e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2024; 16(4); 63-68

Original Research Article

Estimation of Physical Fitness Index in Relation to Body Mass Index Using the Modified Harvard Step Test

Lata S Gupta[1], Sheetal Yuvaraj Markam[2], Anamika Samant[3], Jyothi Vybhavi V S[4]

[1]Professor & Head, Dept of Physiology GMERS Medical College SOLA, Ahmedabad, Ahmedabad, Gujarat

[2]Assistant Professor, Department of Physiology, Travancore Medical College, Kollam, Kerala

[3] Consultant Physician, DNB Medicine, Chaitanya Hospital and Obesity Centre, Virar, Maharashtra

[4]Associate Professor, Department of Physiology, Raja Rajeswari Medical College & Hospital Bangalore, Karnataka

Received: 6-04-2024 / Revised: 15-04-2024 / Accepted: 29-04-2024

Corresponding author: Dr Jyothi Vybhavi VS

Conflict of interest: Nil

Abstract

Background: Physical fitness encompasses more than just being free from debilitating diseases or deformities and the ability to efficiently carry out desk-bound tasks; it also involves a feeling of physical well-being and the ability to handle emergencies that require unusual physical exertion. The Modified Harvard Step Test (HST) is a relatively precise and dependable method for measuring the Physical Fitness Index (PFI). Factors such as body mass index impact cardiorespiratory endurance and lung function. The current study evaluates how body mass index influences cardiac and pulmonary fitness.

Methods: This prospective study was conducted in the Department of Physiology on young and healthy adult male and female medical students. Assessment of Physical Fitness Index (PFI): The PFI level at which the subjects of the research were measured was provided through the use of a modified Harvard Step Test. Anthropometric measurements were noted for each participant and blood pressure was measured as per the standard protocol. PFI rating was done according to the modified Harvard Step Test for males and females.

Results: The majority of the male participants had lower fitness levels. Fitness among females proved to be higher than in males as a whole. It may be because of the higher prevalence of physical activity in females compared to males of this group. This study found a positive correlation between physical activity and physical fitness. Regularly engaging in physical activity proved to be one of the keys to maintaining a proper fitness level. On the other hand, overweight and obesity were associated with a decline in physical fitness assessments. In the study, a correlation was found between exercise and heart rate variability during exercise. Individuals with higher fitness levels exhibited lower heart rate variability.

Conclusion: The findings of the study confirm the traditional connection between exercise and fitness. Regular physical activity is a factor that may influence the level of fitness. Moreover, there was a correlation between fitness levels and heart rate variability during exercise, and the more fit individuals demonstrated lower variability. These results highlight the importance of exercise practice among medical students to increase their physical ability.

Keywords: Exercise, Modified Harward Test, Heart Rate Variability, Physical Fitness Index.

