

# Association of Physical Activity and Motor Skills with Academic Performance in High School Students of Hayatabad, Peshawar: A Cross-Sectional Study

Babar Ali<sup>1</sup>, Seema Gul<sup>2</sup>, Uzair Ahmad<sup>3</sup>, Ikram Ali<sup>4</sup>

<sup>1</sup> Manager Paramedics, Department of Paramedics, MTI, Khyber Teaching Hospital Peshawar, Pakistan

<sup>2</sup> Lecturer, Institute of Physical Medicine and Rehabilitation, Khyber Medical University Peshawar, Pakistan

<sup>3</sup> Assistant Professor, Doctor of Physical Therapy, Northwest Institute of Health Sciences Peshawar, Pakistan

<sup>4</sup> Assistant Professor, Institute of Physical Medicine and Rehabilitation, Khyber Medical University Peshawar, Pakistan

## Author's Contribution

<sup>1</sup> <sup>2</sup> Substantial contributions to the conception or design of the work for the acquisition, analysis or interpretation of data for the work, <sup>2</sup> Drafting the work or reviewing it critically for important intellectual content, <sup>4</sup> Final approval of the version to be published, <sup>1</sup> Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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## Address of Correspondence

Name: Uzair Ahmad

Email Id: [azmatuzair125@gmail.com](mailto:azmatuzair125@gmail.com)

ORCID: 0000-0002-1106-8495

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## A B S T R A C T

**Background:** Regular physical activity has a positive impact on brain function, improves perception, and significantly influences academic achievement.

**Objective:** This study aimed to determine the association of physical activity, motor skills, and academic performance in high school students in Hayatabad, Peshawar.

**Methodology:** A total of 349 students were recruited using stratified random sampling from both public and private high schools within the Hayatabad region, Peshawar, Pakistan from December 2020 to May 2021. Only students in 9th and 10th grades from public and private schools who met the inclusion and exclusion criteria, were included. PA was assessed using the short version of the International Physical Activity Questionnaire (IPAQ). Academic performance was documented based on grades and percentages from recent exams, following Peshawar Board of Education rules. Motor skills were evaluated through vertical jumps, average hand strength, sit-and-reach flexibility, and 60-second pushups.

**Results:** A statistically significant association was observed between PA and academic performance in high school students ( $P < 0.05$ ). Similarly, there was a statistically significant association between motor skills including vertical jump, handgrip strength and academic performance ( $P < 0.05$ ). However, no statistically significant associations were found between sit-and-reach test performance, (60s) push-ups and academic performance ( $P > 0.05$ ).

**Conclusion:** In conclusion, this study demonstrates an association between physical activity (PA) and academic performance in high school students. However, motor skills including vertical jump and handgrip strength is associated with academic performance in high school students.

**Keywords:** Physical activity, Motor skills, Academic performance, Academic achievement.

## Introduction

The World Health Organization (WHO) defines Physical Activity (PA) as "every bodily movement initiated by skeletal muscles that requires energy expenditure".<sup>1,2</sup> PA

encompasses various activities, including sports, walking, cycling, and dynamic forms of recreation such as yoga and Tai chi. It can also be undertaken at home and in the workplace.<sup>3</sup> Although PA is widely acknowledged as a key contributor to the health and well-being of individuals,<sup>4</sup> global

levels of physical inactivity represent a significant public health concern.<sup>5</sup> According to WHO, children and adolescents aged 5-17 years should engage in at least an average of 60 minutes per day of moderate-to-vigorous intensity, primarily aerobic, physical activity throughout the week.<sup>6</sup> Recent evidence indicates that only 27.5% of adults and 81% of adolescents meet the recommended PA levels set by WHO for aerobic exercise.<sup>7</sup> Moreover, a study encompassing 120 countries reveals a concerning upward trend in physical inactivity among children.<sup>8</sup> Both developed and developing nations grapple with the challenge of a rising number of individuals leading sedentary lifestyles.<sup>9</sup> An American study discovered that 19–38% of adolescents aged 12 to 17 years meet the WHO recommendations for PA.<sup>10</sup> In England, 15 to 33% of youths aged 9 to 15 years are involved in moderate or vigorous PA for at least 60 minutes.<sup>11</sup> An Australian study found that only 15% of students aged 12 to 17 years engage in adequate PA.<sup>12</sup> A study by Aqeel et al. affirmed that high PA was more prevalent in male students than females, while moderate PA was greater in females than in males in Islamabad, Pakistan.<sup>13</sup> Ismat et al. revealed that none of the school teenagers in Karachi had a higher PA level.<sup>14</sup>

