications for clinical practice, surveillance, and intervention research. Because of the strong health benefits of VPA in the pediatric population, the use of step counts to discriminate children meeting various levels of the construct may provide further specificity and efficiency for school-based physical activity assessment.

Abbreviations

AUC: Area under the curve
CSPAP: Comprehensive School Physical Activity Program
MVPA: Moderate-to-vigorous physical activity
VPA: Vigorous physical activity
ROC: Receiver operating characteristic curve.

Ethical Approval

The University of Utah Institutional Review Board approved the protocols employed in this study.

Consent

Written assent was obtained from the students and written consent was obtained from the parents prior to data collection.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Association of High Cardiovascular Fitness and the Rate of Adaptation to Heat Stress

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This study aimed to compare changes in genes expression associated with inflammation and apoptosis in response to heat stress caused by sauna between people with varying cardiorespiratory fitness levels. We hypothesis that high cardiorespiratory level caused higher positive changes after four weeks of sauna bathing. Blood samples were taken at rest before and after the first and last sauna sessions and 48 hours after the last sauna session and used to assay HSP70 *(HSPA1A)*, HSP27 *(HSPB1)*, interleukin 6 *(IL6)*, and interleukin 10 *(IL10)* genes expression in blood with quantitative real-time qRT-PCR. Overall, small decreases in rest values of *HSPA1A* and *IL6* mRNA, increase in *HSPB1* mRNA, and a significant increase in *IL10* mRNA were observed after four weeks of exposure to heat stress. Our findings suggest that an adaptive response to heat stress (an anti-inflammatory response) occurs faster in people with higher cardiorespiratory fitness.

1. Introduction

Finnish sauna bathing is a very popular and easily accessible wellness treatment in sports, recreation, and rehabilitation. The effects of sauna bathing can be positive or negative, depending on many factors, for example, differences in physical condition, disease status, and external conditions. Sauna bathing has been observed to influence skeletal muscle [1], reduce oxidative stress [2], activate secretion of adrenocorticotropic hormone (ACTH) and cortisol in young women [3], stimulate the immune system [4], affect genes expression [5, 6], and impact the functionality of other organs (e.g., reducing the viability of sperm cells) [7].

The physiological systems most impacted by sauna sessions are the skin and the thermoregulatory and cardiovascular systems [8]. Despite a normal strong response of the thermoregulatory system, involving an increased production of sweat, internal body temperature typically increases during a dry sauna. Overheating and dehydration are stressors that activate homeostatic mechanisms, such as the increased expression of stress-related genes at the molecular level. Stress-related genes can be overexpressed, especially those associated with apoptosis and the degradation of damaged and denatured proteins, such as Hsp70 *(HSPA1A)* or Hsp27 *(HSPB1)* [9, 10]. These two genes are commonly induced by physiological stress [11–14]. Recently, in the literature there

Table 1: Anthropometric characteristics of the study groups.

	Age (year)	Height (cm)	BMI	Fat (%)	Training experience (years)
Athletes (mean ± SD)	19.5 ± 0.53	179.87 ± 7.75	22.07 ± 1.94	8.21 ± 2.24	8 ± 1.5
Nonathletes (mean ± SD)	19.67± 0.87	183.78 ± 6.83	22.89 ± 2.33	11.34 ± 4.47	-

are some studies in which impact of sauna bathing on the human body was investigated in active and sedentary people on transcriptional level [5, 6]. Cited studies showed that *IL6* mRNA and *CRP* mRNA were higher in people with lower cardiorespiratory fitness after single sauna session [5]. Moreover, sauna can cause higher changes in genes expression (*HSPA1A*, *HSPB1*, *IL6*, or *IL10* mRNA) than moderate exercise [6].

Repeated thermal stress can induce thermos tolerance at the cellular level and that is important for health and physiological possibilities and translates into efficiency in work performed at high temperatures. So we investigated the adaptive effect of four weeks of sauna bathing on the expression of the genes *HSPA1A*, *HSPB1*, *IL6*, and *IL10*. Expression of the genes coding for heat shock proteins (*HSPA1A* and *HSPB1*) and interleukins (*IL6* and *IL10*) is particularly interesting in sports medicine because these genes appear to have the effect of increasing exercise tolerance [6]. We hypothesized that the adaptive effect of total body exposure to the heat stress associated with sauna sessions would vary as a function of the physical condition of the experimental subjects. Specifically, we hypothesized that the sauna-induced increases in the expression of the genes mentioned above would be higher in nonathletes than athletes and any adaptive effect would appear earlier because of the cellular thermotolerance athletes acquire during physical training. Then people with higher cardiorespiratory system easier tolerate work in high temperatures.

