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Is the Cardiorespiratory Fitness Affected by Height of Young Girls?

[1]Lotfali Bolboli, [1]Marefat Siahkouhian, [1]Amehneh Poorrahim, [2]Mohammad Narimani,
[3]Masoud Ganji and [2]Usha Barahmand
[1]Department of Physical Education and Sport Sciences,
Faculty of Human Sciences,
[2]Department of Psychology, Faculty of Human Sciences,
[3]Department of Statistics, Faculty of Basic Sciences,
University of Mohaghegh Ardabili, Ardabil, Iran

Abstract: The purpose of the present study was to examine the effect of height in the predicted VO_{2max} by the Queens Step test among short and tall young girls. A sample of 38 individuals was selected in two stages from a total of 500 individuals and was assigned to two groups of short (n = 20) and tall (n = 18). In order to examine the effect of height in the predicted VO_{2max}, the Queens step protocol and the incremental treadmill speed test were used. Respiratory exchange was measured continuously throughout the test by an automated open-circuit gas analysis system. The study results showed that tall girls revealed a higher VO_{2max} on the Queen's step and treadmill tests than short girls (Queen's: 44.09±2.66 vs. 38.96±1.65; Treadmill: 34.03±7.26 vs. 28.15±5.09 mL/kg/min). Based on the obtained findings it can be concluded that the higher VO_{2max} seen in tall girls on the both protocols, may be due to their physiological and physical properties; therefore, it seems that designing of the adjustable steps to the height of subjects for optimizing the estimation of VO_{2max} is not necessary and other physiological factors may be involved, which require further investigation.

Key words: Height, VO_{2max}, queen's step test

INTRODUCTION

The accurate evaluation of cardio-respiratory fitness and the effects of contributory factors have been an issue of controversy and investigation (Nieman, 1993; Fornetti *et al*., 1999). Being simple and inexpensive, the Queen's step test has been widely used in the examination of factors influencing the estimation of maximum oxygen consumption (Chatterjee *et al*., 2003). Steps adjustable to the height of subjects were designed and developed to optimize the estimation of VO_{2max} using the Queen's step test (Culpepper and Francis, 1987; Francis and Feinstein, 1991; Mazic *et al*., 2001; Howley and Turner, 1998; Welch *et al*., 2002; Willmore and Costill, 1994). To predict maximum oxygen consumption, Welch *et al*. (2002) investigated the reliability of the three minute step test with a specific rhythm. They found that the three minute rate-specific and height-adjusted step test estimates maximum oxygen consumption more accurately than fixed height step tests. Similarly, studies conducted by Culpepper and Francis (1987) indicate that a 73.3 degree angle in the thigh joint is the most suitable angle for the estimation of maximum oxygen consumption in the step test. Several studies reveal that without taking into consideration the effect of height, the step test is a precise and reliable test for the estimation of VO_{2max} (Shefard, 1966). According to Shefard (1966) regardless of the height of the step, the simple step test is a suitable method for the estimation of VO_{2max}. Studies conducted by Keren *et al*. (1980) also show that VO_{2max} is estimated independent of weight and height.

Given the inverse linear relationship between heart rate after physical activity and cardiovascular fitness, heart rate after activity is regarded as the criterion to determine VO_{2max} and thus can be considered to be an evaluation of cardio-respiratory fitness (Willmore and Costill, 1994). Moreover, as the Queen's step test with a fixed step of 16.25 inches (41.3 cm) is used to estimate maximum oxygen consumption in all individuals regardless of differences in their height, the present study was conducted with the main objective to examine the effect of height in the predicted VO_{2max} by the step test.

MATERIALS AND METHODS

Subjects: The subjects of this study were 38 female students from the University of Mohaghegh Ardabili, Ardabil city. Tests were conducted during the 1st

Corresponding Author: Dr. M. Siahkouhian, Department of Physical Education and Sport Sciences,
University of Mohaghegh Ardabili, Ardabil, Iran

Semester of 2007 at the Sport Physiology Lab. Subjects were selected through a stratified random sampling design. The age, height and weight of 500 individuals at the Health Center of Mohaghegh Ardabili University were measured. The subjects were assigned to two groups, short and tall. To rule out the possibility of physical and psychological ill-health, substance use and to obtain the consent of subjects, relevant information was collected using health record forms prior to and during the conduct of the study. Prior to participation in the study, subjects completed specific questionnaires regarding participation in the study and the necessary permit to conduct the study was obtained from the Center for Preservation of Human Rights, University of Mohaghegh Ardabili. The physical and body composition characteristics of subjects are presented in Table 1.

Queen's step test: This test provides a measure of cardio-respiratory or endurance fitness. The subject steps up and down on the platform at a rate of 22 steps per min for a total of 3 min. The subject immediately stops on completion of the test and the heart beats are counted for 15 sec from 5-20 sec of recovery. An estimation of VO_{2max} can be calculated form the test results, using the formula below:

- VO_{2max}(mL/kg/min) = 65.81- 0.1847×heart rate (bpm)

Treadmill incremental protocol: The incremental treadmill speed test consisted of increases in treadmill speed every min until subject's volitional exhaustion. Respiratory exchange was measured continuously throughout the test by an automated open-circuit gas analysis system. The highest averaged 30 sec oxygen uptake VO_2 value was defined as VO_{2max}.

