

Correlations between Physical Activity Participation and Anthropometric Features with Gross and Fine Motor Skills in School Children with Attention Deficit Hyperactivity Disorder

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Abstract

Background: Finding the factors that may affect performance of fine and gross motor skills in children with attention deficit hyperactivity disorder (ADHD) is of great importance. Therefore, the aim of this study was to examine the correlations between physical activity (PA) participation and anthropometric features with gross and fine motor skills in school children with ADHD.

Methods: This was a descriptive-correlational study. The study participants were 320 students with ADHD (including 120 girls; mean age of 7.86 ± 0.89 years) from Tehran, Iran, in 2023. To assess PA, anthropometric features and motor proficiency, the Rapid Assessment of Physical Activity (RAPA) scale (scores range from 0 to 7), standard tools such as a meter and scale, and the short form of the Bruininks-Oseretsky Test of Motor Proficiency (scores from 0-53, and 0-51 for gross and fine skills, respectively) were used. The data were analyzed using independent t-test and Pearson correlation test.

Results: The participants had a relatively low level of PA (mean = 2.23 ± 1.07). Moreover, boys exhibited significantly higher proficiency in gross motor skills compared with girls ($t = 6.282$, $P < 0.001$), while girls demonstrated significantly higher proficiency in fine motor skills ($P < 0.001$). Also, PA was directly and significantly associated with both gross ($r = 0.593$, $P < 0.001$) and fine motor skills ($r = 0.478$, $P < 0.001$). Moreover, body mass index showed an inverse and significant correlation with gross motor skill ($r = -0.681$, $P < 0.001$).

Conclusions: These findings emphasized the importance of promoting more PA and height-to-weight matching processes for optimal motor growth in children with ADHD. Therefore, it is recommended to incorporate programs aimed at enhancing motor skills in children during physical education lessons.

Keywords: Exercise, Motor proficiency, Child, Attention deficit hyperactivity disorder, Anthropometry

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1. Introduction

Childhood is widely regarded as the pivotal stage for motor development, surpassing all other phases of life. Indeed, motor development encompasses alterations in motor behavior and the fundamental mechanisms driving these transformations (1). The foundation of motor development lies in fundamental motor skills, which can be categorized into gross motor skills and fine motor skills (2). Fundamental motor skills play a crucial role in acquiring everyday motor and sports skills. Gross motor skills encompass the movements executed by major muscle groups, including the chest muscles, arms, and legs. These skills are closely intertwined with numerous activities in our daily lives. For instance, they are indispensable

for performing actions like running, walking, and throwing (3). Acquiring these abilities directly contributes to the enhancement of specific motor skills, particularly in sports or physical activities (PA). Mastering fundamental motor skills like jumping and throwing is essential for acquiring sports skills such as basketball and volleyball (4). Insufficiency in gross motor skills is evident in the lack of mastery in more refined skills, necessitating the acquisition of a combination of these essential movements to develop more specialized motor skills. Furthermore, this condition adversely impacts children's social and emotional behaviors, diminishing their inclination to engage in sporting activities (5, 6).

Fine motor skills are fundamental abilities

that play a crucial role in various aspects of daily living, such as work tasks, self-care routines, and recreational pursuits (7, 8). The capabilities are divided into two main elements, namely gross hand skills and fine finger skills. Gross hand skills usually entail manipulating big objects through coordinated arm and hand movements, whereas fine finger skills involve manipulating smaller objects through precise hand and finger motions (9, 10). Fine motor skills are at a higher risk compared to gross motor skills due to various factors. One reason is that a significant portion of the motor and pre-motor cortex regions in the brain are dedicated to controlling fine motor skills. Additionally, because finer muscle groups are involved, these skills tend to exhibit greater functional deficits following injury or illness (11, 12).

