

Comparison of Incremental Shuttle Walk Test and Queen's College Step Test on Oxygen Consumption and Rate of Perceived Exertion in Young Healthy Males

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ABSTRACT

Introduction: Walking tests are the most commonly used for assessing of functional capacity, It is possible that some patients do not complain of walking limitations but have limitations with stair climbing, as the latter is a more strenuous activity. Thus the present study was addressed to compare the two submaximal tests which are Incremental shuttle walk test (ISWT) and Queen's college step test (QCT) by measuring oxygen consumption and rate of perceived exertion (RPE) in young healthy males.

Method: The observational study, purposive sampling with sample size of 117, subjects of 18-24 years healthy male with normal Body mass index (BMI>18.50 & <=24.99) were included in this study. The exclusion criteria were any cardio respiratory problems, orthopedic problems of lower limb, Fracture of lower limb, recent trauma, and neurological involvement. During the session, participants performed the ISWT and QCT in random order and Heart rate (HR), RPE and SPO₂ were measured before and after completion of both the tests. Maximum oxygen consumption (VO_{2max}) was measured using indirect method.

Result: Results were calculated using Mann-Whitney test between two tests. There was statistical difference found in VO_{2max}, RPE, SPO₂ and HR between both the tests.

Conclusion: There is significant difference found between ISWT and QCT for measuring of VO_{2max} and RPE, But more difference found in QCT than ISWT, Both the tests are used to assess oxygen consumption and RPE but both the test are not comparable with each other.

Keywords: Incremental shuttle walk test, Maximum oxygen consumption, Queen's college step test, Rate of perceived exertion, Young healthy males

INTRODUCTION

Cardio respiratory fitness (CRF) is a health-related component of physical fitness defined as the ability of the circulatory, respiratory, and muscular systems to supply oxygen during sustained physical activity. CRF is usually expressed in metabolic equivalents (METs) or maximal oxygen uptake.¹ It is relatively low-cost and useful

health indicator for both symptomatic and asymptomatic patients in clinical practice. Although there is convincing evidence that CRF is associated with morbidity and mortality in both men and women independently of other risk factors.^[1]

Physical fitness performance was better in male students than female students because of decreased physical activity, unhealthy

lifestyle behaviors, which may influence adult behavior and health status. Cardio respiratory fitness has also shown a stronger association with total adiposity, as measured by BMI. Overweight and obesity also be the reason for reduced VO_{2max} .^[2]

Exercise professionals often rely on submaximal exercise tests to assess CRF because maximal exercise testing is not always feasible in the health/fitness setting. The basic aim of submaximal exercise testing is to determine the HR response to one or more submaximal work rates and uses the results to predict VO_{2max} .^[9] VO_{2max} is the maximum amount of oxygen a person can intake and the value does not change despite an increase in workload over time period. VO_{2max} is expressed as liters/min as an absolute value or in milliliters /kg/min as relative VO_{2max} . The VO_{2max} can be estimated using maximal or sub maximal tests, by direct or indirect methods.^[2,3]

There are two Methods of measuring VO_{2max} direct method and indirect method. Direct Method is most reliable method, has limitations like specialized laboratories with sophisticated equipments, professionally trained team, strong motivation and volitional effort, potential risks, and a limited number of investigations annually. And indirect method is low cost, effective, safe and required less time, easy to administer, equations based on preestablished time or distance.^[4]

VO_{2max} is often used as marker of physical fitness and considered the best indicator of aerobic fitness. VO_{2max} estimation by step test is one such test and is considered to be a practical field test for assessing individual aerobic fitness.^[2]

The Borg 6-20 ratings of perceived exertion (RPE) scale is a reliable measure used to quantify, monitor and assess an individual's exercise tolerance and level of exertion. The strong relationship between the ratings of perceived exertion and various physiological (oxygen uptake, heart rate) and physical (work rate) markers of exercise intensity.^[5]

ISWT was created by Singh et al to assess the CRF of patients with chronic pulmonary obstructive disease (COPD) and later used in other conditions or healthy subjects.^[6] In this test, the individual is guided to walk at a progressively faster pace imposed by prerecorded signals.^[7,8]

