Queen’s College Step Test as an Alternative of Harvard Step Test in Young Indian Women

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[Received June 8, 2007; Accepted September 11, 2007]

Indian women often report premature exhaustion in the lower limb while performing the Harvard step test (HST) for measurement of physical fitness index (PFI) whereas they can easily perform the Queen’s college step test (QCT). 155 sedentary females of 19-24 years were selected for the study from Institute of Dental Sciences, UP, India to evaluate the applicability of QCT as an alternative of HST. They were divided into study group (n=100) and confirmatory group (n=55). All subjects performed QCT comfortably but 35 (20 from study group and 15 from confirmatory group) of them could not properly perform the HST due to premature fatigue in their legs and therefore these 35 subjects were discarded from the study. Existence of significant correlation \( r=-0.90, P<0.001 \) between PFI and QCT heart rate depicted the following prediction norm for PFI from QCT heart rate: \( Y = 195.06 - 3.09 \times \) (SEE = 3.09). Prediction of PFI by this norm in the confirmatory group showed insignificant variation with the directly measured value from the HST. Bland and Altman’s analysis also indicated that QCT norm predicts the PFI with 95% confidence interval. Moreover, QCT is easy to perform and the derived norm from QCT predicted the PFI score with substantially small standard error of estimate. Therefore, QCT is recommended as a valid and authentic test for evaluating PFI in young sedentary females of Uttar Pradesh, India.

Keywords: QCT, Harvard step test, PFI, Indian females

1. Introduction

Measurement of Physical fitness index (PFI) is extremely valuable in the field of Sports and Exercise Science and it is determined by Modified Harvard Step Test (HST) (Sloan 1959, Chatterjee, et al., 2002). Sedentary Indians are often compelled to stop the stepping exercise of HST because of some premature fatigue in their lower limbs rather than cardiorespiratory exhaustion (Bandyopadhyay 2007). The subjects report that the stool height and the stepping cadence of HST are very high which hinder the comfortable lifting up and pulling down their legs during the stepping process and that leads to onset of premature fatigue in their legs. The biomechanical efficiency and work rate is determined by the step height (Francis and Brasher 1992). The HST was designed on the Western population whose stature and knee height are generally higher than those of the populations of Eastern countries like India. Culpepper and Francis (1987) reported that accommodation of step height to the subject’s stature height is needed for the better estimation of aerobic capacity, but such adjustment procedure needs complicated modifications for each subject with respect to the individual’s body height, knee height and hip angle. Moreover, Ashley, et al., (1997) reported that step tests based on subjects’ stature do not more accurately predict the aerobic capacity than those using a standardized bench height. These findings suggest that the application of HST in Indian context needs further standardization either by adjustment of stepping height and stepping cadence or by replacement with some other suitable step test protocol.

Queen’s college step test (QCT) is another step test that is frequently used to determine the cardiorespiratory fitness in terms of maximum oxygen uptake or \( \text{VO}_2 \text{max} \) (Das and Bhattacharya 1989, Das and Bhattacharya 1995, Das 1991,
Wassmer and Mukerjee 2002, D’Alanzo, et al., 2006) and it requires the same infrastructure like HST. This particular step test has already been standardized among Indians who can easily perform this test without any premature exhaustion probably for its simple experimental protocol with lower stool height (16.25 inches) and slower cadence (Das and Mahapatra 1996, Chatterjee, et al., 2001, Chatterjee, et al., 2004, Chatterjee, et al., 2005). Thus, QCT can be considered as an alternative step test of HST in Indian population provided it is properly validated and recommended. The application of QCT as an alternative of HST for determination of PFI in Indian males has already been established and recommended (Bandyopadhyay 2007), but similar study in Indian females has not yet been conducted. The present study was therefore undertaken to assess the suitability for application of QCT as an alternative of HST to determine PFI in young sedentary females of Uttar Pradesh, India.

2. Methodology

2.1. Study population

One hundred and fifty five (155) healthy young sedentary female students belonging to age group of 19 to 24 years from the same socio-economic background were recruited for the study on the basis of simple random sampling from Institute of Dental Sciences, Bareilly, Uttar Pradesh, India. Out of the 155 participants, 100 individuals were further separated by simple random sampling method as ‘Study Group’ and the remaining 55 participants were termed as ‘Confirmatory Group’. All the participants performed QCT properly but 20 and 15 participants from ‘Study Group’ and ‘Confirmatory Group’, respectively, reported early onset of pain in the leg muscles while performing the HST and failed to complete the test properly due to the premature fatigue in lower limbs. Hence they were discarded from the study.

