

Original Research Article

Comparison between incremental shuttle run test and Harvard's step test on peak exercise performance in healthy males: a cross-sectional study

Supriya Gondane, Seemi A. Retharekar*, Swaroop V. Kudalkar

Department of Cardiovascular and Respiratory Physiotherapy, Sancheti College of Physiotherapy, Pune, Maharashtra, India

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*Correspondence:

Dr. Seemi Retharekar,

E-mail: seemiretharekar@gmail.com

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ABSTRACT

Background: Cardiovascular fitness is directly related to the physical health of the person. Aerobic capacity (VO₂max) is one of the major criteria to decide the cardiovascular fitness of an individual. To help quantify the fitness level by calculating their VO₂max, there are various indirect maximal tests available but out of these, which one would predict VO₂max better, is a major concern. Hence the purpose of this study was to compare the effects of two indirect maximal tests i.e. Incremental Shuttle Run Test (ISRT) and Harvard's Step Test (HST) on peak exercise performance in young healthy males.

Methods: A cross-sectional study with purposive sampling was performed on healthy untrained 100 males of age group 18-25 years. Day 1 subjects performed ISRT on 20 m track and after a 48 hours rest period, on day 3 same subject performed Harvard's step test. Pre and post-test parameters (Pulse rate, respiratory rate, systolic and diastolic blood pressure and RPE) were measured and predicted VO₂max was calculated.

Results: Post-test parameters i.e. PR, RR, SBP significantly increased (p=0.00*) by Harvard's step test. The diastolic blood pressure did not change significantly (p=0.3) for both the tests. Rating of perceived exertion by both the test was of the range 17-19 (very hard to maximal). Calculated predicted VO₂max was significantly more by ISRT than HST in males (p=0.00*).

Conclusions: Incremental shuttle run test is more efficient in predicting VO₂max than Harvard's step test in healthy adult's males.

Keywords: Harvard's step test, Incremental shuttle run test, Indirect maximal exercise test, Predicted VO₂max

INTRODUCTION

Maximal oxygen consumption (VO₂max) also known as maximal oxygen uptake, peak oxygen uptake or maximal aerobic capacity, is the maximum rate of oxygen consumption as measured during incremental exercise, most typically on a motorized treadmill.¹ VO₂max reflects the maximum capacity of a person to absorb, carry and consume Oxygen (O₂).² It is defined as the point at which VO₂ increases by less than 50 ml/min or

2.1 ml/kg/min in spite of increasing exercise intensity, i.e., when plotted on a graph, the VO₂ curve reaches the plateau.³ In healthy people, a VO₂ plateau occurs at near maximal exercise. Peak exercise capacity is defined as "The maximum ability of the cardiovascular system to deliver oxygen to exercising skeletal muscles and of the exercising muscle to extract oxygen from the blood."⁴

VO₂max is an important determinant of cardiorespiratory fitness and aerobic performance. VO₂max values vary

with age, gender, weight, daily physical activity level and type of exercise; direct measurements of VO₂max during maximal work provide the most accurate value for this parameter, and measurements are reproducible with a coefficient of variation of about 2-4%.^{5,6} Direct measurements of VO₂max are however, technically demanding and require access to expensive laboratory equipment and skilled personnel. As a consequence, various predictive tests have been devised to evaluate aerobic fitness, in which predicted VO₂max is calculated from physiological responses in combination with performance measures.

These include performance related measures, for example walking or running for a given time.⁷ Maximal exercise tests either measure or predict VO₂max and have been accepted as the basis for determining fitness.⁸ Quite a few maximal exercise tests are available; of these the incremental shuttle run test is the most valid and reliable widely used field test to estimate aerobic capacity.⁹ Incremental shuttle run test (ISRT) is a field test and has a standardized procedure. Due to its progressive increase in exercise intensity, may correlate with peak VO₂ better than any other field tests.¹⁰

The Harvard Step Test (HST) is one of the earliest reported step tests. It is the test for aerobic fitness, developed in the Harvard fatigue laboratory in USA to select army personnel during World War II.¹¹ The application of the HST in assessing the physical performance capacity of an individual has aroused interest because of the simplicity and versatility of the test particularly when testing large populations.

Application of the original HST in Indian population has been found to be unsatisfactory because of the step height of 20” which adversely affects Indian men who are relatively shorter. Hence, a modification of the test has been proposed with respect to the stepping mode/height/frequency.

A stepping height of 18” has been routinely taken for boys. These two indirect maximal level field tests have been used to improve the exercise performance and also aerobic capacity in athletes but there is scarcity of studies comparing this effect on peak exercise performance in normal healthy males.