The incremental shuttle WDT (ISWT) measures a symptom limited walking distance over a marked walking course of usually 10 meters (33 feet).^[9]

This distance correlates well with maximal oxygen uptake. The incremental shuttle utilizes an audible pacing timer to incrementally increase pacing frequency. The subjects walk according to the pacing timer frequency until they are too breathless to continue or cannot keep pace with the external pacing signal.^[8]

One such test is the Queens College step test (QCT) developed by Mc Ardle et al, and Molanouri Shamsi et al. The investigators chose the bench height for convenience as most bleachers are approximately 41.25 cm.^[10]

Several researchers have suggested that, if a step is too high, local muscular fatigue may ensue before a true assessment of aerobic capacity can be obtained, so the test may be more a measure of muscular endurance of the legs than of aerobic capacity.^[10]

Step tests are one of the most widely used field tests for estimating VO_{2max} .^[11] stepping requires no elaborate or expensive equipment, no calibration, and can be easily administered to large numbers of people^[12] Most commonly administered step tests are performed at a fixed cadence on a bench of a fixed height.^[10]

Purpose of the study is to know the higher value of maximum oxygen consumption and rate of perceived exertion between two sub maximal test in which one is step test and another one is walk test and also know that which is more comfortable and easier for the patients. Thus the Aim of the study is to compare the incremental shuttle walk test and Queen's college step test on oxygen consumption and rate of perceived exertion in young healthy males.

The objectives of the study are to compare the maximum oxygen consumption, rate of perceived exertion, SPO₂ and HR in Incremental shuttle walk test and Queen's college step test.

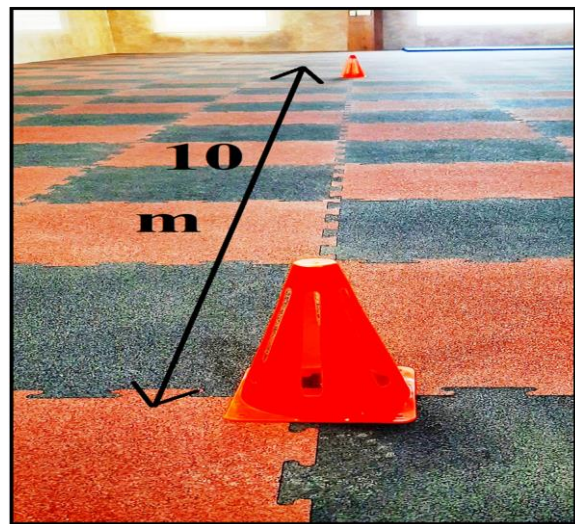
MATERIALS & METHODS

The research design was Observational study. Purposive sampling was done total 117 subjects were recruited according to inclusion and exclusion criteria. The inclusion criteria for this study were age of 18 to 24 years healthy males with normal BMI (BMI>18.50&<=24.99). The exclusion criteria were, any cardio respiratory problems, any orthopedic problems of lower limb, Fracture of lower limb, recent trauma, Neurological involvement

Materials used were Wooden step (16.25 inch), Stopwatch, Pulse Oximeter, Marking cones, Borg scale (6-20) of RPE, Metronomes, Weighing machine, Stadiometer, 10 m course for walking, Chair, Pen, Flat non-slippery surface and Proforma

Based on the sample size calculation, the minimal sample size was 79. Outcome measure taken were Maximum oxygen consumption (VO_{2max}), Rate of perceived exertion (RPE), SPO₂, HR

Ethics approval was taken. All the subjects were informed about the study and written and oral consent was taken. Basic demographic (age, gender) was obtained. Body mass index (BMI) was calculated using the height and weight values. Subjects were selected according to inclusion criteria. During a single test session, participants performed the ISWT and QCT in random order with at least 60 minutes of rest between the tests.



PICTURE 1: 10METER PATHWAY FOR INCREMENTAL SHUTTLE WALK TEST

PROCEDURE:



PICTURE 2: SUBJECT PERFORMING QUEEN'S COLLEGE STEP TEST ON 16.25 INCH HEIGHT STEP STOOL

ISWT was performed in 10 meter of path where subjects were asked to walk according to prerecorded audio signals.