Age of each subject was calculated to the nearest year from the date of birth as obtained from the Institute’s record. Body mass and body height were measured with a standard weighing machine that included a height measuring stand (Avery India Ltd., India). Body mass was measured to an accuracy of ± 0.250 kg and height to an accuracy of ± 0.50 cm.

2.2. Preparation of Participants

The participants reported at 10 a.m. after having light break fast at least 2 to 3 hours prior to the test and refrained from any physical activity during that period. The entire experimental procedure was explained to the subjects to allay their apprehension. QCT and PFI were performed at an interval of 4 days by random sequencing or cross-over design in which QCT was followed by PFI in half of the sample whereas PFI was followed by QCT in the other half of the sample to avoid any possibility of bias (Chatterjee, et al., 2005). The participants had no history of any major disease and did not follow any physical conditioning program, apart from some recreational sports. A regression equation for prediction of PFI from QCT was computed from the study group. The equation was validated in the confirmatory group.

2.3. Determination of PFI

PFI was measured by HST (Sloan 1959, Chatterjee, et al., 2002) which was performed on a stool of 17 inches height with the stepping cadence of 30 cycles/minute which was set by a metronome. The maximum duration of the exercise was 5 minutes or up to that moment when the subject was exhausted. After exhaustion or completion of the exercise, the subject was asked to take complete rest on an easy chair and three recovery heart rates were measured from carotid pulse during 1 – 1.5 min, 2 – 2.5 min and 3 – 3.5 min of the recovery period. The following equation was used to calculate the PFI:

\[
PFI = \frac{(\text{Duration of Exercise in Seconds} \times 100)}{(2 \times \text{Sum of the three recovery heart rates})}
\]

2.4. Queen’s College step test

QCT was performed on a stool of 16.25 inches height for a total duration of 3 minutes with the stepping cadence of 24 cycles/minute, which was set by a metronome. After completion of the exercise, the subject was asked to remain standing and the carotid pulse rate was measured from 5–20 seconds of the recovery period (Chatterjee, et al., 2005).

The Ethics Committee of the Institute had approved the study design and each participant provided written informed consent. All experiments were performed at a room temperature varying from 27 to 30°C and at a
relative humidity ranging between 70 and 85 per cent.

2.5. Statistical Analysis

Paired t-test, Pearson’s product moment correlation, linear regression statistics and Bland and Altman approach for limit of agreement (Bland and Altman 1986) were used for statistical treatment of the data. The level of significance was considered at $P<0.05$.

3. Results

Means and standard deviations of physical parameters, QCT heart rate (QHR) and PFI of the participants are presented in Table 1. The parameters did not show any significant difference between the ‘study group’ and the ‘confirmatory group’. In the study group, existence of significant correlation ($r = -0.90, P<0.001$) between QHR and PFI revealed the following norm for prediction of PFI by using QCT in the studied population:

$$\text{PFI} = 195.06 - 3.09 \times \text{QHR} \ (\text{SEE} = 3.09)$$

Application of this QCT based prediction norm in the confirmatory group depicted insignificant variation between the PFI scores obtained from HST (63.40 ± 5.66) and QCT norm (63.47 ± 6.33). The standard error of estimate (SEE) of the prediction norm (4.87% of the mean PFI score) is substantially small enough to reflect the authenticity of the prediction norm. Bland and Altman’s method for limit of agreement approach (Bland and Altman 1986) also revealed that the mean difference between PFI scores obtained from HST and QCT norm is 0.07 (Figure 1) with 95% confidence interval, indicating that the norm obtained from QCT predicts the PFI value by between 1.27 and -1.13. The limits of agreement (-2.33 and 2.47) are also small enough for QCT to be used confidently as an alternative of HST for prediction of PFI in the studied population.

However, the significant relationship between HST and QCT have been have been explored further in Figure 2.