PA exhibits a beneficial relationship with individual fitness levels and the structure and function of the brain.<sup>15</sup> It is crucial for the physical growth and development of youngsters and is positively associated with their psychological and social development.<sup>16</sup> Neuroscience evidence indicates that regular PA and physical fitness improve brain function.<sup>17</sup> Ludyga et al. found that working memory is enhanced after moderate PA compared to physically inactive students.<sup>18</sup> Moreover, regular PA has a positive impact on brain function, improves perception, and significantly influences academic achievement.<sup>19</sup>

Motor skills encompass goal-directed efforts in subjects during the execution of goal-focused patterns of movement. These skills are categorized into gross motor skills and fine motor skills, with fine motor skills involving smaller muscle groups, such as those in the hand and wrist. Evidence suggests that children with impaired motor skills often exhibit lower achievement in cognitive tasks, linking poor self-esteem and lower PA levels to impaired motor skills, which can affect physical health, including cardiorespiratory fitness and body weight.<sup>20</sup> Previous studies have demonstrated a significant relationship between the development of motor

skills and academic performance, especially between fine and gross motor skills scores and scores in mathematics and reading performance in primary schools.<sup>21</sup>

In the context of academic performance, the term "academic achievement" is commonly used in literature.<sup>22</sup> Academic achievement is associated with learning in various educational settings. The term "academic" encompasses theoretical learning of specific subjects and the practical implementation of learned theoretical knowledge to execute different tasks.<sup>23</sup> Although PA is often neglected during school days and strictly organized during exam preparation, this strategy has shown no improvement in exam results and can be detrimental to health, highlighting a divergence in the association between PA and academic performance.<sup>24</sup>

Various studies worldwide have explored the relationship between PA and academic performance, with hypotheses suggesting that an active lifestyle may improve academic outcomes. A study conducted in Iran by Kalantri et al. concluded that there is no significant association between PA and academic performance, whereas aerobic exercise showed a significant relationship.<sup>25</sup> Similarly, a study by Pandolfo K et al. in Brazil found no significant association between academic performance and PA in high school students.<sup>26</sup> In contrast, significant associations were found between vigorous PA and academic performance in American school students.<sup>27</sup> Another study by Álvarez et al. concluded that if PA interventions are effectively implemented in schools, they can improve academic performance in school children with better motor skills.<sup>7</sup> While some studies have found a positive association between PA and academic performance, others have found no such link, making the relationship controversial.

To contribute to this discussion, this study aims to further assess whether PA and motor skills are significantly related to academic performance in high school students. The author notes an inconsistency of literature regarding PA and motor skills and their impact on academic performance in high schools in Pakistan, motivating the design of this study to investigate the associations of PA, motor skills, and academic performance in high school pupils.

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## Methodology

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This study, adopting a cross-sectional design, was carried out in both public and private high schools within the Hayatabad region, Peshawar, Pakistan from December 2020 to May 2021. The research adhered to the principles set forth in the Declaration of Helsinki. The ethical approval was obtained from the Advance Studies and Research Board

(ASRB) & ethical review board of Institute of Physical Medicine & Rehabilitation, Khyber Medical University Peshawar (Ref No. DIR/KMU-EB/AP/000789). All study participants were briefed on the aims, objectives, and procedures of the study. The permission was taken from school heads and written Informed consent was obtained from students willing to participate.