Introduction

The ability to withstand various types of stress necessitates a foundation in three key domains: muscular, cardiovascular, and functional fitness. Practical fitness is determined by having an intact and efficient musculoskeletal system to perform the associated activity [1]. In physiological fitness, you demonstrate your ability to perform skilfully and fully recover from strain. Psychological fitness for the job will mean being emotionally stable and motivated, with high drive, intelligence, and also being adaptable [2]. An individual who is physically fit shares a more stable physiological condition during moderate work and he or she can cope with the more intense work and return to a new physiological state during moderate work [3]. The same can be said about the two most frequently misused terms- "fitness" and "training" that have no clear definition. Sir Roger Bannister held a different opinion, in his understanding physical fitness is " a state of mental and physical harmony which enables someone to perform their job diligently and happily at an optimal level ". Asmussen then elaborated on the concept of fitness being both absolute (independent capacity) and relative (fit for a particular task). Several physiological parameters, for example: cardiac output, pulmonary ventilation, oxygen consumption, carbon dioxide output, and heart rate, are linked so strongly to each other during and after exercise. By determining these variables, we may determine the others with an approving degree of confidence. The fact that it is simple and handy to measure post-exercise heart rate makes it a common use [4]. The main purpose of functional physical fitness tests is to evaluate the work of some body systems, especially the cardiovascular one. As workouts such as treadmill running, stationary cycling, or step tests are often used because they involve large muscles and do not involve high skill levels. Performance is usually assessed via time as a parameter or total volume of output produced. Indirect agreement with the cardiovascular system is shown by the intensity of the heart rate increase after exercise and its return to the resting baseline. The application of an original Harvard Step Test in the Indian population is less effective because the standard step height of 20 inches does not always apply to the generally shorter stature of Indian men [5, 6]. Eventually, what these researchers came up with was the changes made to the step height and frequency of the steps. Several researchers have experimentally redesigned the original Harvard Step Test in different ways by either lowering step height, decreasing the rate of steps per minute, or shortening the exercise time frame from the long-lasting 5 minutes. As well, this research intends to adjust the Harvard Step test in such a way that reduces both the height and frequency of the steps while holding the duration constant specifically for college students. As this modification includes a grading system with which we divide the Physical Fitness Index (PFI) into different categories. The present study aimed to assess the physical fitness index of young adults aged 20 – 25 years using a modified Harvard step test.

Material and Methods

This study was conducted in the Department of Physiology in Medical College .Written consent was obtained from all the participants of the study after explaining the nature of the study. Those willing to participate willingly were included in the study.

Inclusion Criteria

1. Healthy young Males and females
2. Aged 20 – 25 years
3. Willing to participate in the study voluntarily

Exclusion Criteria

1. History of musculoskeletal abnormalities
2. History of hypertension, diabetes mellitus, and bronchial asthma
3. History of surgery in the recent past
4. History of alcohol and smoking
5. Not willing to participate in the study

Assessment of Physical Fitness Index (PFI): The PFI level at which the subjects of the research were measured was provided through the use of a modified Harvard Step Test. This standardized exercise test necessitates the following equipment: Modified Harvard Step: This platform is exclusively designed for the Harvard step exercise working protocol. A Stopwatch: An accurate stopwatch that can be used to count how many seconds it takes them to run the whole distance. Sphygmomanometer: A standardized sphygmomanometer was used to record the blood pressure. Stethoscope: Applied with a sphygmomanometer to measure blood pressure by auscultatory method. A metronome adjustable (from 40BPM to 200BPM) was used to adjust the frequency of steps.

Table 1: PFI rating according to modified Harvard Step Test

PFI rating	Male	Female
Excellent	>115	>91
Good	103-115	84-91
Fair	91-102	77-83
Poor	<91	<77

PFI Scoring System: Table 1 depicts the PFI rating scheme based on the modified Harvard Step Test results. This table differentiates physical fitness scores for male and female subjects respectively. This shows the differences in assessments to be done based on the gender of the participant. The exercise data from the participants was obtained during the early hours in the morning from 8 AM – 10 AM to avoid the effect of consumption of food and diurnal variations. The subjects reported to the lab 30 minutes before the protocol of exercise began. Explanation of the exercise protocol was given to all participants and a demonstration of the exercise protocol to be followed was also given. Subjects avoided eating or drinking for at least one hour before exercise. The anthropometric measurements were recorded for each participant in a pre-structured proforma. The exercise protocol was applied, and the readings of each participant were recorded accordingly.

Statistical analysis: All the available data was refined and segregated followed by uploading to MS Excel spreadsheet. The continuous variables were recorded as frequency, mean, standard deviation, and percentage. Categorical variables were calculated using the chi-square test,

student's 't' test, and Pearson coefficient correlation 'r' to determine differences between the two groups. The values of p (<0.05) were considered significant.

Results

A total of 185 participants were included in the study out of which males were 110/185 (59.5%) and females were 75/185 (40.56%) of participants (Table 2). The mean of males was found to be slightly more than the mean age of the females. Similarly, the BMI for males was (20.67 kg/m^2 ± 1.93 kg/m^2) and females (21.48 kg/m^2 ± 2.34 kg/m^2) had a mean BMI of the cohort was within the normal weight range as per the World Health Organization (WHO) classification of BMI (18.5 kg/m^2 to 24.9 kg/m^2).