METHODS

Ethical committee approval was acquired for the cross-sectional study with purposive sampling. Untrained healthy young adults of age group 18-25 years fulfilling PAR-Q and YOU questionnaire were included while those undergoing professional (gym) training for 3 months or more or undergone cardio thoracic surgeries or having musculoskeletal injuries in last 6 months or those who are having cardiovascular or pulmonary disease were excluded from the study. The duration of the study was 1 and half year.

Subjects were informed about the study procedure and written consent was taken from each subject. Participants were fully familiarized with the exercise testing procedures and instructed to arrive at the laboratory in a rested and fully hydrated state, at least 3 hours postprandial and to avoid strenuous exercises and smoking in the 48 hours preceding the test session.

Day 1, the subject performed the ISRT and the vital parameters and ratings of perceived exertion (RPE) (Borg’s 6-20 scale) were noted pre and post both the test.

Day 3, the same subject performed the HST at the same time of the day and the vital parameters and Ratings of perceived exertion (RPE) (Borg’s 6-20 scale) were noted pre and post both the test and the predicted VO₂max was calculated.

All the data was then statistically analysed by using SPSS software version 16. Paired t-test was used for comparison within the groups, for pre and posttest values. Unpaired t test was used to compare VO₂max between the two groups. P value was set at <0.05. and confidence interval was set at 95%.

RESULTS

The Table 1 shows the demographic data of the study, representing the mean and standard deviation of age, weight, height, BMI of the participants in the study.

Table 1: Demographic data.

Parameters	Males, Mean±SD
Age (years)	20.49±4.29
Weight (kgs)	58.82±0.71
Height (cms)	167.16±13.79
BMI (kg/m ²)	20.63±2.83

The Table 2 shows comparison between pre and post-test value of pulse rate (PR) by HST and ISRT with mean±SD. On analysis, the p value was found to be highly significant in both the groups implying that there was increment in the PR post-test. From this table we can infer that there was increase in PR in both groups.

Table 2: Comparison of pulse rate (PR).

PR in males			
	Pre-test mean±SD	Post-test mean±SD	p value
HST	75±5.72	156.04±12.95	0.000
ISRT	74.92±5.14	155.16±8.72	0.000

The Table 3 shows comparison between pre and post-test value of respiratory rate (RR) by HST and ISRT with mean±SD. The p value was found to be highly significant implying that there was significant increase in the RR

post-test in males of both the groups. In Table 3, authors can infer that there was increase in RR in both the groups.

Table 3: Comparison between respiratory rate (RR).

RR in males			
	Pre-test mean±SD	Post-test mean±SD	p value
HST	18.92±1.69	40.68±5.63	0.00
ISRT	18.92±1.76	42.16±5.38	0.00

The Table 4 shows comparison between pre and post-test value of systolic blood pressure (SBP) by HST and ISRT with mean±SD. The p value is highly significant implying that there was significant rise in SBP post-test in HST as well as ISRT group. From this Table, authors can infer that there was significant rise in SBP in both the groups.

Table 4: Comparison of systolic blood pressure (SBP).

SBP in males			
	Pre-test mean±SD	Post-test mean±SD	p value
HST	114.84±8.04	155.8±13.58	0.00
ISRT	115.8±8.82	159.48±11.40	0.00

Table 5: Comparison of diastolic blood pressure (DBP).

DBP in males			
	Pre-test mean±SD	Post-test mean±SD	p value
HST	77.08±6.05	76.06±9.15	0.3
ISRT	77.1±5.56	72.02±10.63	0.00

The Table 5 shows comparison between pre and post-test value of diastolic blood pressure (DBP) by HST and ISRT with mean±SD.

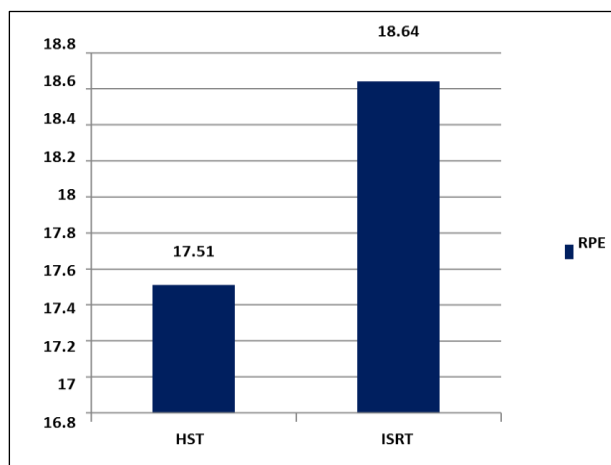


Figure 1: Comparison of ratings of perceived exertion (RPE) achieved by HST and ISRT.

