Original Article

Fitness scores of Indians assessed by the Harvard step test

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Abstract

Background and Aim: The Harvard step test (HST) assesses the physical fitness of individuals. The standard 50.8 cm step of the HST is tailored to western anthropometrics and is rather high for the average Indian whose height is relatively less. Therefore, the height of the step is lower (41 cm) in the modified HST. Even so, it is unlikely that a single step-height will be appropriate for all Indians with different heights. Therefore, the objective of the present study was to verify the same in a group of Indian students with heights ranging from 1.45 to 1.83 m on 41 cm high step.

Methods: This study was conducted on 74 healthy subjects in the age group of 17–22 years. Protocol comprises stepping up and down a 41 cm high step at a rate of 30 times/min for the duration, not >5 min. The total duration of stepping exercise and the post-exercise pulse count for 30 s after 1 min recovery was noted and used for calculating the physical fitness index (PFI).

Results: The height of subjects positively and significantly correlated to the fitness score and also to the duration of exercise. The mean fitness scores of subjects with height ≥1.66 m were significantly higher than mean scores of subjects with height <1.66 m.

Conclusion: The shorter duration of effort and the lower score in short subjects may be due to muscle fatigue rather than cardio-respiratory impairment. Our findings suggest that the height of the step used in the HST should be adjusted according to the height of the subject. Considering our small sample size, further studies are required to delineate the effect of step height on PFI in HST.

Key words: Cardio-respiratory fitness, modified Harvard step test, physical fitness

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INTRODUCTION

The Harvard step test (HST) was devised by Johnson *et al*. to assess the physical fitness of individuals.[1] It comprises stepping up and down a step that is 20 inches (50.8 cm) high at a rate of 30 times/min.[2] The total duration of stepping exercise and the post-exercise pulse rate are noted and used for calculating the physical fitness index (PFI). The higher the fitness of an individual, less is the increase in heart rate and faster is the recovery. However, as the name suggests, the 20" step of the HST is tailored to western anthropometrics and is rather high for Indian whose height is relatively less. Hence, the Harvard step would pose a greater exercise challenge to the Indian with average height. Therefore, the height of the step is lower (16.5'' i.e. 41 cm) in the modified HST that is used in India.[3] Even so, it is unlikely that a single step-height will be appropriate for all Indians with different heights. The objective of the present study was to verify the same in a group of Indian students with heights ranging from 1.45 to 1.83 m on the standard 41 cm step.

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MATERIALS AND METHODS

This study was conducted on seventy four healthy, 1st year MBBS students in the age group of 17–22 years, after obtaining ethics committee of the institute. Students with a history of any cardiovascular disorder, diabetes mellitus, hypertension, bronchial asthma, alcoholism, smoking, major surgery or locomotor, and musculoskeletal abnormalities were excluded from the study.

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The detailed procedure was explained as well as demonstrated to the students. The following anthropometric measurements were made on the subjects prior to the commencement of the test: (1) The height in centimeters was measured with subjects standing without their shoes. (2) The weight in kilograms was recorded using a standardized weighing machine. The data were obtained during the routine undergraduate practical experiments in the clinical physiology laboratory.

Protocol of the Harvard step test

The subjects were asked to be lightly clothed. They were asked to sit quietly for 5 min. Thereafter, they were asked to perform the stepping exercise on a 41 cm high step without shoes. The step used was a heavy wooden step so that it remained steady during the test. The subject stepped up and down the steps 30 times/min. As the signal starts, the subject places one foot on the platform, steps up, places other foot on the platform, straightens both legs and the backbone and then steps down, bringing down the same foot that he placed up first. The signal "UP" is given at 2 s intervals. The subjects were directed to lead off with the same foot each time and not the alternate foot. The observer has to call the rhythm by adjusting the metronome. Subject performed this exercise as long as he/she could, but not in excess of 5 min. After the cessation of exercise, the subjects were made to sit quietly on a chair. After exactly 1 min, the pulse rate was recorded for 30 s. If the subject was dyspneic, felt exhausted or felt pain in chest or legs during the exercise, he was asked to discontinue the exercise immediately. The subject performed the exercise for 5 min unless he stopped earlier due to exhaustion. If the subject could not maintain the stepping rate of 30 times/min for 20 s, he was assumed to be exhausted, and the step-test was discontinued. The duration of the efforts to the nearest second was noted using stop watch. When the subject completed 5 min, he was asked to stop. PFI score was calculated using the formula.[4]

$$PFI = \frac{\text{Total duration of exercise in seconds}}{5.5 \times \text{post exercise 30 s pulse count}} \times 100$$

If the PFI score is below 50, it is interpreted as poor, between 50-80 as average and above 80 as good.

