Journal of Rare Cardiovascular Diseases
ISSN: 2299-3711 (Print) | e-ISSN: 2300-5505 (Online)
www.jrcd.eu
RESEARCH ARTICLE

Physical Fitness Index and Cognitive Ability in Rural Indian Adolescents: A Study of Higher Secondary School Students

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Article History
Received: 11.08.2025
Revised: 30.09.2025
Accepted: 14.10.2025
Published: 05.11.2025

Abstract: ***Background***: Physical fitness, cognitive ability, and body mass index (BMI) are interconnected factors shape adolescents' development and academic outcomes. Their relationship is particularly relevant in rural areas where resources and awareness may be limited. ***Objective:*** To examine correlation between physical fitness and cognitive ability among higher secondary school students in rural Central India. ***Methods:*** An observational study was conducted among 50 students aged 14–19 years in a rural higher secondary school. Physical fitness was assessed using the Harvard Step Test, cognitive ability with structured questionnaire, and BMI by the Quetelet Index. Data were analysed with descriptive statistics, ANOVA, and Pearson's correlation. ***Results:*** A strong positive correlation was found between physical fitness and cognitive ability ($r = 0.724$, $p = 0.000$). Students with normal BMI achieved the highest mean Physical Fitness Index (72.44) and cognitive scores (62.48). Significant differences in PFI were noted across BMI ($p = 0.045$), but not with cognitive scores. ($p = 0.166$). Both PFI and cognition peaked at age 17 before declining slightly. Conclusion: Adolescents with higher fitness and normal BMI perform better cognitively. Incorporating physical activity and health education into school programs could enhance both physical and mental development in rural youth.

Keywords: Academic performance, Adolescents, Body Mass Index (BMI), physical fitness, Rural School Students.

INTRODUCTION

Fitness is a general term used to describe the ability to perform physical work.[1] Physical fitness is not only the absence of a disease, disability, or deformity not merely the capacity to perform sedentary tasks efficiently, but also includes a sense of physical well-being and ability to handle sudden and strenuous physical efforts.[1] Physical activity has always been synonyms with wellbeing and health. Children who follow a healthy and active lifestyle, build healthy musculoskeletal system, reduce the risk of developing chronic disease, improve their mental process and enhance their self-confidence.[2] While defining the term fitness, components such as health-related fitness (including cardiorespiratory endurance) skill related fitness are measured.[1] In addition to its well-known health benefits, it is broadly recognised that physical activity is positively associated with cognitive development, brain health, and consequently academic achievement among children and adolescents. [2]

Physical activity and physical fitness levels can support cognitive function and attention capacity in both children and adults. Children are increasingly drawn to new forms of technology, and excessive technology use is associated with an increased risk of obesity, type 2 diabetes, and all-causes mortality.[3] The cognitive function is a fundamental and essential aspect when performing tasks or engaging in physical exercises for extended periods. It has a positive and significant relationship with physical fitness.[3] A strong association between physical fitness and cognitive function has been reported, showing that better physical fitness is linked to improved learning and development of attention skills in young children.[4]

Dietary and lifestyle factors play an important role in development of diabetes, cardiovascular disease, and obesity.[5] During student life, it is often observed that insufficient attention physical fitness leads to reduced levels of physical fitness, particularly affecting cardiovascular endurance.[1] Therefore the Harvard Step Test is commonly used to access cardiopulmonary efficiency of an individual.[1] The relationship between physical fitness and cognitive function in students play a crucial role in their academic performance.[2]

The aim of this study is to recognize the relationship between cognitive ability and physical fitness in higher secondary students.

MATERIAL AND METHODS

This Observational study was conducted over the period of two months from October to November 2024, at higher secondary Gurukul Academy school of Rural area, involving The Convenient sampling was used. All male and female students, who were able to read and understand English and given consent of parents were included in study. Whereas students with any disease like Cardiovascular diseases, Respiratory diseases, any lower limb pathology, Chronic illness, Disoriented

individuals and Musculoskeletal conditions were excluded from study.

Materials used consent form, height chart, weighing machine, calculator, question paper, steps, diet chart.