The sample size, determined at 349 students, was calculated using the Rao soft online calculator, with total population 3763 (Data obtained from Board of Intermediate and Secondary Education Peshawar), a confidence level of 95% and a margin of error of 5%. A stratified random sampling procedure was carried by the following procedure. Proportionate sampling formula was used to collect data from each stratum proportionally i.e.,  $nh = (Nh/N) \times n$ . Where  $nh$  is the sample size for stratum  $h$ ,  $Nh$  is the population size for stratum  $h$ ,  $N$  is total population size, and  $n$  is total sample size. Sample size for each stratum was: Phase I Hayatabad ( $n=9$ ), Phase II Hayatabad ( $n=28$ ), Phase III Hayatabad ( $n=49$ ), Phase IV Hayatabad ( $n=39$ ), Phase V Hayatabad ( $n=75$ ), Phase VI Hayatabad ( $n=48$ ) and Phase VII Hayatabad ( $n=20$ ). Schools from each stratum were selected by simple random sampling using lottery method.

The inclusion criteria comprised students regularly enrolled in classes 9th and 10th, aged between 15 and 18 years, and included both boys and girls. Additionally, participants needed to be deemed healthy based on the screening results of the Physical Activity Readiness Questionnaire (PAR-Q). The study focused on students enrolled in both public and private schools located in Hayatabad. Conversely, the exclusion criteria encompassed various conditions and situations that might impact physical activity and overall health. Excluded were individuals with a history of chest pain during physical activity, severe joint or limb pain that impedes physical activity, recent ligament or muscle injuries, recent fractures, as well as those with conditions such as Spina bifida, cerebral palsy, clubfoot, and cognitive challenges. Further exclusions included individuals with a history of heart disease, recent surgery, or scoliosis that prevented the performance of motor skills. Additionally, students who did not pass the screening through the Physical Activity Readiness Questionnaire (PAR-Q) were excluded from participation.

After screening through the Physical Activity Readiness Questionnaire (PAR-Q) and applying inclusion criteria, eligible students were selected for participation. Data collection involved obtaining authorization from relevant authorities, briefing school principals, and obtaining

permissions from eligible students. Demographic information, PA levels using the International Physical Activity Questionnaire (IPAQ) short form, academic performance, and motor skills were documented.

The International Physical Activity Questionnaire (IPAQ) short form was utilized to assess physical activity (PA) levels through a set of seven questions pertaining to walking, moderate, and high-intensity activities over the past seven days. Moderate physical effort refers to activities causing modest physical strain, making an individual breathe harder than usual. Vigorous physical activities involve strenuous effort, causing significant breathlessness. Activities not falling into these categories are considered low-level PA. PA levels were quantified using IPAQ scoring guidelines, calculating the metabolic equivalent for task (MET). PA levels were categorized as mild (less than 600 MET-minutes/week), moderate (600 to 3000 MET-minutes/week), and high (more than 3000 MET-minutes/week). IPAQ recommendations excluded subjects with PA exceeding 3 hours per day and those with less than 10 minutes of PA from scoring.<sup>28</sup>

Academic performance was documented based on grades and percentages obtained from recent exams, adhering to the rules of the Peshawar Board of Education. The grading structure ranged from A to E, with Level A-1 representing 80% and above, Level A from 70% to 79.9%, Level B from 60% to 69.9%, Level C from 50% to 59.9%, Level D from 40% to 49.9%, and Level E for scores below 39.9%, considered the minimum passing marks.

Motor skills were assessed using a recognized method, including the vertical jump test, hand grip strength test, sit-and-reach test, and timed push-ups.<sup>29</sup>

In the evaluation of vertical jump performance, participants assumed a standing position, reaching as high as possible to touch the wall with their hand. Marks were made at the standing reach and the highest point reached during a maximal jump, recorded three times. The best outcomes from both points were analyzed, with scores categorized as poor (14 inches), below average (above 14 to 15 inches), average (above 15 to 17 inches), good (above 17 to 19 inches), and excellent (above 19 inches).<sup>29</sup>

For the hand grip strength test, participants used a digital dynamometer, pressing it with full strength in each hand under observation. This process was repeated twice, and the best scores for both hands were noted in kilograms. Average scores for both hands were measured. Girls with a score of  $\leq 47$  kg were considered poor, above 47 and up to 52 fair, above 52 and up to 59 good, above 59 and up to 67 very good, and above or equal to 67 excellent. For boys,

scores of  $\leq 78$  kg were considered poor, above 78 and up to 89 fair, above 89 and up to 97 good, above 97 and up to 107 very good, and above or equal to 107 excellent.<sup>29</sup>