Body composition measurements: To estimate the percentage of body fat the three points skinfold measurement (Chest, Abdomen, Thigh) were taken on the right side. Measurements were taken when the skin is dry, and not overheated. The Lafayette standard caliper was used to measures the skinfold thickness in millimeters.

Table 1: Physical and body composition characteristics of subjects

Variables	Short girls	Tall girls
Number	20.00	18.00
Age (years)	21.45±1.90	22.05±2.04
Height (cm)	151.12±2.67	169.41±3.23
Weight (kg)	49.25±5.75	61.28±6.00
BMI (kg m^{-2})	21.57±2.50	21.30±1.95
Body fat (%)	25.57±4.08	27.57±2.07
Fat mass (kg)	12.75±2.23	16.95±2.53
LBM (kg)	36.50±3.09	44.32±3.88

BMI: Body Mass Index, LBM: Lean Body Mass; All values are mean±standard deviation

The sum of these 3 measurements (mm) was first used with the person's age to calculate body density in a quadratic equation:

- Body density = (1.1093800 - (0.0008267 * (Sum of 3))) (0.0000016*(Sum of 3*Sum of 3)) - (0.0002574* (Age))

Percentage Body fat is then calculated with the following formula:

- Body fat (%) = (((4.95/body density)- 4.50)*100)

Statistical analysis: For statistical analysis of data, descriptive (mean, standard deviation) and inferential (paired t-test), were used. Graphs and figures were drawn using Excel software and data analysis was performed using SPSS 10.05 software under windows. Data were considered significantly different if the level of probability was equal to or less than 0.001.

RESULTS AND DISCUSSION

Results of the paired samples t-test to compare VO_{2max} of each of the groups in the two treadmill and the Queen's step tests showed in the Table 2.

Results showed that tall girls revealed greater VO_{2max} on the both Treadmill and Queen's step tests than short ones (Table 3).

Results displayed in Table 2 reveals significant differences in the mean VO_{2max} obtained with the treadmill and Queen's step tests. In other words, mean VO_{2max} of individuals in each of the groups was greater in the Queen's step test than in the treadmill method. Therefore, it can be said that in comparison with the treadmill method, the estimation of VO_{2max} with Queen's step test exceeds true levels in both groups.

Results of the present study showed a significant difference between VO_{2max} estimated with the Queen's step test in tall and short girls. An association between aerobic capacity and height and weight of young

Table 2: Paired samples t-test results in the treadmill and the Queen's step tests

Method	Group	Mean Diff.	t-test	df	Sig.
Treadmill	Short	10.81	8.97	19	0.001
Queen's	Tall	10.60	7.35	17	0.001

Table 3: Mean VO_{2max} in the treadmill and Queen's step tests

	Groups		
Methods	Tall	Short	p
Treadmill* (mL/kg/min)	34.03±7.26	28.15±5.09	0.001
Step test*	44.09±2.66	38.96±1.65	0.001

(mL/kg/min)All values are Mean±standard deviation, Statistical analysis with Paired t-test, *Difference is significant at the 0.001 level (2 tailed)

footballers (Culpepper and Francis, 1987). Montoye *et al.* (1977) found a significant relationship between maximum oxygen consumption and height and weight of female swimmers. Chatterjee *et al.* (2006) obtained a significant correlation between maximum oxygen consumption and height, weight and body surface area of the young men and women sedentary subjects. Initially, it appeared that in the Queen's step test higher VO_{2max} in the tall subjects comparing with short ones, was due to long leg length and easy administration of the test, but analysis of results regarding treadmill test indicated that tall subjects have higher VO_{2max} than short ones as well. It appears that VO_{2max} of tall subjects in the present study were due to greater lean body mass and larger lungs size than in their shorter counterparts, which provide a larger area for the exchange of oxygen. Therefore, it seems that designing of the adjustable steps to the height of subjects for optimizing the estimation of VO_{2max} is not necessary and other physiological factors may be involved, which require further investigation.

A comparison of predicted VO_{2max} by the treadmill and Queen's step tests revealed that the Queen's step test overestimates the VO_{2max} in the both short and tall subjects. Results of studies by Lamb and Rogers (2007), Buckley *et al.* (2004), Garber *et al.* (1985) and Keren *et al.* (1980) have shown that 20 m shuttle run, Chester and Queen's steps are reliable and valid tests for the estimation of VO_{2max}. Similarly studies by Chatterjee *et al.* (2003) and Zwiven *et al.* (1991) have shown the Queen's step test to be reliable for the estimation of VO_{2max}. Considering the influence of height in estimating VO_{2max}, Mazic *et al.* (2001), Gosling and Carlson (2000), Francis and Feinstein (1991) and Welch *et al.* (2002) showed that height-adjusted step test is a valid and reliable measure of maximum oxygen consumption in field and non-laboratory conditions. Furthermore, results of studies conducted in the University of Alabama, Birmingham (1992) showed that when laboratory methods are complicated and inaccessible, height-adjusted step test is a reliable estimator of maximum oxygen consumption. On the other hand, Typoon (1997) showed that height-adjusted step test cannot predict aerobic capacity of individuals more accurately than standard tests.