Statistical analysis of data

The data were pooled. Mean ± standard deviation was calculated for age, height, body mass index, and weight [Table 1] and also for duration of effort, postexercise 30-s pulse count (1–1.5 min) and score of PFI [Table 2] in Microsoft excel software version 2010 (Microsoft Office, United States). The association of height of subjects with PFI score and duration of effort was analyzed using Student's *t*-test. SPSS software version 21 (SPSS Software Inc., Chicago, IL, USA) was used, and data were analyzed for statistical significance using spearman correlation test. To find out significant association between two variables, coefficient of correlation (r) was calculated.

RESULTS

It was observed that the height positively correlated to the score and also to the duration of exercise [Figures 1 and 2]. These correlations were statistically significant [Table 3]. Further, the students were divided into two groups (A and B) on the basis of their heights. As the average height of the subjects was 1.66 ± 0.09 m, this height (1.66 m) was used as the cut-off value for dividing the subjects in 2 groups. In group-A, students with heights <1.66 m were included and in group B students with height ≥1.66 m were included. The mean scores for both groups were calculated. Both groups were compared using *t*-test and *P* value was calculated. There was statistically significant difference between group A and group B [Table 4]. When

Table 1: Age, height, weight and BMI of the subjects

Parameters	Mean±SD
Age (years)	18.31±1.01
Height (m)	1.66±0.09
Weight (kg)	59.86±10.07
BMI (kg/m^2)	21.65±2.97

The values are expressed in mean±SD. SD: Standard deviation, BMI: Body mass index

Table 2: Duration of effort, post-effort 30 s pulse count and score of PFI (*n*=74)

Parameters	Mean±SD
Duration of effort (s)	201.57±83.35
Post-effort 30 s pulse count	62.39±12.04
Score of PFI	59.54±20.99

The values are expressed in mean±SD. SD: Standard deviation, PFI: Physical fitness index

Table 3: Correlations of height of subject with duration of effort and PFI score (*n*=74)

Association between	*r*	*P*
Height of subject and duration of effort	0.689	>0.0001
Height of subject and score	0.540	>0.0001

PFI: Physical fitness index. Statistical analysis was done using spearman correlation. *P*>0.05 was considered significant

Table 4: Mean±SD of fitness score of group A and B

Group	*n*	Score	*P*
A (<1.66 m)	32	45.34±16.09	<0.01
B (≥1.66 m)	42	70.36±17.65	

SD: Standard deviation. Data are presented as Mean±SD. Statistical analysis of data was done using independent '*t*' test.