1. **Body mass index:** BMI was calculated by the Quetelet Index, which is a statistical measure of the weight of a person scaled according to height. It was developed in 1832, by the Belgian Polymath Adolphe Quetelet.[1]

BMI was calculated based on the formula:

BMI= weight (kg) / [height (m)]2

The participants were divided into four groups based on BMI:

Group1 (underweight)	BMI <18.5
Group2 (normal or healthy weight)	BMI > or equals to 18.5-24.99
Group3 (overweight)	BMI < or equals to 25-29.99
Group4 (obese)	BMI > or equals to 30

2. **Harvard step test:** Participants were asked to wear loose, comfortable clothing. They were instructed to sit quietly for 5 min before beginning the test. Following this rest period, they were asked to perform step-ups and step-downs, --- males for 2 minutes and female for 1 minute – on a sturdy iron step designed to remain stable during the test. Each participant performed the exercise for as long as they could, up to a maximum of 5 minutes. The duration for which the participant was able to perform the test was recorded, and the point at which the participant felt that they could no longer continue was noted as the time of exhaustion. After the completing the test, the participant's pulse rate was recorded during the following intervals: from 1 to 1.5 minutes (pulse rate 1), 2 to 2.5 minutes (pulse rate 2) and 3 to 3.5 minutes (pulse rate 3).
3. **Cognitive ability test:** The participants were seated in a classroom setting and provided with a set of 25 questions. They were instructed to complete the questionnaire within 45 minutes. After the allotted time, they were asked to stop, and the question papers were collected. The responses were then evaluated, and scoring was based on the number of correct answers. The scoring scale for the Cognitive Ability Assessment Questionnaire is as follows:

VERY OFTEN	QUITE OFTEN	OCCASSIONALLY	VERY RARELY	NEVER
4	3	2	1	0

After completing all the tests (BMI, Harvard Step Test, Physical Fitness Index [PFI], and Cognitive Ability Test), the scores were analyzed. The cognitive ability scores were examined in relation to the physical fitness scores.
The relationship between physical fitness index and cognitive ability was assessed among all participants.

DATA COLLECTION: Fifty participants were screened based on the inclusion and exclusion criteria, which included underweight, overweight, and physically fit school-going students. All procedures were thoroughly explained to the participants, and their information was kept confidential. Informed consent was obtained from the parents after explaining the procedure in detail. Descriptive data such as age, gender, height, and weight were recorded. Participants were clearly informed about each step of the procedure.

Intervention delivered post survey:

1. Exercise Protocol and Yoga Asanas were taught to the participants with low fitness to improve their physical fitness and concentration power or cognitive ability. Meditation, Suryanamaskar, Aerobic Exercises, Walking / Running, Padhastasana, Vrikshasana, Weight Training, Dancing (Can also help in developing Cognition)
2. Daily routine diet for developing and improving cognitive ability was also adviced to the students: Proper Hydration, Protien Rich Diet (black gram, peanuts, pulses), Green Leafy Vegetbles, Fruits.

STATISTICAL ANALYSIS: Data were entered in excel and Statistical analysis was evaluated in Epi info Software. Data were described as mean ± SD (standard deviation). Statistical significance was indicated by $P < 0$. The correlation between physical fitness and cognitive ability was noted using Pearson correlation. The nonzero values of "*r*" (rho) between −1 to 0 indicate a negative and 0 to 1 indicate a positive correlation.

RESULTS AND OBSERVATIONS:

In this study involving 50 participants, focusing on age, body mass index (BMI), physical fitness index (PFI) based on the Harvard step test, and cognitive ability scores. The mean age of the participants was 16.56 years, with a standard deviation of 1.36, indicating a relatively narrow age range around this mean. The mean BMI was recorded as 19.81, with a standard deviation of 3.93, reflecting moderate variability in body composition among the participants. The Harvard

test for physical fitness revealed a mean PFI of 64.10, with a standard deviation of 28.26, showing considerable variation in physical fitness levels within the group. Lastly, the cognitive ability scores, measured on a scale of 100, had a mean value of 57.48 with a standard deviation of 20.28, again indicating significant variability in cognitive performance among the cases studied.