Research has demonstrated that children who have physical or mental disorders typically exhibit reduced levels of basic motor skills compared to their peers (13-17). It is essential to thoroughly assess the condition of basic motor skills in children with physical or mental disabilities, and to identify suitable elements that can enhance the development of basic motor skills in children with physical or mental disabilities. Attention deficit hyperactivity disorder (ADHD) is a common childhood disorder that has attracted the attention of psychologists and psychiatrists. ADHD is a neurodevelopmental disorder distinguished by three primary characteristics: attention deficit, hyperactivity, and impulsivity (18). This particular disorder is one of the common neurobehavioral conditions in children that affects a considerable number of people worldwide. Those who are identified with this disorder might face challenges in concentrating on specifics and could display negligence in academic assignments, work responsibilities, or everyday tasks (19). Frequently, there exists a lack of consistency in carrying out tasks, resulting in careless and thoughtless execution. Individuals facing this challenge often struggle to sustain their focus during games and assignments, making it arduous for them to concentrate and complete their tasks (18, 19).

One must take into account a vital factor in this specific field, which is the unique physical challenges faced by these children in contrast to their peers. Children with ADHD exhibit significantly lower motor skills compared to their healthy counterparts, and their motor abilities

fall significantly below the expected level for their age and intellectual capacity (14-16). These children experience difficulties in gross motor skills, motor coordination, fine motor skills, manual manipulation, dexterity, and coercion, along with bilateral coordination. Additionally, these children exhibit delays in acquiring motor development stages, disruptions in movement planning and execution, as well as challenges in maintaining balance and controlling height (18). Typically, children diagnosed with ADHD exhibit deficiencies in motor coordination and clumsiness. The symptoms of this disorder often manifest as poor balance, motor clumsiness, and overall motor skill impairment. Additionally, these children tend to experience more difficulties with balance when compared to their peers of the same age (15, 18).

It is essential to recognize the elements that may affect the enhancement of fine and gross motor skills in children with ADHD. This study focused on examining two factors - PA and anthropometric characteristics - and how they impact the fine and gross motor skills of children with ADHD. The primary objective of this research was to explore the connections between PA engagement, anthropometric traits, and the progression of fine and gross motor skills in school-aged children who have been diagnosed with ADHD.

2. Methods

2.1. Design and Participants

This descriptive-correlational study encompassed 320 students (120 girls) of primary schools in Tehran, Iran, 2023, diagnosed with ADHD (mean age of 7.86 ± 0.89 years). The participants were selected through a convenience sampling technique. The study required participants to meet specific criteria, including: 1) a diagnosis of ADHD, 2) obtaining parental consent, 3) actively participating in the study, and 4) not having any physical abnormalities that could interfere with participation. Prior to the assessment, written consent was obtained from all parents.

2.2. Measures

2.2.1. Physical activity: PA was assessed using the Rapid Assessment of Physical Activity (RAPA) scale (20). This scale consists of seven items that require binary responses of 'Yes' or 'No'. The total

score on this scale can range from 0 to 7. In the present study, the internal consistency reliability of the RAPA scale, measured by Cronbach's alpha, was found to be 0.92. Furthermore, the validity of this instrument has been established by ten specialists, with a CVI of 0.90 and a CVR of 1.00.

2.2.2. Anthropometric features: Standard tools such as meter and scale were used to measure anthropometric features such as height, weight, arm length, leg length, and sitting height.

2.2.3. Gross and fine motor skills: The Bruininks-Oseretsky Test of Motor Proficiency Edition 2 (BOT-2) was used to measure motor skills (21). The overall set of the test includes eight sub-tests (four sub-tests in the group of gross motor skills, three sub-tests in the group of fine motor skills and one sub-test for upper body coordination), which is a suitable tool for measuring gross and fine motor skills. The test set is a comprehensive index and provides an index of motor proficiency as well as individual scales of fine and gross motor skills for ages of 4-21 years old. The long form takes 45-60 minutes and the short form takes 15-20 minutes. In this study, we used the short-form of this test, which contains 14 items and can be used as a quick screening tool. Each child is given a raw

score, which is then transformed into points using a reference table. The scores for gross motor skills can range from 0 to 53, while the scores for fine motor skills can range from 0 to 51. A higher score signifies a higher level of motor proficiency. In this study, the short form of this test has a test-retest reliability coefficient of 0.86. The validity of this instrument has been confirmed by ten specialists (CVI=1.00, CVR=1.00).

