

Association between Physical Activity and Motor Proficiency among Primary School Children

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Received: February 02, 2023; Revised: April 17, 2023; Accepted: May 14, 2023

Abstract

Background: Self-reported instruments have suggested that physical activity correlates with motor proficiency in children. However, due to inherent biases and low accuracy of self-reported instruments, this study aimed to investigate the relationship between objectively measured physical activity (via accelerometer) and motor proficiency in children.

Methods: This study is a descriptive-correlational investigation involving 384 children (comprising 192 boys and 192 girls), aged 7 to 9 years (with a mean age of 7.96 ± 0.73 years). These participants were in the first and second grades from regular primary schools in Tehran, Iran, during 2022, and were selected through a convenience sampling method. We employed the ActiGraph wGT3X-BT accelerometer for an objective measurement of physical activity. The Bruininks-Oseretsky Test of Motor Proficiency's short form was used to evaluate the children's motor proficiency. Data were analyzed using Independent t-test, Pearson correlation test, and multiple linear regression analysis.

Results: The children did not meet the WHO guidelines recommending 60 minutes of moderate-to-vigorous physical activity (MVPA) per day. Boys had significantly more MVPA than girls ($P < 0.001$). The results revealed that sedentary time had a significant inverse relationship with both gross ($r = -0.681$, $P < 0.001$) and fine ($r = -0.584$, $P < 0.001$) motor skills. Moreover, objectively measured physical activity (via accelerometer) showed a direct and significant correlation with gross motor skills ($r = 0.710$, $P < 0.001$), but not with fine motor skills ($r = 0.064$, $P = 0.307$). Sedentary time significantly and inversely impacted both gross ($\beta = -0.68$) and fine motor skills ($\beta = -0.58$). Furthermore, objective physical activity (measured by accelerometer) had a direct and significant impact on gross motor skills ($\beta = 0.71$).

Conclusions: These findings underscore the necessity to enhance the level of physical activity in children, particularly in girls. We also recommend that physical education teachers and sports coaches incorporate programs in their physical education lessons designed to facilitate motor skills development in children.

Keywords: Physical activity, Motor proficiency, Children, Accelerometer, Gender

How to Cite: Dana A, Ranjbari S, Chaharbaghi Z, Ghorbani S. Association between Physical Activity and Motor Proficiency among Primary School Children. Int. J. School. Health. 2023;10(3):128-135. doi: 10.30476/INTJSH.2023.98237.1295.

1. Introduction

Motor proficiency refers to an individual's ability to perform a variety of motor actions, encompassing both fine and gross motor skills (1). Fine motor skills pertain to the ability to generate movements using the small muscles in the fingers, while gross motor skills involve the utilization of larger muscle groups such as the arms, neck, and legs for activities such as climbing, running, and jumping (2). Both fine and gross motor skills serve as foundational elements for many of the more intricate movements required in physical and sports activities (3).

The absence of fundamental motor skill development during preschool and elementary school years often results in a deficit of specialized

skills in adulthood. Movement skill development is not only influenced by growth and maturity but is also affected by the environment (4). Gender differences in motor proficiency are frequently observed, with research indicating that girls tend to develop fine motor skills more rapidly than boys, while boys acquire gross motor skills at a faster pace (5, 6).

Given the significance of children's movement skills for health and fostering an active lifestyle, it becomes crucial to assess and monitor motor skills, particularly during early and middle childhood. Furthermore, devising appropriate strategies for enhancing children's motor development necessitates an understanding of their motor skill level. Research has indicated that regular participation in physical activity is one factor

that can significantly influence a child's motor proficiency (7-11).

Physical Activity (PA) generally refers to any body movement that results from the contraction and relaxation of skeletal muscles, consuming energy in the process (12, 13). Depending on the amount of energy expended during the activity, PA is classified into light (e.g., gentle walking and gardening), moderate (e.g., brisk walking or cycling), and vigorous (e.g., running) categories (14, 15). In children, it has been demonstrated that physical activities lead to enhanced communication between nerve cells and the brain, resulting in numerous beneficial outcomes such as improved motor skills (both gross and fine), increased self-awareness, social skills, language proficiency, creativity, and problem-solving abilities (16-20).

Globally, children are encouraged to engage in at least 60 minutes of moderate-to-vigorous PA (MVPA) daily throughout the week (14). However, children worldwide, including those in Iran, often do not meet this recommended level of PA, which can impact their physical health and motor proficiency (21-26).

Although previous research has explored the link between participation in PA and motor proficiency, most studies have relied on questionnaires to measure PA (7-11), the accuracy of which is questionable (21, 22). Therefore, using more precise tools like accelerometers is recommended. Consequently, the aim of the current research is to investigate the relationship between PA (measured using an accelerometer) and motor proficiency in primary school children. This overarching goal comprises several specific objectives, which include: 1) assessing the amount and intensity of children's PA, 2) evaluating the level of motor proficiency in children as it pertains to gross and fine motor skills, 3) comparing PA and motor proficiency across genders, and 4) examining the correlation between PA and motor proficiency.