Table 2: Shows the profile of participants included in the study.

Gender	Frequency	Mean age in years	Mean BMI (Kg/m^2)
Male	110	21.50 ± 1.67	20.67 ± 1.93
Female	75	20.94 ± 2.19	21.48 ± 2.34
Total	185	21.08 ± 1.92	20.97 ± 1.86

The values of PFI scores obtained from the modified Harvard step test were tabulated and analyzed in Table 3. A critical analysis of the table shows A significantly higher percentage of females achieved excellent PFI scores compared to their male counterparts. The distribution of Good PFI was similar in both groups with p values not significant. The fair results were slightly more prevalent in males as compared to females although the p values were not found to be significant. The poor scores were significantly higher in males as compared to females indicated by a significant p value. Therefore, it appears the physical fitness of females is better than males indicated by a higher percentage of participants in the excellent category.

Table 3: Showing the Physical fitness index as per the Modified Harvard step test done in the participants of the study.

Grade of PFI	Male	Female	Total(%)	P value
Excellent	7 (6.4%)	35 (46.7%)	42 (22.7%)	0.0012*
Good	19 (17.3%)	14 (18.7%)	33 (17.8%)	0.897
Fair	35 (31.8%)	20 (26.7%)	55 (29.7%)	0.153
Poor	49 (44.5%)	6 (8.0%)	55 (29.7%)	0.0001*

*Significant

The relationship between the body mass index and physical fitness index is tabulated in Table 4. The analysis of Table 4 shows that there is a tendency of increasing BMI with decreasing PFI scores and the relationship between the two was not gender specific. This suggests that there is a negative correlation between BMI and PFI when assessed by the modified Harvard step test in this cohort.

Table 4: Relation of BMI with Physical fitness index in the subjects of the study.

Grade of PFI	BMI (Kg/m^2)	
	Male	Female
Excellent	20.01 ± 1.91	20.11 ± 2.06
Good	20.12 ± 2.07	21.34 ± 2.27
Fair	21.04 ± 2.94	22.01 ± 1.91
Poor	21.53 ± 3.13	22.47 ± 2.87

The correlation between pre-exercise systolic blood pressure and post-exercise systolic blood pressure was observed in this study table 5 shows this relation. The data reviewed in the table shows that even after exercise, the mean SBP is slightly higher than it was before exercise. This seems to be the case for all studied PFI subcategories. It may be presumed that the observed outcome of the increase in SBP after the exercise is not statistically significant, as the p-values of all the categories are (>0.05). Subjects of all PFI groups were found during exercise to have insignificant rises in SBP (Systolic Blood Pressure).

Table 5: Showing the Systolic blood pressure and Physical fitness index as per the Modified Harvard step test done in the participants of the study.

Grade of PFI	SBP (mmHg)		T Value	P value
	Before Exercise	After Exercise		
Excellent	115.6 ± 6.48	117.6 ± 6.26	0.72	0.214
Good	110.2 ± 7.32	113.3 ± 7.24	1.33	0.321
Fair	116.7 ± 4.67	118.7 ± 5.97	0.81	0.171
Poor	119.4 ± 5.91	121.6 ± 4.92	0.64	0.137

Table 6 shows diastolic blood pressure levels (DBP). It evaluates the pre-exercise and the post-exercise DBP in the different PFI-assessed categories in the study participants. Mean DBP (mmHg) and standard deviation (SD) for both pre-exercise and post-exercise measurements among the four PFI grades (Excellent, Good, Fair, Poor). After exercise, the mean DBP drops to less than before exercising. Although the size is small, the strength is significant. Among all groups of PFI, there was a drop in DBP right after exercise, but it was very small and even not that clear.