In the sit-and-reach flexibility test, a testing box was placed in front of participants. They were guided to push the ruler forward on the testing box while keeping their feet horizontal on the inner surface of the plate, sustaining the position for 2 seconds. The procedure was repeated three times, and the best outcomes were recorded. For boys, scores of 11 to 13 inches were considered poor, 14 to 15 inches below average, 16 to 18 inches average, 19 to 20 inches good, 20 to 22 inches very good, and above 22 inches excellent. For girls, scores of 14 to 16 inches were considered poor, 17 to 18 inches below average, 19 to 20 inches average, 21 to 22 inches good, 20 to 24 inches very good, and above 24 inches excellent.<sup>29</sup>

During the timed push-ups test (60s), participants were instructed to lower their bodies to the floor in a front-oriented rest posture, then raise and lower their bodies until the upper arms were equivalent to the ground. They were instructed to keep the spine straight, with locked elbows. For girls, modified pushups began in a kneeling posture on an exercise mat, keeping hands below the shoulders and knees behind the pelvis to maintain a straight spine. Scores were categorized for boys as very poor ( $<20$  per minute), poor (20-34 per minute), average (35-44 per minute), good (45-54 per minute), and excellent ( $>54$  per minute). For girls, scores were categorized as very poor ( $<6$  per minute), poor (6-16 per minute), average (17-33 per minute), good (34-48 per minute), and excellent ( $>48$  per minute) for modified pushups.<sup>30</sup>

The collected data underwent coding and analysis using SPSS version 22. Initially, a descriptive analysis was conducted, where frequencies and percentages were calculated for categorical data, and the mean and standard deviation (SD) were calculated for continuous variables such as age and BMI. The Chi-Square test was employed for categorical variables, with a significance level set at  $P < 0.05$  to determine associations between two categorical variables.

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## Results

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A total of 349 students were included in our research study. Out of the total, 228 (65.3%) were males, and 121 (34.7%) were females. One hundred ten (31.5%) students were aged 16, while 56 (16%) students were aged 18. Within the total population ( $n=349$ ), 164 (47%) were studying in 9th

grade, and 185 (53%) were studying in 10th grade. The majority of students, 302 (86.5%), belonged to private schools, while 47 (13.5%) were affiliated with government schools (Table 1).

Similarly, the majority of schools, 272 (79.9%), had a playground, while 77 (22.1%) had no playground. The physical education class was not included in the timetable for 172 (49.3%) students. Most students, 243 (69.6%), engaged in 1-4 hours of self-study within 24 hours, while those involved in 10-14 hours of study were 33 (9.5%). Sleep data revealed that the majority of students, 270 (77.4%), slept for 5-8 hours (Table 1). Data regarding psychological well-being showed that 151 (43.2%) students reported having very good psychological well-being, while only 4 (1.1%) reported very bad psychological well-being. One hundred forty-five (41.5%) students classified themselves as alright in terms of fitness level. The majority, 72.2%, were normal, and only 8 (2.3%) were classified as obese (Table 1).

Table 2 reveals that the majority of students, 323 (92.6%), had both father and mother alive, while only 5 (1.4%) students had both parents deceased. Similarly, most students, 321 (92.0%), were supported by both parents for their study and routine care expenses. The remaining 28 (8%) were supported by other family members such as grandfather, uncle, brother, sister, father, or mother. The income and level of education of the students' fathers and mothers are presented in Table 2. Father's income data reveals that the majority, 140 (40.1%), have an average income, while only the fathers of 6 (1.7%) students were classified as very poor. Regarding educational status, the majority of fathers, 211 (60.5%), have no formal education, and only 1 (0.3%) has earned a post-doctoral fellowship.

Similarly, mother's income status indicates that the majority, 275 (78.8%), have no income, and only 8 (2.3%) were classified as very rich. In terms of educational status, most mothers, 211 (60.5%), have no formal education, and only 1 (0.3%) has pursued a post-doctoral fellowship (Table 2).