2. Methods

The current research represents a descriptive-correlational study. The study was conducted in accordance with the ethical guidelines set forth in the Declaration of Helsinki. Parents of the children provided informed consent for their participation in this research.

2.1. Participants

The sample consisted of 384 children (192 from each gender), aged between 7 to 9 years ($Mage=7.96\pm 0.73$ years). They were in the first and second grades from various primary schools in Tehran, Iran, in 2022. The participants were selected through a convenience sampling method. Those who did not complete the physical activity (PA) protocol or the motor proficiency test were excluded from the study.

2.2. Measures

2.2.1. Physical Activity

For objective measurement of physical activity, we utilized a thigh-worn ActiGraph wGT3X-BT accelerometer (ActiGraph LLC; Florida, US). Children were instructed to wear the device on their right hip for seven consecutive days, including weekends. They were advised to keep the device on their thigh at all times, except when bathing, participating in water activities or martial arts, or while sleeping. Both children and their parents were instructed on how to affix the device on the thigh and record information regarding when the device was removed. It is important to note that the examiner maintained daily contact with the children and their parents to ensure accurate data recording. The accelerometers were initialized at a frequency of 30 Hz, and data were processed using the appropriate software.

Intensity of physical activity was measured using the guidelines provided by Evenson and colleagues (27) and the algorithm proposed by Bruininks (28) including light physical activity (100–1951 counts/min), moderate PA (≥ 1952 –5724 counts/min), and vigorous PA (≥ 5725 counts/min). Moderate and vigorous physical activity were grouped together as moderate-to-vigorous physical activity (MVPA). Prior studies have indicated a high reliability for the ActiGraph accelerometer, with a Cronbach's alpha coefficient of 0.806 (27). In this study, the validity of the device was confirmed by 10 experts (CVI=0.90, CVR=0.88).

2.2.2. Motor Proficiency

We utilized the short form of the Bruininks-Oseretsky Test of Motor Proficiency Edition 2 (BOT-2) to measure children's motor proficiency. BOT-2 is

a series of standardized reference tests designed to assess the motor performance of children aged 4.5 to 14.5 years. Bruininks (28) developed this test by modifying Oseretsky's original motor proficiency test. The short form takes approximately 15-20 minutes to complete. This instrument comprises eight subtests and 14 items, drawn from a total of 46 items, that evaluate abilities such as:

1. Running speed and agility (one item),
2. Static and dynamic balance (two items),
3. Bilateral coordination (two items),
4. Leg muscle strength (one item),
5. Upper limb coordination (two items),
6. Reaction speed (one item),
7. Visual-motor control (three items), and
8. Upper limb agility and speed (two items).

Items 1 to 4 assess gross motor skills, items 6 to 8 evaluate fine motor skills, and item 5 measures a combination of both. The retest reliability coefficient of this test in the short form is 0.86 (28). This test has also been standardized in Iran, with an alpha Cronbach's coefficient of 0.826 for the total test (29, 30). Ten specialists confirmed the validity of this instrument (CVI=1.00, CVR=1.00). Each child receives a raw score, which is converted into points according to a guide table. The range of gross and fine motor skill scores is 0-53 and 0-51, respectively. A higher score signifies better motor skills.

2.3. Data Analysis

We used the mean and standard deviation to describe variables. The independent t-test was applied to compare gender differences. We utilized the Kolmogorov-Smirnov test to measure the normality of data. The Pearson correlation test was

used to assess linear relationships between physical activity (PA) and motor proficiency. Finally, we applied multiple linear regression with forward selection to identify the influence of sedentary time, light PA, and moderate-to-vigorous physical activity (MVPA) on gross and fine motor skills. The significance level was set at $P < 0.05$.

3. Results

3.1. Demographic Data

The study involved 384 children aged 7 to 9 years ($M_{age} = 7.96 \pm 0.73$ years) in the first and second grades from primary schools in Tehran, Iran, in 2022. Table 1 presents the demographic characteristics of the children, including age, height, weight, and body mass index (BMI) across boys and girls. The data suggest that boys and girls have similar ages ($P = 0.867$), heights ($P = 0.938$), weights ($P = 0.671$), and BMI ($P = 0.779$).