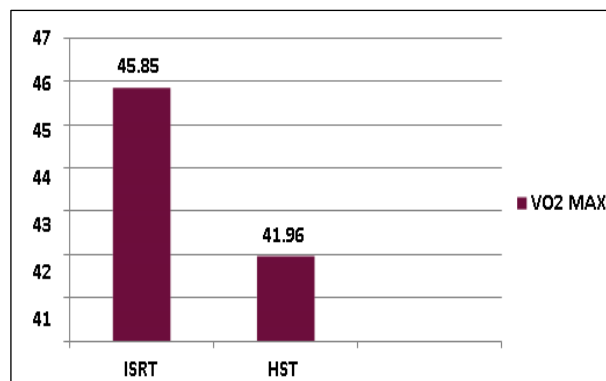


Figure 2: Comparison of VO2max by HST and ISRT.

The p value is significant in ISRT group implying that there was significant drop in DBP while it is non-significant in HST group implying that there was no statistically detectable change in DBP. From this table authors can infer that there was significant decrease in DBP only in ISRT group.

From the Figure 1, authors can infer that the value of RPE achieved during ISRT is more than that achieved during HST.

From the Figure 2, authors can infer that the VO2max attained during ISRT is much greater than that attained during HST.

DISCUSSION

Cardiorespiratory fitness is the capacity of heart, lung, and blood vessels to make oxygen available for muscle activity.¹² Also, having good physical health is indirectly related to efficiency of Cardio-respiratory system and the rate of maximum oxygen consumption (VO2 max) of the person.¹³ VO2max is the maximum amount of oxygen that a person consumes during maximal exercise. It is a method for evaluating aerobic fitness and an important factor for predicting the cardiorespiratory endurance.¹⁴ The cardiorespiratory fitness of the individual can be measured by various direct measurements however, these methods are technically demanding and require access to expensive laboratory equipment and skilled personnel.

As a consequence, alternative procedures have been developed in which predicted aerobic capacity is calculated from physiological responses in combination with performance measures.¹⁵ The aim of the present study was to compare two indirect methods of assessment i.e. Incremental Shuttle run test and Harvard’s step test which are used to measure or predict VO2 max and to see which amongst the two is more beneficial to predict maximum VO2 and thus to improve cardio respiratory fitness of the person. Each subject performed these two tests with an interval of 48 hours as rest period between the two.

About 100 male subjects performed the two tests, their pulse rate, respiratory rate and systolic blood pressure post Harvard's step test showed significant increase ($p=0.00$), but the change in diastolic blood pressure was non-significant ($p=0.3$). On the other hand, the pulse rate, respiratory rate, systolic blood pressure and change in diastolic blood pressure post shuttle run test showed significant change ($p=0.00$).

In healthy subjects, heart rate increases nearly linearly with increasing VO₂. Increase in HR is initially mediated by a decrease in parasympathetic activity and, subsequently, almost exclusively increased sympathetic activity. Achieving maximal HR during exercise is often used as a reflection of maximal or near maximal effort and presumably signals the achievement of VO₂ max.^{16,17}

Similar study which concluded that walking speed has significant influence on perceived exertion of whole the body as well as local area like buttocks, thigh region and shank area. Increased walking speed cause significant increase in muscle activity, hence on gender effect females showed significantly higher muscle activity, more ankle motion, vertical ground reaction forces and average heart rate than males.¹⁸

As seen in the study, both the tests are responsible for eliciting immediate normal cardiovascular responses to exercise test intensity. All the parameters i.e. heart rate, respiratory rate, systolic blood pressure increased due to sympathetic stimulation which causes vasoconstriction of the arterioles and small arteries in most tissue of the body except the active muscles, increased pumping activity of the heart and a great increase in mean systemic filling pressure caused mainly by venous contraction.¹⁹

RPE achieved by HST i.e. 17.51 and by ISRT i.e. 18.64, showed significant difference ($p > 0.000^*$).

RPE has direct correlation with maximal oxygen consumption (VO₂max).

- RPE <12 - light- 40% to 60% of VO₂max
- RPE between 12 to 13 - somewhat hard (moderate), 60% to 75% of VO₂max
- 14 to 18 - hard (heavy), 75% to 90% of VO₂max - as explained by Fletcher GF. et al in 1995.

Predicted VO₂max was calculated for both the tests, this was found to be significantly higher post ISRT (45.85) than HST (41.96) with p value (0.00*). This could be due to variations in stature of the individuals. Power and the oxygen cost of stepping on to a relatively higher step are expected to be greater. Secondly the stride length and step length which is more so they could complete more no. of laps in given allotted time in the ISRT.

As said earlier, the VO₂max achieved post incremental shuttle run test was more than Harvard's step test in males; this could be due to linear correlation between

oxygen consumption and the running speed. As the running speed increases the oxygen consumption also increases.

CONCLUSION

Of the two maximal tests studied, incremental shuttle run test proved more efficient in predicting VO₂max than Harvard's step test in young healthy adult males.

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