Table 6: Showing the Diastolic blood pressure and Physical fitness index as per the Modified Harvard step test done in the participants of the study.

Grade of PFI	DBP (mmHg)		T Value	P value
	Before Exercise	After Exercise		
Excellent	76.66 ± 3.54	72.49 ± 3.45	0.31	0.717
Good	77.21 ± 4.16	70.37 ± 2.94	0.84	0.618
Fair	78.91 ± 3.91	74.02 ± 3.17	0.72	0.334
Poor	79.34 ± 3.37	71.39 ± 3.08	0.91	0.141

The correlation between different parameters and PFI has been depicted in Table 7. A negative correlation can be seen (-0.61) between BMI and PFI scores, meaning that the fitness level is getting lower with a high body mass index. In this investigation, a significant positive (0.78) correlation is observed between females and PFI scores, indicating that females characteristically have higher PFI scores than their male counterparts. There seems to be a fairly negative relationship between BMI (-0.69) and pulse. In the past, only fit people used to show a lower resting heart rate, but now it is more favorable to hold a higher average pulse rate during the measurement period as they manage the recovery more quickly than in the previous period. There is a positive relationship between physical fitness (0.60), which means those with better physical fitness often have higher systolic blood pressure. From the analysis, we can conclude that physiological changes that occur in the cardiovascular system during the process of regular physical activity could be the reason for this. A strong positive correlation is found (0.70) with DBP and PFI. Hence, it seems to be in line with the trend between PFI and SBP, and DBP will change together. It is true to say that there is a weak positive correlation (0.30). A little correlation (0.41) that is positive exists, implying that individuals whose level of physical activity is high, may also have a slightly higher level of systolic blood pressure, this may be due to the adaptations of the heart induced by the physical exercises.

Table 7: correlation between physical fitness and various factors including BMI, gender, physical activity, and cardiovascular variables

	PFI Score	BMI	Physical Activity Score	Gender	Pulse Rate	SBP	DBP
PFI Score	-	-0.61*	0.51*	0.78*	-0.69*	0.60*	0.70*
BMI	-0.61*	-	-0.21	0.30*	-0.12	0.32	-0.34
Physical Activity Score	0.51*	-0.21	-	0.22	-0.19	0.41*	0.13
Gender	0.78*	0.30*	0.22	-	0.17	0.21	0.71
Pulse Rate	-0.69*	-0.12	-0.19	0.17	-	0.11	0.10
SBP (Systolic Blood Pressure)	0.60*	0.32	0.41*	0.21	0.11	-	0.23
DBP (Diastolic Blood Pressure)	0.70*	-0.34	0.13	0.71	0.10	0.23	-

*Significant

Discussion

The objective of this study was to assess the physical fitness level in young medical students considering the MHST (modified Harvard step test) as a fitness test measure. The MHST will grade fitness by using the scores generated from the recovery session after exercise. This particular method has proven its effectiveness numerous times it was utilized in previous studies focusing on Indian populations [7-9]. The survey encompassed 185 students of medicine who were aged 21.08 ± 1.92 years and had a mean BMI index of 20.97 (Kg/m^2). Thus, the results underpin the relevance of physical fitness awareness in the training of doctors, which emphasizes the significance of striving for improvements among medical professionals. The results showed that there was a striking phenomenon in fitness level indicating that they were different between males and females. The females had higher rates for "excellent" physical fitness (46.7%) with males coming in at the lower side (6.4%). On the other side, 44.5% male group was categorized as physically "poor" and this rate was 0.8% for the female group (table 3). The research revealed fitness scores and physical activity levels had a positive relationship. However, among these 52% of females were engaged in sporting activities including gym workouts, while 31-8% of males were also located.