We employed the Chi-square test to explore the association between Physical Activity (PA) and academic performance. Among the 102 students with low PA, 40 achieved grade A, representing 39.2%. For the 125 students with moderate PA, 46 secured grade A, constituting 36.8%. Additionally, among the 122 students with high PA, 45 (36.9%) attained grade A in their academics. There was a



statistically significant association between PA and academic performance in high school students with  $P < 0.05$  (Table 3).

Table 1: Demographics characteristics (n=349)		
Variable	Frequency	Percentage
<b>Age (Years)</b>		
15	86	24.6
16	110	31.5
17	97	27.8
18	58	16
<b>Gender</b>		
Male	228	65.3
Female	121	34.7
<b>Grade</b>		
9 <sup>th</sup>	164	47
10 <sup>th</sup>	185	53
<b>School Type</b>		
Government	47	13.5
Private	302	86.5
<b>School Play Ground</b>		
Yes	272	77.9
No	77	22.1
<b>Physical Education Class</b>		
No	172	49.3
1 day in a week	123	35.3
2 days a week	23	6.6
3 days a week	31	8.9
<b>Self-Study Hours</b>		
1-4 Hours	243	69.6
5-9 Hours	73	20.9
10-14 Hours	33	9.5
<b>Total Sleep time in 24 Hours</b>		
0-4 Hours	6	1.7
5-8 Hours	270	77.4
9-12	73	20.9
<b>Psychological Well Being (self-rating response)<sup>a</sup></b>		
Very good	151	43.3
Good	117	33.5
Alright	60	17.2
Bad	17	4.9
Very bad	4	1.1
<b>Physical fitness (self-rating response)<sup>b</sup></b>		
Very good	19	5.4
Good	133	38.1
Alright	145	41.5
Bad	48	13.8
Very bad	4	1.1
<b>BMI</b>		
Underweight	57	16.3
Normal	252	72.2
Overweight	32	9.2
Obese	8	2.3
<sup>a</sup> How would you rate your quality of life in relation to your psychological or emotional well-being?		
<sup>b</sup> How would you rate your level of physical fitness in comparison with others of your age?		

Table 2: Parents details of students		
Variable	Frequency	Percentage
<b>Is your mother &amp; father both alive?</b>		
Yes both are alive	323	92.6
Father is deceased	18	5.5
Mother is deceased	13	0.9
Both are deceased	5	1.4
<b>Child support</b>		
Both parents	321	92.0
Only father	2	0.6
Only Mother	2	0.6
Grandfather	4	1.1
Uncle	7	2.0
Brother	11	3.2
Sister	2	0.6
<b>Father Income</b>		
Very rich	24	6.9
Rich	96	27.5
Average	140	40.1
Poor	59	16.9
Very poor	6	1.7
No income	24	6.9
<b>Father education level</b>		
Post-doctoral	1	0.3
PhD	5	1.4
Masters	17	4.9
Bachelor degree	25	7.2
Secondary	22	6.3
High	47	13.5
Elementary	21	6.0
No education	211	60.5
<b>Mother Income</b>		
Very rich	8	2.3
Rich	11	3.2
Average	43	12.3
Poor	6	1.7
Very poor	6	1.7
No income	275	78.8
<b>Mother education level</b>		
PhD	2	0.6
Masters	73	20.9
Bachelor degree	76	21.8
High school	105	30.1
Secondary	23	6.6
Elementary	22	6.3
No education	48	13.8

