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Original Article

Association between Objectively measured Physical Activity and Sedentary Behavior with Body Composition among Primary School Children

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Abstract

Background: Physical activity (PA) plays a crucial role in the overall well-being of children in the long term. The present study aimed to investigate the correlation between PA, sedentary behavior (SB), and body composition (BC) among primary school children.
Methods: This descriptive-correlational study was conducted in Ali-Abad-Katoul, Iran in 2023. A sample size of 322 boys was selected using convenience sampling method. ActiGraph wGT3X-BT accelerometer and Body Composition X-Scan Plus II were used for measuring PA pattern and BC. Pearson correlation and Independent t tests were used to analyze the data.
Results: The accelerometer data revealed that participants spent 67.55% of the total time in SB. Moreover, on average, daily moderate-to-vigorous physical activity (MVPA) was 49.71±22.37 minutes. Accordingly, the daily energy expenditure was 558.39±250.17 kcal. SB was directly and significantly associated with Body Mass Index (BMI) ($r=0.628$, $P<0.001$) and Mass of Body Fat (MBF) ($r=0.347$, $P<0.001$). In addition, our results revealed an inverse and significant correlation between MVPA with BMI ($r=-0.849$, $P<0.001$) and MBF ($r=-0.716$, $P<0.001$). Finally, the children who did meet the MVPA guideline had significantly lower BMI ($t=-3.781$, $P<0.001$) and MBF ($t=4.892$, $P<0.001$) and higher Skeletal Muscle Mass (SMM) ($t=4.209$, $P<0.001$) than those who did not meet the MVPA guideline.
Conclusions: These findings suggested that vigorous PA and SB play a role in controlling children's adiposity, highlighting the importance of engaging children in high-intensity PA and reducing SB.

Keywords: Child, Exercise, Obesity, Sedentary, Intensity

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1. Introduction

Today, very few people have healthy nutrition and participate in regular physical activity (PA), and are considered to have a sedentary life (1). From the point of view of general public health, sedentary lifestyle tends to become epidemic, and the economic effect of such immobility with the pressure it puts on societies and health systems to manage diseases related to immobility is worth considering (2). SB is one of the causes of death, and an inverse linear correlation exists between the amount of PA and all causes of death (3). Based on the evidence, there is a growing trend of sedentary behavior (SB) in children, with a key feature being the high occurrence of obesity within this demographic (4).

For children, sports are the most common form of PA. Sports are mainly played as games during school or as extracurricular activities (5). From a health perspective, the primary purpose of PA should be related to meeting sufficient energy or time expenditure to improve or maintain health-related physical fitness (6). However, modern technology, which has reduced children's PA, led to the reduction of opportunities for human activities, and replaced the former active and dynamic lifestyle of children with SB (5, 6).

By drawing the correlation between physical work capacity and suffering from metabolic, cardiovascular and chronic diseases over the life span, it is clear that the effect of PA in childhood is more than in other periods of life (7, 8). In fact, the role of sports activity in preventing the development of obesity and related diseases, muscle and bone development, improving the quality of sleep and reducing anxiety, which are all components of health during growth, in childhood, has a more prominent and effective role in the health of later periods of life (9, 10).

The health effects associated with regular childhood PA are widely documented and well accepted by health professionals (11, 12). Therefore, regular participation in PA is associated with increasing bone mass, maintaining a healthy weight, reducing high blood pressure, and improving psychosocial outcomes in children (13-16). Engaging in physical activity during childhood serves a dual purpose beyond just enhancing physical fitness outcomes. First, there is ample evidence to support the positive effect of regular PA on healthy growth and development. On the other hand, early engagement with PA seems to be associated with better adherence to a healthy lifestyle and a lower likelihood of metabolic and cardiovascular diseases (17-20). Therefore, children who meet daily PA recommendations may have higher healthy growth and are less likely to develop chronic noncommunicable diseases in adulthood (21). However, several studies have shown that children around the world do not meet the WHO guidelines of 60 minutes of moderate-to-vigorous PA (MVPA) per day (22-24). This makes it necessary to constantly check the PA level of children. Therefore, the primary aim of this study was to objectively assess PA levels of elementary school students using an accelerometer.