Table 1: Age-wise Distribution of Body Mass Index, Physical Fitness Index (PFI), and Cognitive Ability Scores

Age (in years)	Body mass index		Harvard step test (PFI)		Cognitive ability score (100)	
	Mean	SD	Mean	SD	Mean	SD
14 years	18.1	2.1	51	21	39	6
15 years	19.2	5.8	59	31	56	27
16 years	21.5	6.3	52	20	56	14
17 years	19.9	3.4	73	31	68	19
18 years	19.8	3.0	67	29	52	21
19 years	19.7	.4	61	38	56	28

Body Mass Index (BMI): BMI increased from an average of 18.1 in 14-year-olds to a peak of 21.5 in 16-year-olds. It then decreased slightly and remained stable in the older age groups, with 17, 18, and 19 year olds showing average BMIs of 19.9, 19.8, and 19.7, respectively.

Physical Fitness (PFI): Physical fitness, as measured by the Harvard test, was lowest in 14-year-olds, with an average PFI of 51. It showed a gradual improvement across age groups, peaking at 73 in 17-year-olds then slightly declined in 18-year-olds (average PFI of 67) and further in 19-year-olds (average PFI of 61).

Cognitive Ability Scores: Cognitive ability scores started at 39 for 14-year-olds and improved consistently with age, peaking at 68 for 17-year-olds. However, the scores declined in 18-year-olds, with an average of 52, and remained stable in 19-year-olds at 56.

Table 2: Mean PFI comparison among BMI categories of the study participants

BMI categories	N	Mean PFI	SD	F	p
Underweight	18	57.33	24.29	3.322*	0.045*
Normal	27	72.44	28.22		
Overweight	5	43.40	29.84		
Total	50	64.10	28.26		

*One way ANOVA test.

The findings examine the relationship between BMI categories and physical fitness index (PFI) among 50 participants. Participants classified as underweight had a mean PFI of 57.33 ± 24.29, indicating moderate variability in their fitness levels. Those in the normal BMI category demonstrated the highest fitness levels, with a mean PFI of 72.44 ± 28.22. Overweight participants had the lowest fitness levels, with a mean PFI of 43.40 ± 29.84, showing considerable variability. The one way ANOVA analysis revealed a statistically significant difference in PFI among different the BMI categories (F = 3.322, p = 0.045).

Chart 1: Comparison between PFI & BMI categories:

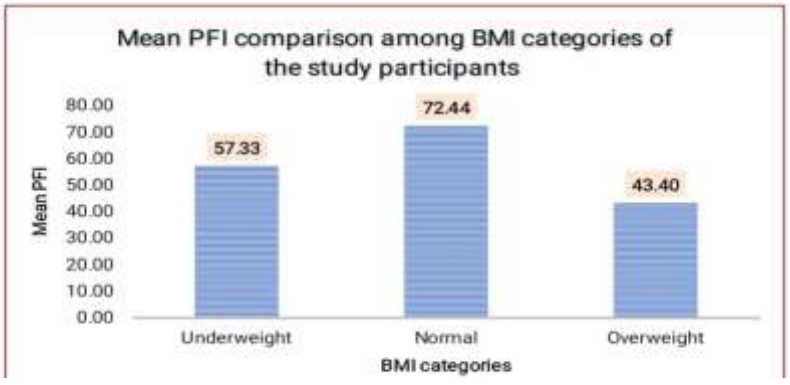

Table 3: Comparison among BMI categories & cognitive ability score of the participants.

BMI categories	N	Mean cognitive ability score	SD	F	p
Underweight	18	51.22	17.60	1.867	0.166
Normal	27	62.48	22.03		
Overweight	5	53.00	14.04		
Total	50	57.48	20.28		

Above table analyzes the relationship between BMI categories and cognitive ability scores among 50 participants by one way ANOVA. Underweight participants had a mean cognitive ability score of 51.22 ± 17.60, indicating moderate variability in their cognitive performance. Participants in the normal BMI category demonstrated the highest mean cognitive ability score of 62.48 ± 22.03, reflecting better cognitive performance compared to other groups. Overweight participants had a mean cognitive ability score of 53.00 ± 14.04, with relatively lower variability. The analysis showed no statistically significant difference in cognitive ability scores across the BMI categories (F = 1.867, p = 0.166).