As the type of training may affect gene expression [15], we chose to study athletes playing the same sport. We therefore monitored footballers, who we considered the experimental group, and sedentary people, who were considered to be the control group. In our opinion, differences in responses between groups for sauna bathing may be similar to those obtained by physical exertion [6]. Therefore we hypothesized that the upregulation of anti-inflammatory rather than proinflammatory interleukins would be faster in people with higher cardiorespiratory fitness.

2. Material and Methods

2.1. Ethics Statement. The study was approved by the Bioethics Committee for Clinical Research at the Regional Medical Chamber in Gdańsk (KB14/14). The authors were obliged to respect the principles of the Helsinki Declaration. All participants gave written, informed consent to participate in the study and could withdraw consent at any time for any reason.

2.2. Participants. Twenty-two healthy men participated in the experiment: eleven athletes playing football (average career length was 8 years) and eleven nonathletes. No significant differences between the groups' body mass, BMI, and body height were found (Table 1).

Athletes trained for 2 sessions per day, 6 days per week (25–28 hours). Control group participants reported recreational physical activity such as running, swimming, or team sports maximum 2 times a week, for a duration of 45 minutes per session. All subjects had a normal health status during the two months prior to the study (no drugs, alcohol, nicotine, negative medical history for injures, and situations that may influence the results).

2.3. Study Design. Participants avoided use of a sauna and intensive sunbathing for a month before the experiment and during the time of experiment (beyond the impact of the experiment). The experiment was performed in January during a break in training and competitive football for the athletes; participants in the control group reported average levels of spontaneous physical activity during the study period (on average 2 sessions per week). Athletes and the control group participated in a dry sauna bath 3 times a week, for 4 weeks. Participants spent time in a Finnish sauna room at 98.2°C and 10 ± 2% humidity; the time was comprised of two 15-minute stints during the same session (total time: 30 min per session) with a 5-minute break for cooling under the shower (water temperature was 18±2°C). Before and after each session in the sauna, weight and percent body fat were measured using an InBody 720 Segmental Body Composition Analyser, Biospace (Korea).

2.4. RNA Extraction, qRT–PCR. Two millimeters of venous blood was collected five times: sample (1) was taken immediately before the first sauna, sample (2) 15 minutes after the first sauna, sample (3) immediately before the twelfth sauna, sample (4) 15 minutes after the twelfth sauna, and sample (5) 48 hours after the twelfth sauna. The samples were processed immediately after each collection. Erythrocytes were lysed using RBCL buffer according to the manufacturer's instructions (A&A Biotechnology, Gdynia, Poland). The remaining white blood cells were lysed using Fenozol according to the manufacturer's instructions (A&A Biotechnology, Gdynia, Poland). Isolation of total RNA was carried out by a chemical method described by Chomczynski and Sacchi [16]. Purity and concentration of the isolated RNA were determined by spectrophotometry (Eppendorf, BioPhotometer Plus, Germany). cDNA synthesis from 2 micrograms of total RNA was performed with a TranscriptMe Kit, using oligo dT and random hexamers (Blirt, Gdańsk, Poland).

2.5. Quantitative Polymerase Chain Reaction (q-PCR) Assay to Determine Gene Expression. For the analysis of gene expression, real-time PCR (LightCycler 480II, Roche, Poland) was

Table 2: Primers used to real-time PCR.

HSPA1A	Forward primer: TGGACTGTTCTTCACTCTTGGC Reverse primer: TTCGGAGAGTTCTGGGATTGTA
HSPB1	Forward primer: AAGGATGGCGTGGTGGAGATCA Reverse primer: GAGGAAACTTGGGTGGGGTCCA
IL6	Forward primer: TCCACGGCCTTGCTCTTGTTT Reverse primer: GACATCAAGGCGCATGTGAAC
IL10	Forward primer: GAATCCAGATTGGAAGCATCC Reverse primer: AATTCGGTACATCCTCGACGG

twice performed in triplicate for each sample using LightCycler polymerase (Roche, Poland). The temperature-time protocol of each reaction was programmed according to the manufacturer's instructions. For each reaction, melting curve analysis was performed. The B-tubulin *(TUBB)* was used as a reference gene. Primer sequences are shown in Table 2.