Table 3: Association of PA and Motor skills with Academic Performance									
Variables			Academic performance						<sup>a</sup> P-value
			Grade A-1	Grade A	Grade B	Grade C	Grade D	Grade E	
Physical Activity MET	Low PA	Count	35	40	22	3	1	1	<0.001
		%	34.3%	39.2%	21.6%	2.9%	1.0%	1.0%	
	Moderate PA	Count	42	46	29	7	0	1	
		%	33.6%	36.8%	23.2%	5.6%	0.0%	0.8%	
	High PA	Count	17	45	37	20	3	0	
		%	13.9%	36.9%	30.3%	16.4%	2.5%	0.0%	
Motor skill (vertical jump)	Poor	Count	77	102	62	16	1	1	<0.001
		%	29.7%	39.4%	23.9%	6.2%	0.4%	0.4%	
	Below Average	Count	5	11	10	6	1	0	
		%	15.2%	33.3%	30.3%	18.2%	3.0%	0.0%	
	Average	Count	7	11	12	4	2	0	
		%	19.4%	30.6%	33.3%	11.1%	5.6%	0.0%	
	Good	Count	3	2	2	4	0	0	
		%	27.3%	18.2%	18.2%	36.4%	0.0%	0.0%	
Motor skill (handgrip strength)	Excellent	Count	2	5	2	0	0	1	0.041*
		%	20.0%	50.0%	20.0%	0.0%	0.0%	10.0%	
	Poor	Count	77	85	64	19	2	2	
		%	30.9%	34.1%	25.7%	7.6%	0.8%	0.8%	
	Fair	Count	15	38	18	11	1	0	
		%	18.1%	45.8%	21.7%	13.3%	1.2%	0.0%	
	Good	Count	2	4	6	0	1	0	
		%	15.4%	30.8%	46.2%	0.0%	7.7%	0.0%	
	Very Good	Count	0	4	0	0	0	0	
		%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	

Significance level: p<0.05\*

Table 4: Association of Motor skills with Academic Performance									
Variables			Academic performance						<sup>a</sup> P-value
			Grade A-1	Grade A	Grade B	Grade C	Grade D	Grade E	
Motor skill (Sitand Reach test)	Poor	Count	79	114	74	26	4	1	0.694
		%	26.5%	38.3%	24.8%	8.7%	1.3%	0.3%	
	Below Average	Count	12	15	8	4	0	1	
		%	30.0%	37.5%	20.0%	10.0%	0.0%	2.5%	
	Average	Count	3	1	4	0	0	0	
		%	37.5%	12.5%	50.0%	0.0%	0.0%	0.0%	
	Good	Count	0	1	2	0	0	0	
		%	0.0%	33.3%	66.7%	0.0%	0.0%	0.0%	
Motor skill (60s push-ups)	Very Poor	Count	72	102	65	24	4	2	0.935
		%	26.8%	37.9%	24.2%	8.9%	1.5%	0.7%	
	Poor	Count	18	26	21	4	0	0	
		%	26.1%	37.7%	30.4%	5.8%	0.0%	0.0%	
	Average	Count	3	3	1	1	0	0	
		%	37.5%	37.5%	12.5%	12.5%	0.0%	0.0%	
	Good	Count	1	0	1	1	0	0	
		%	33.3%	0.0%	33.3%	33.3%	0.0%	0.0%	

<sup>a</sup>Chi-square test, significance level set at P < 0.05

The results of the chi-square test indicate that among the 259 students with poor vertical jump performance, a substantial number, 102 (39.4%), secured grade A. In the cohort of 33 students with below-average vertical jump, 11 (33.3%) achieved grade A. Similarly, among the 36 students with an average vertical jump, 12 (33.3%) attained grade B in their academics. Students with good vertical jump, numbering 11, saw 4 (36%) achieving grade C. Notably, among the 10 students with excellent vertical jump, 5 (50%) achieved grade A in their academics. A statistically significant association was found between motor skill (vertical jump) and academic performance in high school students with  $P < 0.05$  (Table 3).

In relation to hand grip strength and its association with academic performance, it was observed that among the 249 students with poor hand grip strength, a noteworthy 85 (34.1%) achieved grade A. For the 83 students with fair handgrip strength, a substantial portion, 38 (45.8%), secured grade A. Similarly, among the 13 students with good handgrip strength, 6 (46.2%) attained grade A. Additionally, all 4 students with very good handgrip strength achieved grade A, representing a 100% success rate. A statistically significant association between average handgrip strength and academic performance was found with  $P < 0.05$  (Table 3).

In the association between motor skill sit-and-reach test and academic performance, 298 exhibited poor performance, with a noteworthy 114 (38.3%) attaining grade A. For the 40 students with below-average sit-and-reach test performance, 15 (37.5%) achieved grade A. Eight students demonstrated average performance in the sit-and-reach flexibility test, with only 1 (33.3%) securing grade A. Additionally, in the category of good performance in the sit-and-reach test, 3 students were identified, and 1 student (33.3%) achieved grade A in their academic examination. However, there is no statistically significant association between sit-and-reach test performance and academic performance in high school students with  $P > 0.05$  (Table 4).