Level	Speed m/s	Number of shuttles per level	Distance ambulated at the end of each level (m)
1	0.50	3	30
2	0.67	4	70
3	0.84	5	120
4	1.01	6	180
5	1.18	7	250
6	1.35	8	330
7	1.52	9	420
8	1.69	10	520
9	1.86	11	630
10	2.03	12	750
11	2.20	13	880
12	2.37	14	1020

Figure 1: Layout and Pacing Algorithm for Shuttle Walk Distance Test

VO_{2max} was measured using ISWT by keeping values in formula:

$$VO_{2max} (ml \cdot kg^{-1} \cdot min^{-1}) = 0.359(\text{number of laps}) - 0.59(\text{BMI}) - 4.5(\text{gender: } 1 = \text{boys, } 2 = \text{girls}) + 50.8$$

QCT was performed on 16.25 inch stool stepper where subject is asked to step up and down according to metronome beats for 3 minutes in which 24 times per minute for male.

VO_{2max} was measured using QCT by keeping values in formula:

$$VO_{2max} = 111.33 - (0.42 \cdot \text{pulse rate beats/minute})$$

Heart rate, RPE and Spo_2 were measured before and after completion of both the tests.

Ethical approval was taken. 117 subjects were selected in the study according to inclusion criteria.	
Informed written and oral consent were obtained from the subjects	
Total 117 subjects were participated in study from which all subjects completed ISWT and 14 subjects were not able to complete QCT, because of fatigue, inability to maintain cadence and balance problems. Total 103 subjects were included in study.	
Subjects randomization N= 103	
ORDER 1	ORDER 2
Baseline parameters recorded (HR,SPO ₂ ,RPE) test	Baseline parameters recorded (HR,SPO ₂ ,RPE) test
Subject performed ISWT	Subjects performed QCT
Post test parameters were recorded (HR,SPO ₂ ,RPE, VO_{2max}) test	Post test parameters were recorded (HR,SPO ₂ ,RPE, VO_{2max}) test
60 minutes of rest period before performing QCT	60 minutes of rest period before performing ISWT
Subject performed QCT	Subject performed ISWT
Post test parameters recorded (HR,SPO ₂ ,RPE, VO_{2max}) test	Post test parameters recorded (HR,SPO ₂ ,RPE, VO_{2max}) test

Statistical Analysis

Statistical analysis was done using SPSS version 16 and Microsoft Excel 2017 was

used to generate graphs and tables. Confidence interval was kept 95% and level of significance was kept at 0.05. Before

applying statistical tests, the data was screened for normal distribution. Shapiro-Wilk test was applied to test the normality. Data of HR, SPO₂, VO₂max, and RPE were not normally distributed, so non-parametric tests were used. Mann-Whitney test was used between two tests.

Total 117 subjects participated in the study of which all subjects completed ISWT and 14 subjects were not able to complete QCT. 103 subjects completed both the tests.

RESULT

A total 103 subjects were included in the study with mean and standard deviation of