3.2. Gender Differences

Table 2 presents descriptive data for Physical Activity (PA) such as Sedentary Time%, Light PA%, MVPA%, and Daily MVPA, as well as Motor Proficiency including Gross and Fine Motor Skills, across genders. Our results confirmed that the data followed a normal distribution (all $P > 0.05$). Pertaining to PA, it is evident from the results that the children in this study did not meet the recommended guidelines of 60 minutes of Moderate-to-Vigorous Physical Activity (MVPA) per day. Furthermore, boys exhibited a significantly higher MVPA than girls ($P < 0.001$). Nonetheless, no significant gender differences were observed in Light PA ($P = 0.794$). Lastly, girls demonstrated significantly higher Sedentary Time compared to boys ($P < 0.001$).

In terms of motor proficiency, we discovered that boys were significantly more proficient in Gross Motor Skills than girls ($P < 0.001$), whereas girls were significantly more proficient in Fine Motor Skills than boys ($P < 0.001$).

Table 1: Demographic characteristics of the children

Variable	Boys	Girls
Age (years)	7.92±0.70	7.89±0.81
Height (m)	1.28±0.15	1.27±0.10
Weight (kg)	27.33±7.28	26.70±6.38
BMI	18.23±1.94	18.17±1.17

Table 2: Physical activity and motor proficiency across gender

Variables	Boys		Girls		Comparison
	Mean	SD	Mean	SD	
Physical activity					
% Sedentary time	62.21	5.86	68.39	7.17	t=5.971 P<0.001
% Light physical activity	25.51	3.71	26.11	5.86	t=0.234 P=0.794
% MVPA	12.28	1.82	5.50	1.25	t=8.258 P<0.001
Daily MVPA (minutes)	48.67	12.67	29.19	9.96	t=-8.697 P<0.001
Motor proficiency					
Gross motor skills	39.84	7.28	32.59	6.40	t=4.091 P<0.001
Fine motor skills	34.18	5.09	41.28	6.35	t=-6.813 P<0.001

SD: Standard deviation; MVPA: Moderate-to-vigorous physical activity

Table 3: Results of Pearson correlation between physical activity and motor proficiency

	Sedentary time	Light physical activity	MVPA%	Daily MVPA
1. Gross motor skills	r=-0.681 P<0.001	r=0.034 P=0.857	r=0.793 P<0.001	r=0.710 P<0.001
2. Fine motor skills	r=-0.584 P<0.001	r=0.021 P=0.949	r=0.079 P=0.239	r=0.064 P=0.307

MVPA: Moderate-to-vigorous physical activity

Table 4: Results of multiple linear regression analysis to discover the influence of sedentary time and MVPA on gross and fine motor skills

		Coefficient	SE	Standardized Coefficient	P values
Gross motor skills	Sedentary time	-0.681	7.23	-0.594	<0.001
	MVPA%	0.793	8.34	0.617	<0.001
	Daily MVPA	0.710	7.84	0.718	<0.001
Fine motor skills	Sedentary time	-0.584	6.07	-0.551	<0.001
	MVPA%	0.239	3.13	0.198	0.458
	Daily MVPA	0.307	4.25	0.326	0.493

MVPA: Moderate-to-vigorous physical activity

3.3. Associations between Physical Activity and Motor Proficiency

Table 3 displays the results of Pearson correlation tests between Physical Activity (PA) measures like Sedentary Time%, Light PA%, MVPA%, and Daily MVPA, and Motor Proficiency variables such as Gross and Fine Motor Skills. The results indicated that Sedentary Time was inversely and significantly associated with both Gross and Fine Motor Skills (both P<0.001). Moreover, MVPA displayed a direct and significant association with Gross Motor Skills (P<0.001), but not with Fine Motor Skills. Finally, Light PA showed no significant association with either Gross or Fine Motor Skills (both P>0.05).

3.4. Regression Analysis

Table 4 reveals the results of a multiple linear

regression analysis using forward selection to investigate the influence of Sedentary Time and MVPA on Gross and Fine Motor Skills. The findings suggested that Sedentary Time inversely and significantly influenced both Gross (P<0.001) and Fine Motor Skills (P<0.001). Additionally, MVPA% had a direct and significant effect on Gross Motor Skills (P<0.001). Lastly, Daily MVPA was found to directly and significantly impact Gross Motor Skills (P<0.001).

4. Discussion

Previous studies utilizing self-reported measures have indicated a connection between physical activity (PA) and motor proficiency in children. However, due to the potential for bias and the inaccuracy of self-reported instruments, the present research was designed to investigate the association

between objectively measured PA (captured by an accelerometer) and motor proficiency in children. The preliminary results revealed that the children participating in this study did not meet the recommended 60 minutes of moderate to vigorous physical activity (MVPA) per day. Moreover, boys were found to be significantly more physically active than girls, and girls had significantly higher sedentary time than boys. These findings aligned with previous research (20, 22, 25, 26) and suggested a low level of PA among children, especially girls. Therefore, it can be inferred that a lack of mobility is a common issue among girls. This could be attributed to various factors such as educational limitations, lack of access to sports facilities and equipment, the costliness of certain sports activities, and cultural norms. As such, the physical activity behavior of children, particularly girls, demands special consideration in the context of health-related interventions and programs (31-34).