Body composition (BC) is a subject of study in biology that refers to each component of the human body (25). BC assessment may underpin physical fitness assessment as it provides the ability to classify individuals in terms of health, growth, and performance (26). In addition, several chronic adaptations that occur as a result of exercise or PA, diseases, or growth correspond to changes in BC more closely related to body weight (26-28). In particular, the assessment of BC is the basis for the assessment of nutritional status in the clinical structure of obesity diagnosis (27). The study of BC can be divided into five levels: atomic, molecular, cellular, tissue-organ, and whole body. Molecular level is the most common and fat mass (FM) and fat free mass (FFM) are the most important components of this level (29, 30). Although BC is considered an important component in children's health, the role PA plays in children's BC has received less attention. Therefore, the second aim of this study was to investigate the correlation between objective PA (measured by accelerometer) and BC of primary school children. Overall, the present study aimed to explore the correlations between physical activity and sedentary behavior with body composition among primary school children.

2. Methods

2.1. Design and Participants

This descriptive-correlational study was conducted among primary school students aged 9 to 12 in Ali-Abad-Katoul city, Iran in 2023. A sample size of 322 boys was selected based on the sample size calculation for correlational research (31), with $\alpha=0.05$, $\beta=0.05$, and $r=0.20$. The mean age of the participants was 10.83±0.93 years old. Participants were selected using the convenience sampling method and had to meet the inclusion criteria: students in grades 3-6, obtaining parental consent, completing required protocols, and nophysical abnormalities that would prevent participation. Parental consent was obtained prior to the assessment.

2.2. Measures

2.2.1. Physical Activity and Sedentary Behavior

PA and SB were measured using an ActiGraph wGT3X-BT accelerometer (ActiGraph LLC, Pensacola, FL, USA) with a frequency of 80 Hz. This three-axis accelerometer records the participant's activity information with high accuracy. Then, the information is sent to the computer system via Bluetooth and analyzed using the Accelerometer-specific Acti-Life software. Using the accelerometer is a non-invasive method and is worn 24 hours a day for a week. The device determines the intensity (including light, moderate, and vigorous) and duration of PA, duration of SB, and amount of energy consumed related to PA (32-34).

2.2.2. Body Composition

In this study, BC was measured using the Body Composition X-Scan Plus II (Gyeonggi-do, South Korea). To do so, first the height of the children was measured using a standard meter with an accuracy of 0.1. Then, the participant was placed on the device and his weight was measured. This device passes electrical impulses through different tissues through 8 electrodes and measures BC, including BMI, skeletal muscle mass (SM), and fat weight (MBF) from the speed of the electrical impulses.

2.3. Data Analysis

We applied descriptive statistics such as mean and standard deviation (SD) to depict the variables of the study. To assess the normal distribution of the data, the Kolmogorov-Smirnov test was employed. Additionally, the Pearson correlation test was conducted to evaluate the relationship between the research variables. An independent t-test was performed to compare BC based on MVPA categories. The significance level was set at 0.05. Data analysis was carried out using SPSS version 26.

3. Results

3.1. Demographic Data

The demographic characteristics of the study participants are shown in Table 1. A total number of 322 children, evenly spread across different school grades, participated in this study. The majority of parents (74.5%) had completed college education. Additionally, a large portion of students woke up between 6:00 to 7:00 A.M (56.5%) and went to sleep between 22:00 to 23:00 (80.1%).

3.2. Physical Activity Pattern

Table 2 shows mean and SD for PA pattern. The accelerometer data revealed that participants spent 67.55% of the total time in SB. Moreover, they spent 24.39% of the total time in light PA, while the percentage of moderate PA was 4.40%. In addition, the amount of vigorous PA was 3.66% of the total time. Also, the percentage of MVPA was 8.06% of the total time. In absolute numbers, the total time spent with MVPA was on average 348.22 minutes per week and the daily MVPA was 49.71 minutes. These values are clearly below the WHO-guideline of at least 60 minutes of MVPA per day. In fact, our data showed that only 135 children (41.9%) achieved the recommended MVPA. Accordingly, the daily energy expenditure was 558.39 kcal.

3.3. Body Composition

Table 3 shows mean and SD for BC components.