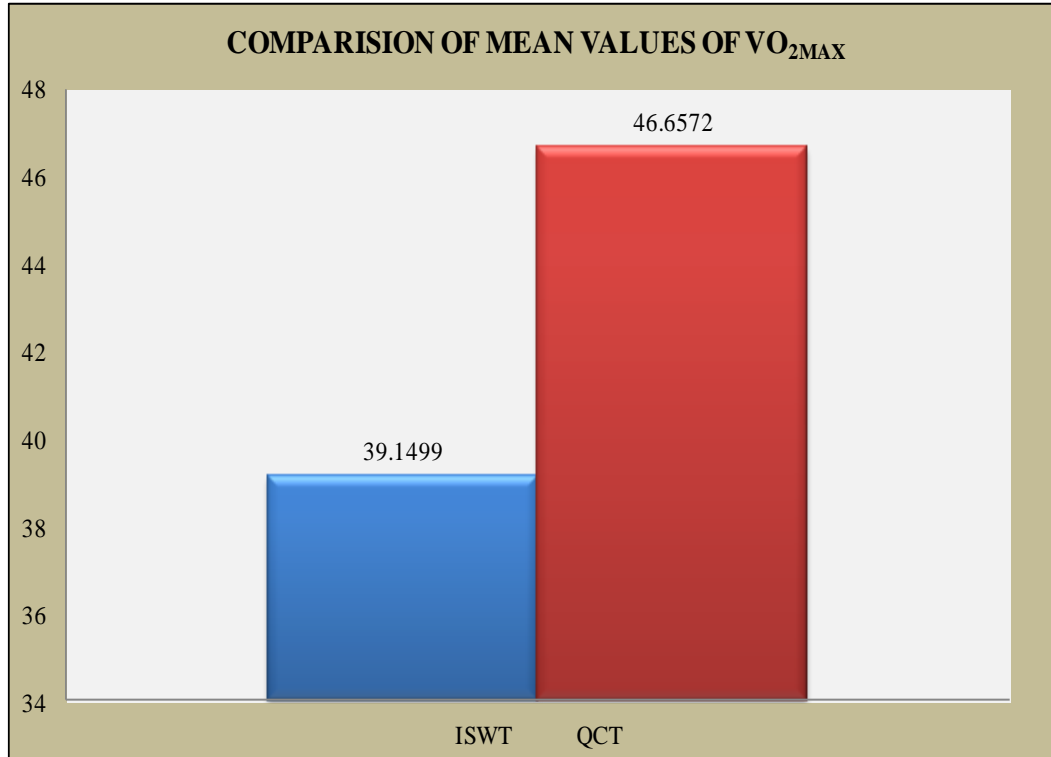
age (21.359±1.71434) and BMI (22.3641 ±4.40782) Which shown in table 1. According to results obtained, there was significant difference was found in VO₂max, RPE, HR, SPO₂) comparing two test which is shown in table 2.

TABLE 1: SHOWS MEAN AND STANDARD DEVIATION (SD) OF AGE (YEARS) AND BMI (KG/M²) OF PARTICIPANTS.

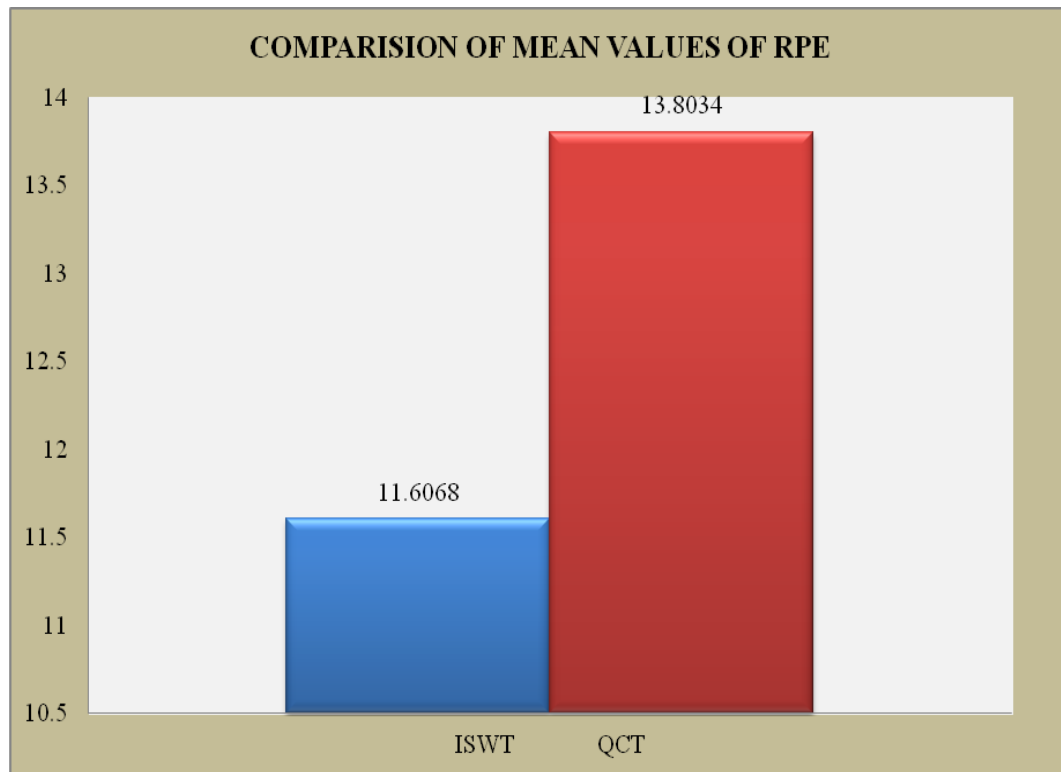
CHARECTERISTICS	MEAN	STANDARD DEVIATION
AGE(Years)	21.359	1.71434
BMI(Kg/m ²)	22.3641	4.40782