A quick examination of studies reveal that height has been shown to influence the estimation of VO_{2max} by the Queen's step test in some studies, while in others height is reported to have no influence. The results of the present study are congruent with those of Typoon (1997). The reason for this study results may be attributed to the movement pattern and age group of subjects. Therefore, it is suggested that these factors be taken into consideration in future studies in the field of sports physiology.

CONCLUSION

To sum up, based on findings of the present study, it can be concluded that taller subjects had greater VO_{2max} than short ones in the treadmill and Queen's step tests. Furthermore, VO_{2max} overestimated by the Queen's step test in the both tall and short subjects. Accordingly, height is considered as influential in the estimation of VO_{2max} using the treadmill and Queen's step test.

REFERENCES

Buckley, J.P., J. Sim, R.G. Eston, R. Hession and R. Fox, 2004. Reliability and validity of measures taken during the Chester step test to predict aerobic power and to prescribe aerobic exercise. Br. J. Sports Med., 38 (2): 197-205.

Chatterjee, S., P. Chatterjee, P. Mukherjee and A. Bandyopanhyay, 2003.Validity of Queen's college step test for use with young Indian men. Br. J. Sport, 38 (2): 289-291.

Chatterjee, S., P. Chatterjee and A. Bandyopadhyay, 2006. Prediction of maximal oxygen consumption from body mass, height and body surface area in young sedentary subjects. Indian J. Physiol. Pharmacol., 50 (2): 181-186.

Culpepper, M. and K. Francis, 1987. An anatomical model to determine step height in step testing for estimating aerobic capacity. J. Theor. Biol., 129 (1): 1-8.

Fornetti, W.C., J.M. Pivarnik, J.M. Foley and J.J. Fiechtner, 1999. Reliability and validity of body composition measures in female athletes. J. Applied Physiol., 871(3): 1114-1122.

Francis, K. and R. Feinstein, 1991. A simple height-specific and rate-specific step test for children. Sought Med. J., 84 (2): 169-174.

Garber, C., T. Laster and R. Garleton, 1985. A simple, valid step test for estimating maximal oxygen uptake in epidemiologic studies. Am. J. Epidemiol., 121 (3): 382-389.

Gosling, C.M. and J.S. Carlson, 2000. A multi-stage step test protocol for people with low exercise capacity. Exer. Rehabilitation. Res. Clin. Kinesiol., 54 (1): 67-71.

Howley, T.E. and J.M. Turner, 1998. Step test: Description and physiology. The University of Tennessee. Knoxville.

Keren, G., K. Magazani and Y. Epstein, 1980. A comparison of various methods for the determination of VO_{2max}. Eur. J. Applied Physiol. Occup. Physiol., 45 (1): 117-124.

Lamb, K.L. and L. Rogers, 2007. A re-appraisal of the reliability of the 20 m multi-stage shuttle run test. Eur. J. Applied Physiol., 100 (3): 287-292.

Mazic, S., M. Zivitic-vanovic, I. Igracki, S. Zivanic and S. Velkovski, 2001. A simple and reliable step-test for indirect evaluation of aerobic capacity. Med. Pregl., 54 (11): 522-529.

Montoye, H.J., W. Block, J.B. Keller and P.W. Willis, 1977. Glucose tolerance and physical fitness: An epidemiologic study in an entire community. Eur. J. Applied Physiol. Occup. Physiol., 37 (3): 237-242.

Nieman, D.C., 1993. Fitness and Your Health. 2nd Edn. Bull Publishing Company, London.

Shefard, R.J., 1966. The relative merits of the step test, bicycle ergometer and treadmill in the assessment of cardio-respiratory fitness. Eur. J. Applied Physiol., 3 (2): 219-230.

Typoon, A., 1997. A modified step test based on a function of subjects stature. Percept Mot skills, 3 (1): 987-993.

University of Alabama Birmingham, 1992. A height-adjusted step test for predicting maximal oxygen consumption in male. J. Sport Med. Phys. Fitness, 32 (3): 282-287.

Welch, G., P. Crawford and S. Raveling, 2002. The validity of the height-adjusted, rate specific, three minute step test for predicting VO_{2max} as compared to a treadmill VO_{2max} stress test performed on the Q-®Plex gas analyzer. ISU Department of Physical and Occupational Therapy.

Willmore, J. and D. Costill, 1994. Physiology of Sport and Exercise. 4th Edn. Human Kinetics, USA.

Zwiven, L., P. Freedson, A. Ward and J. Rippe, 1991. Estimation of VO_{2max}: Comparative analysis of the five exercise test. Res. Q. Exec. Sport, 62 (2): 73-80.