Table 1: Demographic characteristics of the participants

	n	%
Grade		
Primary-school grade 3	75	23.3%
Primary-school grade 4	79	24.5%
Primary-school grade 5	82	25.5%
Primary-school grade 6	86	26.7%
Parental Education		
High-School and less	82	25.5%
College	240	74.5%
Wake-Up Time		
5:00–6:00	140	43.5%
6:00–7:00	182	56.5%
Sleep Time		
21:00–22:00	49	15.2%
22:00–23:00	258	80.1%
After 23:00	15	4.7%

Table 2: Mean and standard deviation of physical activity pattern

	Mean	SD
Sedentary Behavior (%)	67.55	9.67
Light PA (%)	24.39	5.91
Moderate PA %	4.40	2.20
Vigorous PA %	3.66	2.47
MVPA %	8.06	3.60
Total MVPA (minutes per week)	348.22	150.49
Daily MVPA (minutes)	49.71	22.37
Energy expenditure (Kcal per day)	558.39	250.17

SD: Standard Deviation; PA: Physical Activity; MVPA: Moderate-to-Vigorous Physical Activity

Table 3: Mean and standard deviation of body composition's components

	Mean	SD
Height (cm)	140.68	5.73
Weight (kg)	34.86	2.17
BMI	17.6	1.29
SMM	23.7	3.71
MBF	9.59	3.55

BMI: Body Mass Index; SMM: Skeletal Muscle Mass; MBF: Mass of Body Fat, SD: Standard Deviation

The mean BMI of the participants was 17.6, indicating a healthy range. Within this, 32 children (9.9%) were underweighted, 245 participants (76.1%) were at normal weight and 45 children (14.0%) were overweighted/obese. Moreover, of interest, mean MBF of the participants was 9.59, indicating a normal range. Within this, 44 children (13.6%) were under fat, 227 participants (70.5%) had normal fat and 51 children (15.9%) were overfat.

3.4. Correlations Between Research Variables

Table 4 presents the results of Pearson correlation examinations between PA and BC. The findings revealed that SB had a direct and significant connection with BMI and MBF (both P<0.001), while it had an inverse and significant relationship with Skeletal Muscle Mass (SMM). Furthermore, there was no significant correlation between light PA and any of BC components (P>0.05). Additionally, our findings demonstrated an inverse and significant correlation between MVPA and BMI and MBF (both P<0.001), but it exhibited a direct and significant association with SMM (P<0.001). Lastly, energy expenditure exhibited an inverse and significant correlation with BMI and MBF (both P<0.001), but it had a direct and significant relationship with SMM (P<0.001).

3.5. Body Composition According to MVPA Categories

In order to investigate the effect of adhering to WHO guidelines regarding BC, we conducted a comparison between children who met the MVPA guideline and those who did not (Table 5). The findings revealed that 135 children (41.9%) successfully achieved the recommended MVPA,

Table 4: Correlations between physical activity pattern and body composition's components

	BMI	SMM	MBF
Sedentary Behavior (%)	r=0.628 P<0.001	r=-0.418 P<0.001	r=0.347 P<0.001
Light PA (%)	r=-0.015 P=0.824	r=0.030 P=0.882	r=-0.017 P=0.830
Moderate PA %	r=-0.234 P<0.001	r=0.350 P<0.001	r=-0.490 P<0.001
Vigorous PA %	r=-0.581 P<0.001	r=0.488 P<0.001	r=-0.671 P<0.001
Daily MVPA (minutes)	r=-0.849 P<0.001	r=0.927 P<0.001	r=-0.716 P<0.001
Energy expenditure (Kcal per day)	r=-0.566 P<0.001	r=0.747 P<0.001	r=-0.587 P<0.001

BMI: Body Mass Index; SMM: Skeletal Muscle Mass; MBF: Mass of Body Fat, PA: Physical Activity, MVPA: Moderate-to-Vigorous Physical Activity

Table 5: Mean and standard deviation of the Body composition according to MVPA categories

Variable	MVPA<60 min/day	MVPA≥60 min/day	Difference
BMI	17.9±1.42	16.7±1.72	t=-3.781 P<0.001
SMM	22.41±3.09	24.63±3.89	t=4.209 P<0.001
MBF	10.28±3.27	8.93±3.81	t=4.892 P<0.001

BMI: Body Mass Index; SMM: Skeletal Muscle Mass; MBF: Mass of Body Fat, MVPA: Moderate-to-Vigorous Physical Activity while 187 (58.1%) did not meet the MVPA guideline. The results clearly indicated that the children who met the MVPA guideline exhibited significantly lower BMI and MBF, as well as higher SMM as compared with those who did not meet the MVPA guideline (P<0.001).