TABLE 2: BETWEEN THE TWO TESTS COMPARISON OF POST HR, SPO₂, RPE, VO₂MAX OF ISWT AND QCT.

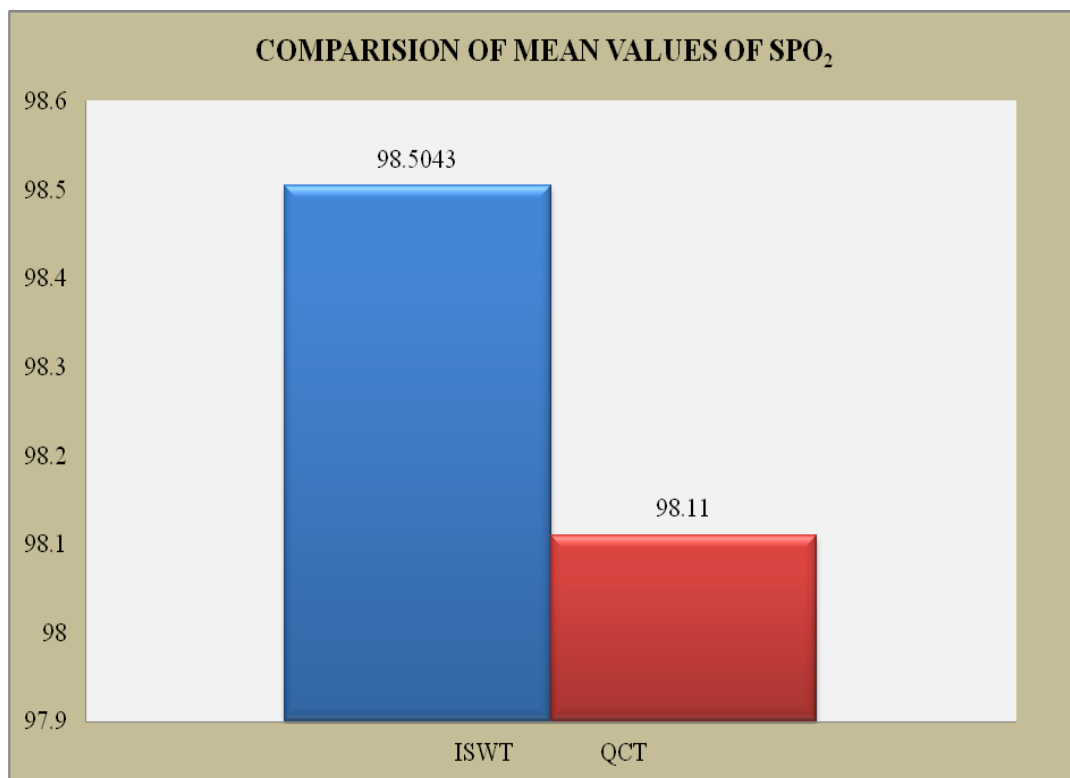
PARAMETERS	MEAN±SD		P VALUE	Z VALUE	U VALUE	INTERPRETATION
	QCT	ISWT				
VO ₂ MAX	46.65718±6.426417	39.14988±3.412856	-8.650	0.000	2.366	SIGNIFICANT
RPE	13.80342±1.5605	11.60684±1.547842	-9.112	0.000	2.187	SIGNIFICANT
HR	153.9829±15.30099	132.2991±16.83401	-8.633	0.000	2.376	SIGNIFICANT
SPO ₂	98.11111±0.917058	98.50427±0.749988	-3.695	0.000	5.106	SIGNIFICANT