2.6. Statistical Analysis. The data were collected and relative gene expressions were analysed in Excel 2005. In order to calculate the level of gene expression, the comparative C_T method of Schmittgen and Livak [17] was used. The results are expressed as mean C_T values and standard deviations. The data were transformed to linear values and to assess statistical significance, the following tests were used: normal distribution was checked with the Shapiro-Wilk's test, and the nonparametric Wilcoxon test was used to compare results before and after the sauna baths. To determine the significance of differences between the groups, a one way ANOVA was applied. All calculations and graphics were performed using GraphPad Prism 6.0 (ftx.pl/program/graphpad-prism). Statistically significant differences were considered at a level of $p \leq 0.05$.

3. Results

3.1. Changes in Somatic Indicators and Dehydration. Small changes of body weight and percent body fat were observed before and after four weeks of sauna sessions in both groups: the mean weight of the group of athletes decreased from 72.26 ± 2.4 kg to 71.78 ± 3.8 kg (a decline of 0.48 kg), while the mean weight of the nonathletes decreased from 77.6 ± 5.7 to 77.3 ± 5.5 kg (a decline of 0.3 kg). Weight change due to dehydration during a single session in the sauna ranged from 0.42 to 1.1 kg. There were no significant differences either within or between groups in terms of loss of body mass, dehydration, or duration of their stay in the sauna.

3.2. Genes Expression. Rest value of *HSPA1A* mRNA was slightly higher in sedentary people before saunas (first and last) and after first sauna bathing, contrary to *HSPB1* mRNA (higher before and after first sauna bathing and significantly lower before and after last sauna bathing, Figures 1(a) and 1(b)). Changes in relative expression of *HSPB1* mRNA were from 2^0.2 before last sauna to 2^0.24 after last sauna in control group and 2^0.04 before last sauna to 2^0.08 after last sauna in athletes ($p = 0.004$). Changes in *IL6* mRNA caused by first and last sauna bathing were lower in athletes while in *IL10* mRNA they were significantly higher at the same time, significantly after last sauna bathing (2^0.11 in control and 2^0.25 in athletes, $p = 0.04$, Figures 1(c) and 1(d)).

Adaptation to heat stress was determined by comparison rest value before first sauna bathing and 48 h after last sauna bathing and results as 2^-fold changes are presented at Figure 2.

Decreases in the expression of *HSPA1A* and *IL6* mRNA in response to heat stress were observed after four weeks of sauna sessions in both groups, while expressions of *IL10* mRNA in athletes significantly increased in the time span and were 2^2.04-fold in athletes and 2^1.27-fold in sedentary people, $p = 0.04$. For *HSPA1A* mRNA, decreases in 2^-fold changes were slightly higher in athletes (to 2^0.6-fold in athletes and to 2^0.85-fold in sedentary people). For all genes tested, similar adaptive effects were reported for each individual group. The differences in response in genes expression obtained after first and last (12) sauna sessions are presented at Figure 3.

No changes in delta 2^-fold changes (2^-fold changes after first sauna/2^-fold changes after last sauna) in *HSPA1A* were observed in both groups, while increases in *HSPB1*, *IL6,* and *IL10* mRNA were seen. Changes in response in *IL6* mRNA after the last sauna compared to the first one differed between groups and were 2^1.44-fold in athletes and 2^1.26-fold in sedentary people, while in *IL10* mRNA they were 2^2.14-fold in athletes and 2^1.28-fold in sedentary people. The differences between groups in delta 2^x-fold changes were not significant (ANOVA one way).

4. Discussion

There are a number of studies examining the effect of high temperature on gene expression, but we are not aware of *in vivo* investigations of mRNA levels of stress-related genes after sauna bathing. Furthermore, little has been reported on the impact of physical activity on the molecular response of leukocytes to the same stressor. The small differences in expression seen in this study occurred between a sample taken at rest before and 48 hours after a course of 12 sauna baths. Four weeks of sauna sessions caused a significant increase in *IL10* mRNA in people with high cardiorespiratory fitness. In our studies faster adaptation to heat was observed in active people.