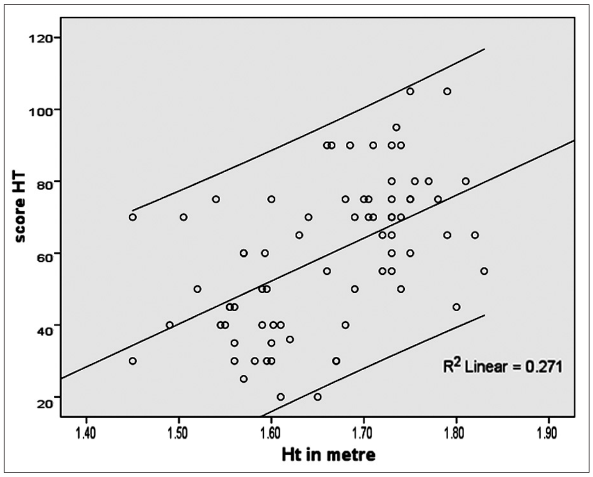

Figure 1: Scatter plot between height and physical fitness index score

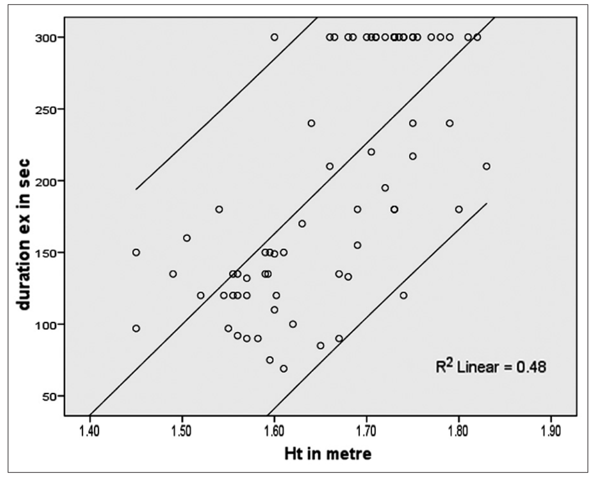

Figure 2: Scatter plot between height and duration of exercise

the scores of groups A and B were compared the scores of group B were significantly higher than a group A [Table 4]. In addition, in these two groups (A and B), the number of students scoring good, average, and poor scores were counted, and frequency distribution was noted. In group A, >60% subjects scored poorly while in group B, >60% subjects scored average [Table 5]. All the subjects who scored good belonged to group B that comprised of taller subjects.

Table 5: Number and percentage of subjects in each of group A and B with good, average, and poor score

Group	Number of subjects with good score (>80) (%)	Number of subjects with an average score (50-80) (%)	Number of subjects with the poor score (<50) (%)	Total number of subjects (%)
A (<1.66 m)	0 (0.0)	12 (37.50)	20 (62.5)	32 (100)
B (≥1.66 m)	9 (21.40)	29 (69.90)	4 (9.50)	42 (100)
Total (A+B)	9 (12.20)	41 (55.40)	24 (32.40)	74 (100)

DISCUSSION

The purpose of this study was to determine whether the height of the subject has any effect on the fitness index score using the modified HST (step height 41 cm). Our study suggests that the height of subjects does have a positive correlation with the score and also the duration of effort.

Maximum tension is generated at the optimal length of the muscle. The optimal length of lower-limb muscles depends on the knee angle at the start of exercise while placing the limb on the bench of a particular height. The knee angle is determined by the length of tibia and femur and, therefore, predominately by the leg length and subject's height. The shorter duration of effort and the lower score in short healthy subjects may be due to muscle fatigue rather than cardio-respiratory impairment. Considering that the step height is standard, taller people are at an advantage as it will take less energy to climb up onto the step while the lower height of short people hinder the comfortable lifting up and lowering of their legs during the stepping process. This leads to the onset of premature fatigue in their legs. Hence, although for Indian context, the step height has been reduced from the original 20 inch to 16.5 inch, this height of the step may not be applicable uniformly to the entire Indian population. HST for people with less height may prove to be a test of local endurance of the legs, rather than a test of cardio-respiratory fitness. The height of subjects may influence the validation of the HST and introduce error of measurement. In earlier studies also, leg length has been considered as a factor which might influence the PFI.[2,5-7]

The low correlation coefficient may be due to less sample size as it is a preliminary study conducted during routine practical sessions of undergraduate medical students. The outlier values in scatter plot may be due to errors in data collection or compilation defects.

Limitations of the study

Study was conducted during routine practical sessions of undergraduate medical students so strict experimental conditions could not be followed. Also, the difference obtained between group A and group B may also be due to gender, as group A predominately consists of females. Therefore, future studies with larger sample size should be conducted to further establish the application of these results.

CONCLUSION

The height of subjects was found to be positively and significantly correlated to the score and also to the duration of exercise. Hence, although for Indian context the step height has been reduced from the original 20 inch to 16.5 inch, this height of the step may not be applicable uniformly to the entire Indian population. HST for people with less height may prove to be a test of local endurance of the legs, rather than a test of cardio-respiratory fitness. The height of subjects may influence the validation of the HST and introduce error of measurement. Further studies are required to verify that the shorter duration of effort and the lower score in short healthy subjects is due to muscle fatigue or due to cardio-respiratory impairment.

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