Chart 2: Comparison between Cognitive ability & BMI categories:

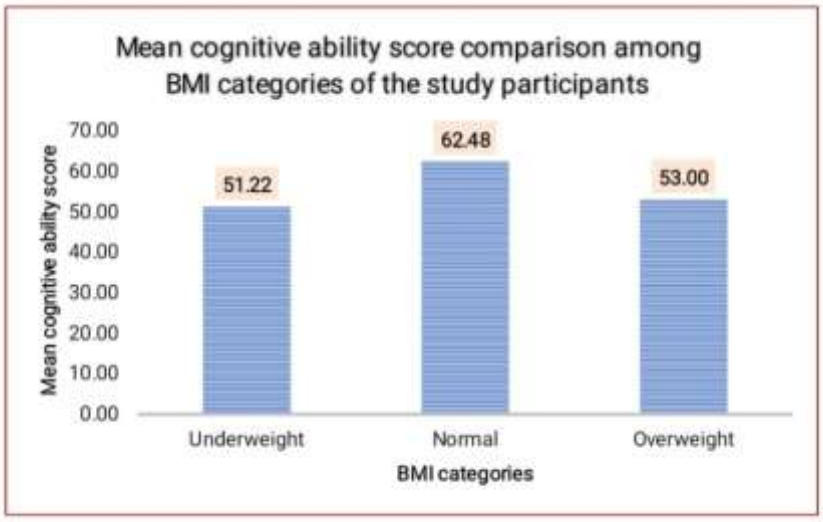

Table 4: The correlation between cognitive ability score and physical fitness index (PFI)

	N	r (correlation coefficient)	p
Harvard test (PFI)	50	0.724	0.000

Above table shows correlation between cognitive ability scores and the physical fitness index (PFI) from the Harvard test. The analysis revealed a strong positive correlation between cognitive ability scores and PFI, with a correlation coefficient (r) of 0.724. This indicates that higher physical fitness levels are associated with higher cognitive ability scores. The correlation was statistically significant, with a p-value of 0.000.

CONCLUSION

This study found a strong positive correlation between physical fitness and cognitive ability in adolescents, aligning that physical activity positively influences academic outcomes.[2] Among 50 higher secondary school students, aged 14 to 19years the mean Physical Fitness Index (PFI: 73) before declining slightly, mirroring trends in cognitive ability, which also peaked at 17 years (mean score: 68). BMI significantly influenced PFI, with participants in the normal BMI category showing the highest fitness levels (mean PFI: 72.44), while underweight and overweight groups performed lower, this suggests that a balanced body composition contributes positively to physical performance. Although cognitive scores were highest in the normal BMI category. This result reinforces the growing body of evidence that physical activity not only enhances physical health but also supports brain function. Excessive technology use was linked to reduced physical activity levels, consistent with earlier studies.[3] Regular exercise contributes to chronic disease prevention and cognitive health, highlighting the importance of physical activity in youth.[4] This study examined the relationship between the physical fitness index (PFI), cognitive abilities, and BMI among higher secondary school students, providing an opportunity to analyze potential differences between

rural and urban students. Location—whether rural or urban—can significantly impact health and cognitive outcomes due to variations in lifestyle, environmental exposure, socioeconomic factors, and access to resources. Overall, this study supports the integration of structured fitness programs into school curricula to enhance both physical and mental well-being. This was also done to raise the awareness about the importance of physical fitness among school students as a means to improve their cognitive and mental abilities.

CONCLUSION

The study establishes a significant relationship between physical fitness, cognitive ability, and BMI in higher secondary school students aged 14–19 years. Both physical fitness and cognitive ability scores improved with age, peaking at 17 years, and followed by a decline in older students. Students with a normal BMI demonstrated the highest physical fitness and cognitive ability scores. A statistically significant difference in physical fitness was observed across BMI categories ($p = 0.045$), though cognitive ability differences were not statistically significant ($p = 0.166$). Notably, a strong positive correlation ($r = 0.724$, $p = 0.000$) was found between physical fitness and cognitive ability, emphasizing that higher physical fitness is closely associated with better cognitive performance. These findings underscore the need for promoting physical activity and healthy lifestyles to support optimal cognitive and physical development in adolescents. The result shown by this study is that physical fitness, BMI and cognitive ability are interrelated, and students with higher physical fitness and a healthy BMI tend to exhibit better cognitive abilities.

Source Of Funding: None
Conflict Of Interest: None

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