Stress-related genes are overexpressed after exercise, as shown by Neubauer et al. [18], Büttner et al. [19] and Radom-Aizik et al. [20], Rasmus et al. [21], and Szołtysek et al. [22]. Regardless of the stressor, a cellular response involves several hundred stress genes, including production of heat shock proteins or interleukins [23, 24]. Increased expression of genes encoding anti-inflammatory interleukins like *IL10* can result in lower expression of *IL6* mRNA, important indicators of inflammation. Four weeks of sauna bathing caused a decrease in rest value of *IL6* mRNA (not significant) and an increase in *IL10* mRNA (significant in active people).

Stimulation of the synthesis of heat shock proteins and interleukins in leukocytes in response to stressors including temperature was studied by Pizurki and Polla [25] and Jacquier-Sarlin et al. [26]. Using *in vitro* study of leukocytes, these authors found that increasing the temperature to 41°C

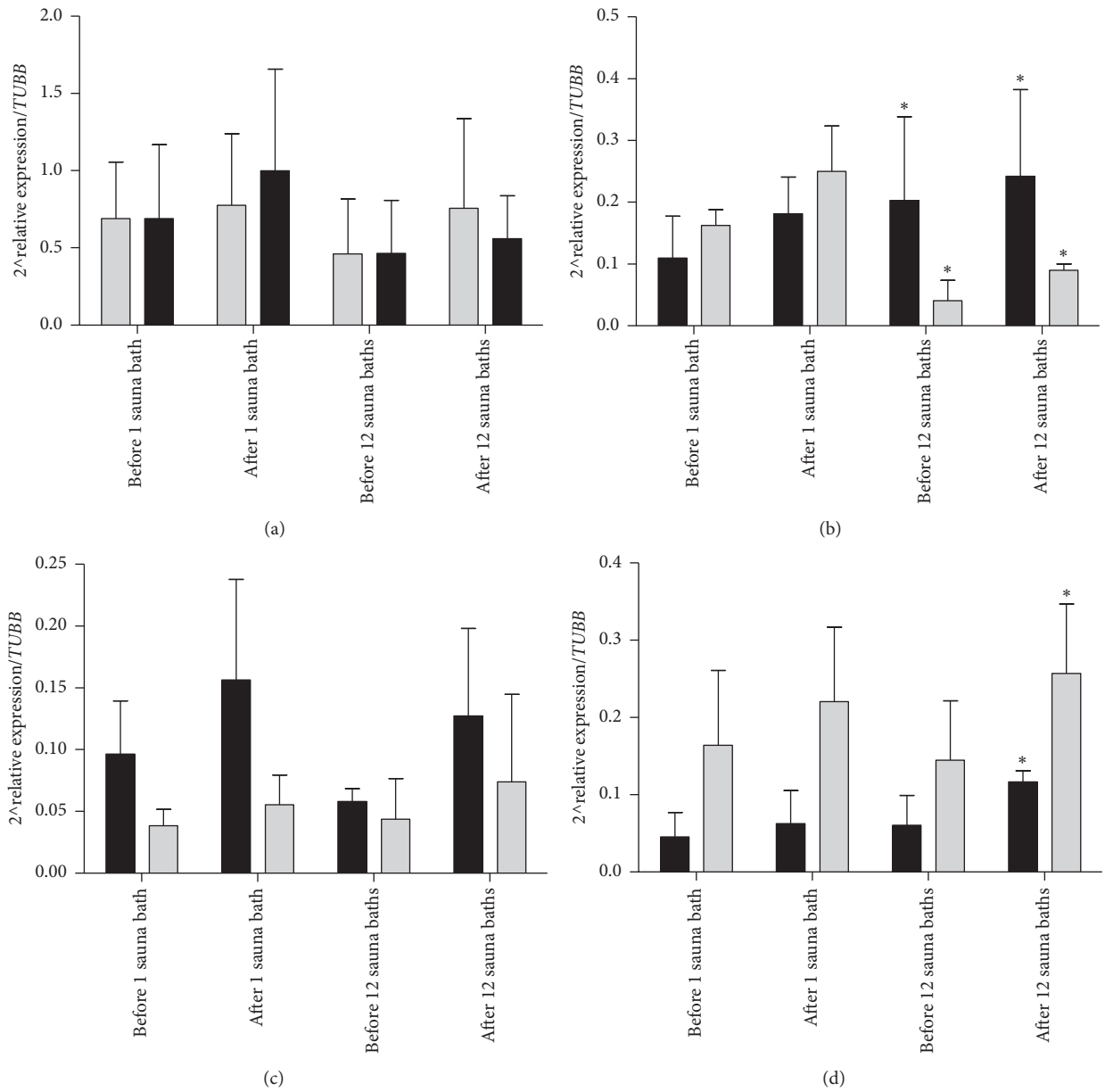

Figure 1: 2^relative expression in athletes (gray bars) and control group (dark bars) before and after first and last sauna bathing. (a) *HSPA1A*, (b) *HSPB1*, (c) *IL6*, and (d) *IL10*. * *Significant differences between groups* ($p < 0.05$).