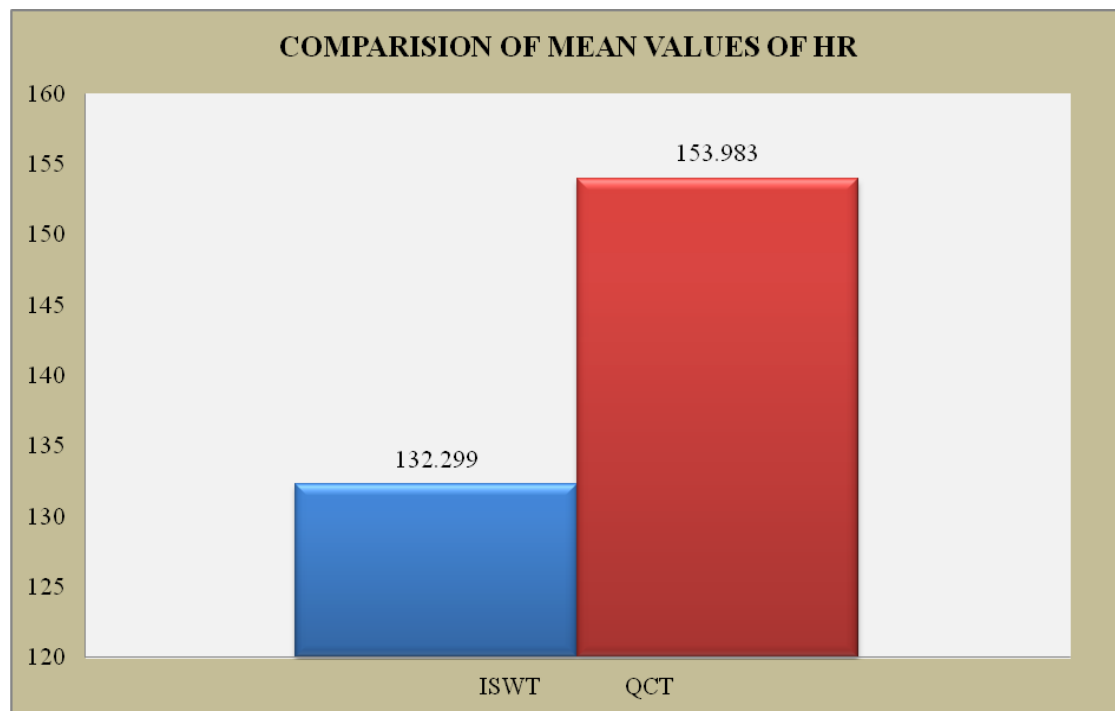
GRAPH 1: BETWEEN TEST COMPARISON OF VO₂MAX VALUES OF ISWT AND QCT



GRAPH 2: BETWEEN TEST COMPARISON OF RPE VALUES OF ISWT AND QCT



GRAPH 3: BETWEEN GROUP COMPARISON OF SPO₂ VALUES OF ISWT AND QCT



GRAPH 4: BETWEEN GROUP COMPARISON OF HR VALUES OF ISWT AND QCT

DISCUSSION

During exercise testing heart rate increases due to effects of autonomic nervous system. ANS function is determined by activity of its sympathetic and parasympathetic components. Heart rate increases largely due to rapid withdrawal of sympathetic tone (vagal tone) as well as increased sympathetic tone. [13,14]

In present study heart rate is increased after performing both the test. There are significantly increases heart rate in QCT than the ISWT.

In healthy subjects, heart rate increases nearly linearly with increasing VO_2 . 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 VO_{2max} . [16]

In present study VO_{2max} obtained after performing QCT is higher than that in ISWT.