In terms of motor proficiency, the children in this study demonstrated above-average levels of motor proficiency, indicating they possess robust motor skills. Further, boys were significantly more proficient in gross motor skills than girls, while girls outperformed boys in fine motor skills. These results are consistent with previous research (5, 6). The disparity in the execution of gross motor skills may be attributed to physical differences such as a higher muscle mass in boys and a lower stroke volume in girls. Furthermore, boys tend to engage more in physical activities that rely on large muscle groups, affording them the opportunity to experience and develop a variety of gross motor skills (5). In contrast, girls typically prefer to engage in sedentary activities that require the use of small muscles, making them more adept at performing fine motor skills. Additionally, girls often reach developmental milestones in motor abilities earlier, yet their subsequent motor development can be influenced by cultural stereotypes and societal expectations of both genders. In our society, boys traditionally engage more in activities that involve throwing, jumping, and hitting balls, whereas girls are often provided with fewer opportunities and resources to participate in such activities (6). This discrepancy could potentially be due to the different types of games and sports preferred by boys and girls, as well as the tendency of parents and teachers to focus more on boys' motor development. Consequently, it is plausible that boys possess higher levels of gross motor skills

than girls.

In this study, we observed an inverse relationship between sedentary time and both gross and fine motor skills. Conversely, moderate to vigorous physical activity (MVPA) was found to be positively and significantly associated with gross motor skills, but not with fine motor skills. In contrast, light physical activity showed no significant relationship with either gross or fine motor skills.

These findings suggested that while gross motor skills are influenced by physical activity, not all forms of such activity are effective in promoting them. Specifically, to foster gross motor skills in children, it is recommended that they engage more in MVPA and limit their light physical activity.

In general, this study's findings affirm previous research that used self-reported questionnaires to determine the impact of sedentary time and physical activity on children's motor proficiency. However, our use of an accelerometer has added fresh insights to the literature. We found that higher intensity levels of physical activity, such as MVPA, led to improved motor proficiency among children, while less intense activities (i.e., light physical activity) did not significantly enhance motor proficiency.

Engaging in sedentary activities, such as completing school assignments and playing computer games, was found to negatively affect motor development in children. Nevertheless, we believe that a child's participation in organized weekly activities could foster motor skills development. Given that MVPA tends to increase physical strength in children, we can reasonably expect that gross motor skills, which require stronger large muscles, would be positively influenced by MVPA.

It is essential to note that motor development during a child's developmental stages is not spontaneous but is significantly influenced by environmental factors, activities, and the child's lifestyle. Consequently, regular participation in physical activities, under the guidance of parents and teachers, has been found to be highly effective in fostering motor development. In this context, physical education teachers and sports coaches play a crucial role in facilitating the development of motor skills in children. They can design physical

education programs that enhance children's motor skills.

4.1. Limitations

One limitation of the present research was its cross-sectional design, which precludes examination of contributing factors. However, a significant strength of this study was the use of an accelerometer to measure physical activity, which yields more precise data than self-report tools such as questionnaires.

5. Conclusions

Current research suggested that children do not meet the WHO recommended guideline of 60 minutes of Moderate to Vigorous Physical Activity (MVPA) per day. It has been observed that girls typically engage in lower levels of MVPA compared to boys, indicating a need to boost physical activity, particularly in girls. Interestingly, MVPA has been found to correlate with gross motor skills, though no association has been found with fine motor skills. Conversely, sedentary time is inversely associated with both gross and fine motor skills. These findings highlighted the importance of more intense physical activity levels and reduced sedentary time for children's motor development. Therefore, it is advisable for physical education teachers and sports coaches to incorporate programs into their curricula to enhance children's motor skills.

Ethical Approval

Ethics Committee of Islamic Azad University of Aliabad Katoul affirmed current research with the code of IR.IAU.AK.REC.1398.004. Also, parents of the children provided informed consent for their participation in this research.

Funding Support

We attained no grant for current research.

Authors' Contribution

A.D: Substantial contributions to the design of the work, data acquisition, analysis, and interpretation, critical revision of the manuscript. Sh.R: Substantial contributions to the conception of the work, drafting, and critical revision of the

manuscript. Z.Ch: Substantial contributions to the conception of the work, drafting, and critical revision of the manuscript, S.Gh: Data acquisition, analysis, and interpretation, critical revision of the manuscript. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work, such that the questions related to the accuracy or integrity of any part of the work.

Acknowledgments

We appreciated the participants who took part in current research.

Conflicts of Interest: None declared.

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