In this study, most of the subjects were in a normal body mass index (BMI). The gender difference in BMI values was evident, as the females had a higher average BMI (21.48 kg/m^2) than males (20.67 kg/m^2). However, an inverse relationship between BMI and physical fitness was evident for both genders. This study agrees with findings from Ganeriwal et al. [10] who reported a negative correlation between fitness rating and body weight/pulse rate and a positive correlation between fitness rating and body height. This goes along with Jorge M et al. [11] who concluded a relation between higher BMI and lower cardiorespiratory fitness in females which is in accordance with our results. Individuals in the good PFI subgroup displayed the least variations in pulse rate variability both before and after exercise while the ones with low PFI exhibited the highest pulse rate variations in both pre- and post-training sessions. This is in concordance with the finding of Hammond et al. [12] of lowering resting and exercise heart rates in long-distance runners which could be attributed to the changes in the heart reacting to exercise. As also observed by Ted D et al. [13] we also observed a decrease in resting heart rate after the exercise program. However, systolic and diastolic blood pressure variability (before and after exercise), in most cases remained nearly the same in different fitness categories.

In this study, physical fitness variables had a significant correlation with BMI, physical activity, gender, and cardiovascular variables. Being physically fit was negatively correlated with BMI and it is significant. We found that physical fitness and BMI were negatively correlated with a statistically significant value. This supports the finding of Rodrigues et al. [14], where physical well-being was compromised among those with high heart rates (often linked to the higher BMI category). Subjects who regularly exercised scored higher on fitness scales and had a positive correlation between these indicators. Their output is in agreement with Smith et al. [15] which indicated that non-residential schoolchildren who lacked physical activity often recorded poor physical fitness scores compared to their active counterparts. The outcomes from this research signify an inverse association between physical fitness and the resting heart rate. This is in agreement with Elbel et al. [16] Keen et al. [17], and Cullumbine et al. [18], who all reported a similar conclusion. Alongside that, according to Albert W et al. [19] and Joshi et al. [20], studies show that training can reduce the resting heart rate, which is in line with our observations. Remarkably, both systolic and diastolic blood pressure have been found to have a positive connection with the physical condition. The present result complies with Bhave et al. [21], who also showed an increased blood pressure during exercise stress testing. Therefore, this study proves the previously established relationship between physical fitness and health factors such as BMI, physical activity, and cardiovascular measures. It not only shows the importance of the programs but also the tangible results of getting into shape.

Physical fitness was correlated with BMI, physical activity, gender, and cardiovascular variables. Physical fitness had a statistically significant negative correlation with BMI. We found a statistically significant negative correlation was found between physical fitness and BMI. This aligns with research by Anabel et al. [14], who observed lower physical fitness in individuals with a faster heart rate (often associated with higher BMI). Subjects with regular physical activity exhibited better physical fitness, supporting a positive correlation between the two. This finding is consistent with Dipayan et al. [15], who reported lower physical fitness scores in non-residential schoolchildren who lacked regular physical activity compared to their active counterparts. This study observed a negative correlation between physical fitness and resting heart rate. This aligns with previous research by Elbel et al. [16], Keen et al. [17], and Cullumbine [18], who reported similar findings. Additionally, studies by Albert W et al. [19] and Joshi et al. [20] suggest that training can lead to lower resting heart rate, supporting our observations. Interestingly, systolic and diastolic blood pressure showed a positive correlation with physical fitness. This finding is consistent with Bhave et al. [21], who reported increased blood pressure during exercise stress testing. Overall, this study confirms the established link between physical fitness and various factors, including BMI, physical activity, and cardiovascular variables. It also highlights the potential benefits of training programs in improving physical fitness.

Conclusion

The result of this study reveals that a lot of medical students specifically males have poor fitness levels. This could be a result of various reasons such as less involvement in sports activities and more focus on academics. Interestingly enough, the females in the study demonstrated greater fitness levels including elevated levels of involvement in physical activity as females showed more engagement. The findings of the study confirm the traditional connection between exercise and fitness. Regular physical activity is the factor that may influence the level of fitness shown. Moreover, there was a correlation between fitness levels and heart rate variability during exercise, and the more fit individuals demonstrated lower variability. These results highlight the importance of exercise practice among medical students to increase their physical ability. Institutions might consider ways to motivate the involvement of students in sports and games. Involving physical activities in the syllabus. Promoting the benefits of exercise at both physical and mental levels. This way, medical schools can create a learning environment promoting physical activities which might come in handy for students to put their health before everything else and thus produce caregivers who are more likely to be active in the future.