The association between motor skill (60s) push-ups and academic performance reveals that a majority of 269 students exhibited poor performance in 60-second push-ups, with 102 (37.9%) securing grade A. Among the 69 students with poor push-up performance, 26 (37%) achieved grade A. Additionally, for the 8 students who performed average push-ups in 60 seconds, 3 (37.5%) attained grade A. Remarkably, only 3 students demonstrated good push-up performance.

However, there is no statistically significant association between motor skill (60s) push-ups and academic performance in high school students with  $P > 0.05$  (Table 4).

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## Discussion

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This study uncovered a significant association between physical activity (PA) and motor skills, specifically vertical jump and average hand grip strength, with academic performance in high school students. However, no significant associations were found between other motor skills, such as sit and reach flexibility and push-ups, with academic performance.

Academic achievement is influenced by various factors, encompassing both cognitive and non-cognitive behaviors. In our study, a noteworthy association was identified between PA levels and academic performance, with students exhibiting higher PA levels achieving better grades. These findings align with studies such as the one by So WY, conducted among Korean adolescent students, which demonstrated a positive correlation between vigorous PA and academic performance in males, and a positive correlation between moderate PA and academic performance in both genders.<sup>31</sup> Contrastingly, our results diverged from certain studies, including those by Jaakkola et al. in Finland,<sup>32</sup> Iri R et al. in Turkey<sup>33</sup> and Pandolfo K et al. in Santa Maria city,<sup>26</sup> which reported no significant correlation between PA and academic performance. These discrepancies could be attributed to variations in study populations, methodologies, and cultural contexts.

Examining specific motor skills, our study revealed no significant association between sit and reach flexibility, push-ups, and academic performance. These results are consistent with the findings of Kalantari's study, which found no significant relationship between various fitness tests, including sit and reach, and academic achievement.<sup>25</sup> On the other hand, our results contradicted with Van Dusen et al.'s study, which reported a strong and significant relationship between fitness and academic performance.<sup>34</sup> However, our study demonstrated a significant association between average handgrip strength and academic performance. Another study found a significant correlation between physical fitness and academic achievement. Particularly, students with privileged levels of physical fitness tend to have superior academic performance.<sup>35</sup>

Analyzing vertical jump performance, our study showed a significant association with academic performance, consistent with Gil-Espinoso FJ's findings associating

cardiorespiratory fitness, muscular strength, and flexibility with academic performance.<sup>36</sup>

This study underscores the multifaceted relationship between PA, motor skills, and academic performance in high school students. The variations in findings compared to existing literature highlight the complexity of these relationships, emphasizing the need for continued research with diverse populations and methodologies.

**Limitations:** While our study contributes valuable insights into the association between physical activity (PA), motor skills, and academic performance, it is essential to acknowledge its limitations. One prominent limitation lies in the study's geographic scope, as it was exclusively conducted in the Hayatabad township of District Peshawar. Consequently, the generalizability of our findings to broader populations may be restricted. The unique characteristics and socio-cultural aspects of Hayatabad might differ from other regions, limiting the external validity of our conclusions. Moreover, the cross-sectional design employed in this study captures a snapshot of the relationships between PA, motor skills, and academic performance at a single point in time. This design precludes the establishment of causality or the examination of how these variables evolve over an extended period. Longitudinal studies would be necessary to explore the dynamic nature of these relationships and provide a more comprehensive understanding. The study suggests several recommendations for promoting the holistic development of school students. It advises government bodies to reconsider approval for schools lacking playgrounds and underscores the importance of integrating physical education into school timetables. Encouraging students to actively participate in physical activity is emphasized, with a call for media to advocate the significance of high physical activity levels. The study also stresses the need for tailored support for female students in both academic and physical pursuits.

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## Conclusion

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In conclusion, this study demonstrates an association between physical activity (PA) and academic performance, along with a significant association between vertical jump (motor skills) and academic achievements in high school students. Moreover, the hand grip strength of both hands (motor skills) is also associated with academic performance in high school students. Conversely, no significant associations exist between sit-and-reach flexibility, 60s push-

ups, (motor skills) and academic performance in high school students.

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