2.3. Data Analysis

We used mean and standard deviation (SD) to describe variables. To compare gender differences, we employed the independent samples t-Test. The Kolmogorov-Smirnov test was used to assess the normality of the data. The Pearson correlation test was conducted to examine the associations between PA and anthropometric features with gross and fine motor skills. A significance threshold of $P < 0.05$ was set.

3. Results

3.1. Descriptive Data and Gender Differences

Table 1 shows a summary of the descriptive statistics and distinctions between genders.

Table 1: Descriptive data and gender differences

Variables	Total (n=384)		Boys (n=194)		Girls (n=190)		Gender differences
	Mean	SD	Mean	SD	Mean	SD	
Age (years)	7.86	0.89	7.90	0.92	7.84	0.88	t=0.140 P=0.847
Physical activity	2.23	1.07	2.68	1.20	2.06	1.22	t=8.579 P<0.001
Anthropometric features							
Height (cm)	126.36	4.85	127.48	5.07	125.39	4.41	t=0.209 P=0.527
Weight (kg)	22.36	3.79	22.90	3.91	22.09	3.49	t=-0.581 P=0.310
BMI	15.28	0.39	15.97	0.37	14.83	0.22	t=-0.103 P=0.127
Arm length (cm)	55.27	3.24	56.43	3.69	54.20	3.08	t=0.630 P=0.290
Leg length (cm)	60.55	4.96	61.17	4.27	59.89	3.67	t=0.127 P=0.873
Sitting height (cm)	66.41	4.33	67.59	4.51	65.70	4.93	t=0.141 P=0.850
Motor skills							
Gross motor skills	30.46	3.90	34.60	3.51	28.03	3.47	t=6.282 P<0.001
Fine motor skills	33.16	3.48	29.69	3.52	35.97	3.07	t=8.210 P<0.001

BMI: Body Mass Index

Table 2: Correlations between physical activity and anthropometric features with gross and fine motor skills

	Physical activity	BMI	Arm length	Leg length	Sitting height
Gross motor skills	r=0.593 P<0.001	r=-0.681 P<0.001	r=0.043 P=0.576	r=0.003 P=0.992	r=0.010 P=0.951
Fine motor skills	r=0.478 P<0.001	r=0.023 P=0.792	r=0.009 P=0.937	r=0.044 P=0.586	r=0.029 P=0.750

BMI: Body Mass Index

The mean age of the participants was 7.86 ± 0.89 years, and no notable variations between genders were observed ($P=0.847$). Totally, 196 students (61.2%) were in the first grade, and 126 children (38.8%) were in the second grade of primary school. Furthermore, our data revealed that the participants had relatively low PA (mean= 2.23 ± 1.07). Furthermore, boys had significantly higher PA ($P<0.001$). Regarding anthropometric features, we observed no significant gender differences (all $P>0.05$). Lastly, our findings showed that boys exhibited significantly higher proficiency in gross motor skills compared with girls ($P<0.001$), while girls demonstrated significantly higher proficiency in fine motor skills compared with boys ($P<0.001$).

3.2. Correlations between Research Variables

Table 2 shows the result of Pearson correlation tests between PA and anthropometric features with gross and fine motor skills. The findings showed a direct and significant correlation between PA and both gross and fine motor skills (both $P<0.001$). Furthermore, BMI demonstrated an inverse and significant correlation with gross motor skills ($P<0.001$), but not with fine motor skills. Moreover, there were no other significant correlations found between anthropometric features and gross and fine motor skills (all $P>0.05$).

4. Discussion

Our research showed that the participants engaged in minimal PA levels. Additionally, male students demonstrated higher levels of PA in contrast to female ones. These findings were consistent with prior research (22-24) and emphasized the generally low PA levels in children with ADHD, especially girls. Therefore, it can be deduced that a lack of physical movement is widespread among girls. The reasons behind the lower PA levels in girls could be attributed to educational limitations, restricted availability of sports facilities and equipment, the expenses linked to specific sports activities, and cultural influences. Considering the

numerous benefits linked to regular PA (25-28), it is important to investigate various approaches and implement suitable intervention exercises to enhance the involvement of children with ADHD in PA. It is crucial to prioritize PA patterns of children, particularly girls, by focusing on health interventions and programs. At the same time, it is important to implement strategies that enhance motivation for children with ADHD to participate in regular PA.