References

1. Kell RT, Bell G, Quinney A. Musculoskeletal fitness, health outcomes and quality of life. Sports Med. 2001;31(12):863-73.
2. Endo T, Sekiya H, Raima C. Psychological pressure on athletes during matches and practices. Asian Journal of Sport and Exercise Psychology, 2003; 3(3): 161–70.
3. Johnson RE. Applied physiology. Am Rev Physol 1946;81;585.
4. Luck JM and Hall VE. Annual Review of Physiology. Volume 39. White and company. Johannesburg 1969; p.105-09.
5. Sunil KR, Das, et al. Determination of physical fitness index(PFI) with modified Harvard step test(HST) in young men and women. Ind J Physiol and Allied Sci, 1993; 47(2): 73-76.
6. P. K. Banerjee, S Chatterjee. Harvard Step Test as a measure of physical fitness in adolescent boys. Ind J Med. Res. 1983; 79: 41 3-17.
7. Sunil KR Das, Susmita Mahapatra, Gautam Bhattacharya, Debatri Mukherjee. Determination of Physical Fitness Index (PFI) with modified Harvard step Test (HST) in young men and women. Indian J Physiol and Allied Science. 1993; 47(2):73-76.
8. Ganeriwal SK, Sen SC, Khandare SS. Test of physical fitness (Harvard Step Test) in Indian females. Indian J Med Res 1968; 56:845-49.
9. Banerjee PK and Chatterjee S. Harvard Step Test as a measure of physical fitness in adolescent boys. Indian J Med Res 1983; 79:4 13-17.
10. Ganeriwal SK, Sen SC, Khandare SS. Test of Physical Fitness (Harvard Step Test) in Indian females. Indian J Med Res 1968; 56:845-49.
11. Jorge Mota, Luana Flores, Luis Flores, Jose C Riberio, Maria P Santos. Relationship of a single measure of cardio-respiratory fitness and obesity in young school children. Am J Hum Biol 2006; 18:335-41.
12. Hammond. Association of decreased myocardial β-receptors and chronotropic response to isoproterenol and exercise in pig following chronic dynamic exercise. Circulation Research 1987; 60: 720-26.
13. Ted D Adams, Frank G Yanowitz, Garth A Fisher, Douglas J Rides, Kreed Lovell, Allen T Pryor. Non-invasive evaluation of exercise training in college-age men. Circulation 1981; 64(5):958-64
14. Anabel N Rodrigues, Anselmo Jose Perez, Luciana Carlett, Nazare S Bissoli. The association between cardio-respiratory fitness and cardiovascular risk in adolescents. J Paediatri (Rioja). 2007; 83(5):1-12.
15. Dipayan C, Soma C, Vasanta AK. Physical fitness and non-residential schools. Indian J Physiol and pharmacology 2002;46(3):328-32.
16. Elbel. Comparison of certain tests of physical fitness & certain bodily measurements. J Appl Physiol 1958; 12:37-38.
17. Keen EN, Sloan A W. Observation on the Harvard Step Test. J Appl Physiol 1958; 13: 241-46.
18. Cullumbine H. Relationship between resting pulse rate, blood pressure & physical fitness. J Appl Physiol 1949; 2:275-76.
19. Albert W. A Physiological analysis of the effect of two training programs. J Sports Med 1971; 11:252-56.
20. Joshi AR, Pansare MS. Effect of training on physical fitness & skilled performance. SNIPES 1980;3(4):56-62.
21. Bhave S, Pherwani AV, Desai AG, Dattani KK. Cardio-respiratory response to stress test in normal Indian Pediatrics 1989; 26:882-87.