4. Discussion

As an initial finding, it was observed that the participants in this study spent 67.55% of their total time engaged in SB, while only 8.06% of their total time was dedicated to MVPA. In terms of actual duration, the average time spent on MVPA per day was 49.71 minutes. These figures fall significantly below the WHO guideline of a minimum of 60 minutes of MVPA per day. In fact, our data revealed that only 135 children (41.9%) managed to meet the recommended MVPA level. These findings aligned with previous studies (11, 12, 15, 16, 19, 20, 22, 24), which emphasized that children are not allocating sufficient time to PA that promotes good health. Given the numerous benefits associated with regular PA for children's health (14, 17, 23, 24), it is strongly advised that health practitioners pay special attention to PA behavior of primary school children. Consequently, it is imperative to identify interventions and strategies aimed at increasing MVPA levels among primary school children.

Regarding BC, the results of this study revealed that although the average BMI in the sample was in a healthy range, 23.9% of the whole sample were underweighted or overweighted/obese. Moreover, 29.5% of the whole sample were underfat or overfat. Since obesity is one of the causes of many diseases in childhood and adulthood, and given that a significant percentage of children in the present study have not healthy weight, it is necessary to find ways to improve children's weight ratio so that they can achieve the benefits of a healthy weight.

Our study indicated that there is a correlation between high levels of PA and lower body fat percentage. Children who did not reach the recommended levels of MVPA displayed notably higher levels of body fat compared with those who adhered to the guidelines. Approximately 41.9% of children met the suggested daily average of 60 minutes of MVPA. Furthermore, the present investigation revealed that 67.55% of the total time of the participants was spent in SB. Previous research has consistently demonstrated that increased SB is linked to unfavorable BC indicators in children (25, 27, 28, 29). Consequently, it is evident that prolonged periods of SB can have adverse effects on health. Although the findings of the present study only indicated a tendency towards a positive and significant association between SB with BMI and MBF, it is crucial to implement interventions aimed at reducing SB. Substituting SB with high-intensity activities has been shown to yield beneficial health outcomes (17, 23, 26, 28).

Children in this study, similar to other studies conducted globally, spend a greater amount of time engaging in light PA as compared with MVPA (16, 17, 19). However, there is limited evidence regarding the beneficial effects of light PA on BC, and further research is necessary. The findings of the present study did not indicate any significant correlation between light PA and BC. Consistent with previous research (16, 18, 22, 23), it has been observed that spending more time in MVPA is associated with a decreased risk of obesity, as indicated by BMI and MBF measurements. Both studies have demonstrated that engaging in high-intensity PA is linked to a lower likelihood of obesity (16, 17, 20, 22). While it is generally believed that MVPA is associated with lower fatness, it seems that vigorous PA plays a more prominent role due to its higher energy expenditure (17, 19, 22). In this particular study, it was found that higher volumes of vigorous PA were associated with reduced BMI and MBF, highlighting the crucial role of vigorous PA in reducing adiposity in children.

4.1. Limitations

The main limitation of the present study was its cross-sectional design, preventing the analysis of contributing factors. Yet, a notable advantage of this study was using an accelerometer to assess PA, providing more accurate data compared with self-report tools like questionnaires. The findings from this study may benefit physical educators in improving the health-related outcomes of children.

5. Conclusions

In this study, the participants exhibited low levels of PA, emphasizing the need for targeted strategies to increase PA among primary school children. Additionally, higher intensity of PA was associated with lower BMI and MBF levels, suggesting that vigorous PA plays a role in controlling children's adiposity. Furthermore, SB was found to be a significant factor in childhood obesity, highlighting the importance of engaging children in high intensity PA and reducing SB. In conclusion, these findings underscored the critical importance of addressing PA and obesity in children, necessitating the implementation of effective strategies to promote an active lifestyle in children.

Ethical Approval

The present study was approved by the University Ethics Review Board with the code of IR.IAU.AK.REC.1402.008. Additionally, the parents of the children provided written informed consent.

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Authors' Contribution

Maosud Shakki: Substantial contributions to the conception and design of the work; acquisition, analysis, and interpretation of data for the work, drafting the work. Reza Rezaeeshirazi: Contribution to the design of the work, drafting the work and reviewing it critically for important intellectual content. Neda Aghayei Bahmanbeglou: Substantial contributions to the conception and design of the work; interpretation of data for the work, drafting the work. Saeed Ghorbani: Analysis and interpretation of data for the work, drafting the work. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work, such as the questions related to the accuracy or integrity of any part of the work.

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