4. Discussion

Proper corrections of step height and hip angle can accommodate a subject to perform a step test more conveniently and that provides a better estimation of aerobic capacity (Culpepper and Francis 1987). But, the practical problem of such corrections is that it is to be adjusted in case of each and every individual who is performing the test and that deviates from the standard norm of a testing protocol. Moreover, it consumes more time that may pose as a hurdle when the study is being conducted in a large sample.
Ashley, et al., (1997) contradicted that step tests based on subjects’ stature do not more accurately predict aerobic capacity than those using a standardized bench height. So, it is desirable to recommend one specific protocol with a particular step test that can be acceptable to a particular population.

Indian females often fail to complete the HST because of premature fatigue in their lower limb though they do not reach their cardiorespiratory exhaustion level. This is due to the higher stool height and faster cadence of HST. It has been reflected in the present study that 35 out of 155 participants failed to complete the HST because of such premature fatigue where as all of them could complete the QCT satisfactorily. The similar finding was also observed in their male counterparts (Bandyopadhyay 2007). So, replacement of HST by QCT would be a desirable solution as far as measurement of PFI among Indian females is concerned.

The PFI score obtained in the present study corroborates with the previous findings in Indian females (Hasalkar, et al., 2005) but the value is lower than their male counterparts (Bandyopadhyay 2007). Paired t-test indicated that the PFI values obtained from the HST and from the QCT norm, respectively, exhibited insignificant variation between their means. Further analysis of the data by Bland and Altman’s method of limit of agreement approach (Figure 1) depicted that QCT can be applied to determine the PFI score in young sedentary female population of Uttar Pradesh, India. Moreover, QCT is more suitable and practicable because (i) it will enable the participants to complete the step test conveniently without any premature fatigue, (ii) measurement of only one recovery heart rate will predict the PFI, and (iii) by using the same heart rate subject’s VO$_{2\text{max}}$ can also be predicted by using the following equation (Chatterjee, et al., 2005):

\[
\text{VO}_{2\text{max}} \text{ (ml/kg/min)} = 54.12 - 0.13 \times \text{QCT Heart Rate}
\]

5. Conclusion

From the present observation the Queen’s College Step Test or QCT is recommended as a valid test and alternative method of HST to evaluate PFI by using the currently derived equation in young sedentary females of Uttar Pradesh, India. Moreover, application of QCT in the studied population will simultaneously provide the PFI score as well as the VO$_{2\text{max}}$ of the subject.

References
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Brief Biographical History:

∥ Academic Qualification:
Obtained Bachelor of Science (B.Sc.) with Honours in Physiology and Master of Science (M.Sc.) in Physiology with specialization in Sports & Exercise Physiology from the University of Calcutta in 1997 and 1999, respectively, securing First Class in both the examinations. Awarded Ph.D. in September 2004 from the University of Calcutta.

∥ Research Experience:
Ongoing research career started in January 2000. Dr. Amit Bandyopadhyay has been conducting various short term and long term research projects time to time in the field of Sports and Exercise Physiology. Published twenty five (25) research papers in the scientific journals of national and international repute. Many abstracts and full papers have been published in the conference proceedings for the oral presentations. Participated in conferences and other related scientific programs with invited lectures and award winning papers.

∥ Awards Received:
Received cash award under the National Scholarship Scheme of Government of India for the outstanding performance in the B. Sc. (Honours) Examination. Honoured with prestigious Prof. B. B. Sarkar Memorial Research Award in 2001 by The Physiological Society of India. Awarded Dr. Satyaranjan Dasgupta Memorial Prize in 1999.

∥ Teaching Experience:
Parallel with research, devoted in teaching as Permanent and Pert-time or Guest Lecturer of General Human Physiology in undergraduate and postgraduate courses of different Universities since December 1999. Currently working as a Lecturer of Exercise Physiology under the Sports Science Programme (undergraduate and postgraduate) of University Sains Malaysia, Malaysia.

∥ Hobby:
Playing Table Tennis, Traveling

Main Works:


∥ Chatterjee S, Mukherjee PS and Bandyopadhyay A. Assessment of body mass index, percentage of body fat, skinfold and girth measurements in Bengalee School Boys. Indian Biologist (India) 34: 51-57, 2002.


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Membership in Learned Societies:

• Life member and Fellow of International College of Nutrition (FICN).
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