The results of this research revealed an average motor proficiency level in terms of gross and fine motor skills, indicating that the motor skills of the participants in the study are not optimal. Additionally, boys showed notably higher proficiency in gross motor skills than girls, while girls displayed significantly higher proficiency in fine motor skills compared to boys. These findings were consistent with prior research (15, 18). The diversity in the performance of gross motor skills may be linked to physical variances, with boys possessing higher muscle mass and girls having reduced stroke volume. Additionally, boys are more inclined to engage in PA that involve the utilization of major muscle groups, enabling them to develop and enhance their gross motor abilities (16, 19). Boys in our society are more inclined towards activities that require physical strength and coordination, such as throwing, jumping, and playing with balls. On the contrary, girls usually show a preference for sedentary games that focus on using small muscles, which helps improve their fine motor skills. Moreover, girls tend to reach a higher level of motor development at an earlier age, but their progress is frequently shaped by cultural norms and societal standards regarding gender roles. Girls often have limited chances to engage in PA that involve physical exertion compared to boys (14, 16). Discrepancies in game preferences, sports choices, and the varying levels of attention from parents and teachers towards boys' motor development could be contributing factors to the higher gross motor skills seen in boys compared to girls. The diminished motor skill performance

in children with ADHD might be due to longer response times and an increase in response errors. Children with ADHD tend to react swiftly, leading to a rise in errors, while the number of omission errors decreases. This suggests that the items identified as targets are not solely based on attention and precision, but rather on the child's attempt to quickly pinpoint the designated targets.

The results of this research revealed that PA plays a crucial role in improving motor skills among children diagnosed with ADHD. Studies have shown that children who engage in higher levels of PA exhibit higher levels of proficiency in both gross and fine motor skills (29, 30). Engaging in PA not only boosts children's physical fitness, but also strengthens their muscles. Enhanced muscle strength is associated with better motor function, suggesting that children who are more physically active typically demonstrate superior physical fitness, resulting in improved motor skills (31, 32).

Moreover, the results of the current investigation suggested that BMI has a notable influence on the progression of gross motor abilities in children diagnosed with ADHD. Conversely, other physical measurements do not contribute positively to motor skill proficiency in children with ADHD. These findings emphasized the significance of the height-to-weight ratio and its effectiveness in improving motor skill performance among children with ADHD (11, 22, 23). It is essential to incorporate height-to-weight matching procedures in children diagnosed with ADHD. Considering the importance of PA in regulating weight in children, this element can serve as a method to boost physical fitness and ultimately enhance motor skills in children with ADHD.

4.1. Limitation

One limitation of this study was the utilization of a questionnaire to measure PA, which could result in inaccuracies due to self-reporting. To address this obstacle, it is suggested that future studies integrate device-based instruments such as accelerometers for a more accurate assessment of PA. Furthermore, considering the low levels of PA, it is strongly recommended that experts introduce programs and strategies to boost PA levels in children diagnosed with ADHD, particularly among girls.

5. Conclusions

The results indicated a low level of PA among children with ADHD. Moreover, it was noted that girls have lower PA as compared with boys. These results underscored the need to boost PA in children with ADHD, especially among girls. Additionally, the study revealed a positive relationship between PA and both gross and fine motor skills. Furthermore, BMI was negatively correlated with gross motor skills but not with fine motor skills. These findings stressed the significance of encouraging more PA and implementing height-to-weight matching procedures to support optimal motor development in children with ADHD. As a result, it is advised to integrate programs focused on improving motor skills in children with ADHD.

Authors' Contributions

Farrokhlegha Najafzadeh: Substantial contributions to the conception and design of the work, acquisition, analysis, and interpretation of data for the work, reviewing the work critically for important intellectual content. Hassan Shafaei: Contribution to the design of the work, drafting the work and reviewing it critically for important intellectual content. Somayeh Alizadeh: Contribution to the design of the work, drafting the work and reviewing it critically for important intellectual content. Amir Dana: Acquisition, analysis, and interpretation of data for the work, reviewing the work critically for important intellectual content. 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.

Ethical Approval

The Institute Ethics Review Board approved the present study with the code of IR.SSRC.REC.1398.017. Also, written informed consent were obtained from parents of children.

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