Hunter Bennett et al, (2015), [15] studied validity of submaximal step tests to estimate maximum oxygen uptake in healthy adults

by Queen's college step test and concluded that there is relationship between VO_{2max} and various markers of health. The use of step test can be done to measure health in both the general adult population and rehabilitation setting. Queen's College step test is recommended as a valid method to evaluate cardiorespiratory fitness in terms of VO_{2max} for large numbers within the young population. [19]

The Incremental shuttle walk test requires patients to walk at a gradually increasing speed until they reach a symptom limited maximum, for cardiac patients the end point is usually set at a specific workload (80% of maximum heart rate) or rating of perceived exertion (RPE of 15). The wide range of walking speeds in the ISWT allows the accommodation of all ambulant patients, from those with minimal disability to those with severe symptoms. [16]

Singh SJ et al, (1992) also found that the shuttle walking test constitutes a standardized incremental field walking test that provokes a symptom limited maximal performance. [17]

One factor important to test is its completion rate. Some individuals were unable to complete the QCT. In present

study 14 students were drop out because of subjects were not able to complete QCT (all stopping within 2 minutes of starting). particularly those who were older, of shorter stature, extremely obese were unable to complete 3MST. The importance of weight is not surprising as the vertical work associated with negotiating a 12 inch step is influenced by a participant's mass. Specifically, work is the product of force and distance while force is the product of mass and acceleration. Distance in the 3MST is fixed at 12 inches. Acceleration in the 3MST is essentially fixed by set cadence. That leaves mass as the chief determinant of work. Use of a lower step and/or cadence would have reduced the work and potentially increased the completion rate but would have also rendered the test less challenging for more able individuals²⁰. Similarly **Beutner et al, (2015)** ^[21] also reported that 17% of their participants did not complete 3 minute step test; participants who were older and more obese.

Oxygen desaturation is also more pronounced during whole-body exercise, such as rowing or running, than during leg exercise, and leg exercise is more capable of inducing hypoxemia than is arm exercise. This suggests that the amount of muscle mass involved in the exercise influences the development of oxygen desaturation. ^[22, 18]

In the present study desaturation was found in both the tests but while comparing the tests more desaturation is there in QCT as it is more work demanding than the ISWT.

Daniel Machado Seixas et al (2013) conducted a study on Oxygen desaturation in healthy subjects undergoing the incremental shuttle walk test and concluded that Healthy individuals can present oxygen desaturation after during any intense physical activity. Using the Submaximal test to predict subtle respiratory abnormalities can be misleading. In healthy subjects, oxygen desaturation is common after the ISWT. ^[22]

Danielle M. et al (2009) concluded that There is a strong relationship between the

Borg 6-20 RPE scale and physiological criteria in their study, with a commensurate rise in the RPE and VO₂ producing a high correlation across the duration of the exhaustive exercise test. ^[5] which was similarly in present study.

In present study RPE is increased more in QCT than in ISWT as subjects felt more exertion after performing QCT

The step and the shuttle walking test both use less space than a self paced corridor test. Stepping may not be a familiar activity and coordination may be difficult. Limitation to this type of exercise may in practice be muscle weakness or soreness rather than ventilation. In addition, the step test appears to have poor reproducibility. The shuttle walking test offers an alternative to the self paced walking test and the paced step test and is a substitute for both. ^[23]

Limitations of present study are that this study could be performed on large number of population; the subjects taken for this study were males only.

The Future studies can be done on subjects with different age group, both the genders, different BMI, with larger sample size and effect is also could be seen among the cardiorespiratory diseased patients comparing with the normal individuals. Other outcome measures for cardiorespiratory functional capacity like; Respiratory rate, blood pressure, could be studied.

CONCLUSION

The present study concluded that that there is significant difference found between incremental shuttle walk test and Queen's college step test on oxygen consumption and rate of perceived exertion in young healthy males. Queen's college step test is more efficient to measure the oxygen consumption in young healthy males. Also the rate of perceived exertion was more in Queen's college step test compare to incremental shuttle walk test. Both the tests are used to assess the functional capacity of healthy individuals as well as for the

patients but both the test is not comparable with each other.

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Conflict of Interest: None

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Ethical Approval: Approved

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