caused a 10-fold increase in HSPs [25, 26]. The aim of our study was to determine adaptive effect to heat stress, but our results were not this high. This difference confirms the substantial differences between *in vivo* and *in vitro* testing [27]. However, repeated heat stress caused an visible increase in the expression of *HSPB1* mRNA at rest value and after 12 sauna baths compared to the first sauna bath and decrease expression of *HSPA1A* and *IL6* mRNA at rest value (Figures 2 and 3). By analysing changes in the expression of *HSPB1, IL6*, and *IL10* mRNA, it can be seen that a four-week course of whole body exposure to high temperature caused slightly higher expression of these genes in response to the last saunas compared to the first one. Changes in rest value showed decrease in *HSPA1A* and *IL6* mRNA and increase in *HSPB1* and *IL10* mRNA, measured before experiment and 48 hours after last sauna session. The same thermal load caused in the similar direction of changes occurred faster in people with higher cardiorespiratory fitness. It is possible that adaptive effect to heat stress occurs faster in physically active people.

Based on our results, we suggest that the adaptation of regulation of genes associated with apoptosis and the immune response to heat stress may be associated with level of physical activity. Furthermore, the changes achieved in our groups after four weeks of overheating consisting of decrease in proinflammatory and increase in anti-inflammatory genes expression indicated positive impact on health (more pronounced in athletes). This is an important conclusion for planning biological regeneration and for people who work in

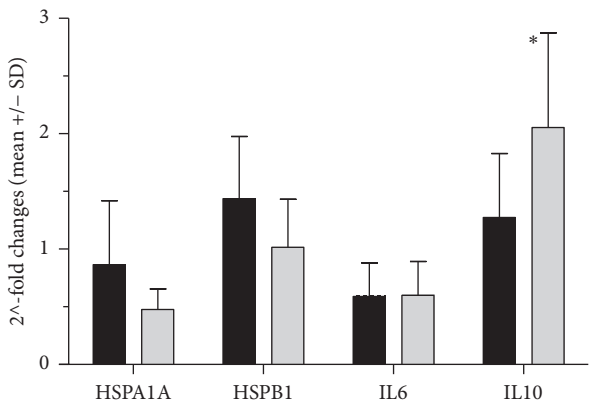

Figure 2: 2^-fold changes in the expression between rest before and 48 h after experiment in athletes (gray bars) and sedentary people (dark bars). 2^-fold changes were calculated as 2^-fold changes before/2^-fold changes after experiment. *Significant changes between rest value before experiment and 48 h after experiment ($p \leq 0{,}05$).

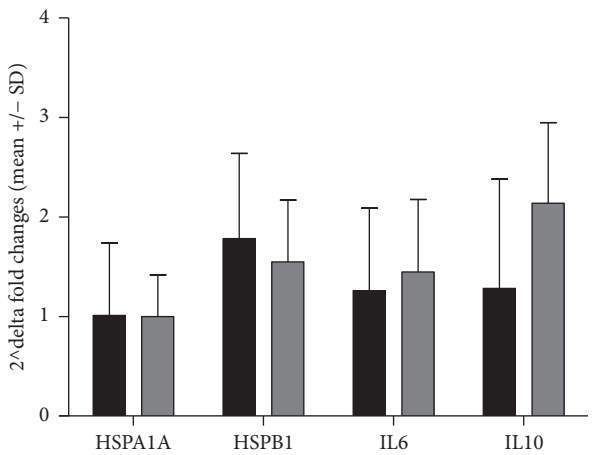

Figure 3: Differences in 2^-fold changes (delta 2^fold) in response to first and last (12) saunas in athletes (gray bars) and sedentary people (dark bars). Delta 2^-fold changes = 2^-fold changes after last sauna bath (rest value/post rest value)/2^-fold changes after first sauna (value before/after sauna).

environment with elevated temperature as it improved work efficiency and acclimatization will occur faster in people with high cardiovascular fitness.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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