

## Effect of step height on cardiorespiratory responses during aerobic step test in young Indian women

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**Abstract:** *Background:* Step aerobics is practiced in health centres, fitness training gyms, and academic institutions in India. This exercise module is gaining popularity day by day. But, these kind of aerobic exercise tests are less investigated for Indian women population. *Objective:* A widely practiced aerobic step test was applied to a group of young female to explore the effect of step height on physiological responses and suggest the best height of stepping. *Method:* Eight physically fit and active female university students with mean age 19.7 ( $\pm 2.3$ ) yrs, height 156.2 ( $\pm 6.5$ ) cm, weight 51.2 ( $\pm 7.9$ ) kg, and  $VO_{2max}$  35.7 ( $\pm 4.8$ ) ml.min<sup>-1</sup>.kg<sup>-1</sup> volunteered for the study. Each subject performed 30 minutes of step test in two Reebok steps heights (6 inch and 8 inches) with a rhythm of 120 beats.min<sup>-1</sup>. At this cadence 30 cycles of stepping up and down were completed in 1 min. Relative work load (%  $VO_{2max}$ ), energy expenditure (EE), Heart rate (HR), percentage of age predicted maximum HR were measured using K4b<sup>2</sup> Cosmed system. *Result:* The results showed that eight inch step is offering a significant higher value across most of the parameters investigated compared to six inch step. So it can be inferred that the higher the step height the higher will be the physiological responses. *Conclusion:* The present study clearly demonstrates that aerobic stepping on 6 inch bench height for 30 minutes with a cadence of 120 beats. min<sup>-1</sup> may be more suitable and safe exercise module to improve cardio respiratory fitness for Indian young females. Further investigations are required to identify suitable exercise modules in terms of bench height, cadence and duration for different age groups and according to their fitness level (trained/untrained) and height on larger sample size.

**Keywords:** Bench step aerobics, cardiovascular fitness, bench height.

### Introduction

People are encouraged to take part in regular physical activity for health and fitness benefits [1]. It is believed that the low physical fitness level of an individual is associated with higher mortality rate [2]. Different exercise modalities have been explored in the tale of time to promote cardiovascular fitness. Aerobic dance, walk-jog combination, and bench step aerobics are important examples [3]. Bench step aerobics were innovated by Gin Miller around 1989. It is distinguished from other forms of aerobic exercise by its use of an elevated platform (the step or bench) which offer more vigorous work out compared to other forms of aerobic exercises. Reebok has developed plastic benches with variable heights which are frequently used for bench step test. These benches are accepted worldwide; hence these steps are often referred to

as Reebok steps. Bench step aerobics exercise has been shown to help individuals to meet the recommendations of American College of Sports Medicine (ACSM)[4] for improvement of cardiovascular fitness, body composition and aerobic capacity in a wide variety of populations including patients with cardiac failure [3, 5-7]. Stepping exercise is often recommended during interval training to enhance physical fitness [8-9]. Since late 1980's this exercise format has become a widely practiced fitness modality, especially among the female population [3]. Rothenberger et al. [10] reported that inappropriate selection of frequency and duration of aerobic exercise causes exhaustion and overuse injuries in lower back and ankle.

Step aerobics is practiced in health centres, fitness training gyms, and academic

institutions all over the World. Step test is gaining popularity among the Indian women population because of its simplicity to carry out in gyms as well as in households. Recent investigation of acute cardiorespiratory responses to the current popular style of bench step exercise has validated its use in improving aerobic physical fitness particularly in women [11]. Efficacy of step test aerobics as a safe fitness training module for Indian women has not yet been established. Hence, the present study was undertaken to assess the effect of best step height on cardiorespiratory responses during 30 min aerobic bench step test in young Indian females. The study was also aimed to identify suitable stepping bench height to develop and maintain cardiorespiratory fitness safely by Indian females at cadence of 120 beats.min<sup>-1</sup>.

### Material and Methods

**Subjects:** Eight physically fit and active female university students of age group 18-24 yrs volunteered for the study. Height, weight and body mass index (BMI) were measured by using BMI measuring instrument (Seca 767, Hamburg, Germany). The physical characteristics of the subjects are given in table-1. All the subjects were thoroughly informed about the purpose, risk and benefits of the study. The study protocol was approved by the Institute's ethics committee and this experiment conforms to the principles outlined by the declaration of Helsinki protocol, 1964. Subjects gave their informed consent before the start of the experiment.

**Measurement of  $VO_{2max}$ :** On the first and second day the subjects were habituated to walking at various speeds and gradients, on a motorized treadmill (Taeha, Intertrack 6025, Korea) in the laboratory. Following the process of treadmill habituation,  $VO_{2max}$  of the subjects was measured in treadmill on the third and fourth day with regular increase in gradient [Harbor Protocol, 12]. During the measurement of  $VO_{2max}$  subjects wore T-shirt, shorts and physical training (PT) shoes. Subjects were allowed to rest on the fifth day.

**Exercise protocol:** Thirty minutes of step test in two Reebok bench (length 40 inch and height 6 and 8 inch) with a cadence of 120 beats.min<sup>-1</sup> (musical rhythm) was used by each subject for experimental purpose. The choreographed exercise included 'traditional' stepping such as

"right foot up left foot up, right foot down, left foot down" followed by the opposite e.g. "left foot up, right foot up, left foot down, right foot down". These steps were alternately repeated in the exercise bout. Figure-1 shows the performance of step test on Reebok bench. This arrangement was finalized when every participant became familiar with the protocol. A certified physical education and aerobics trainer (female) monitored training and exercise protocol throughout the study. From the sixth day onwards bench step aerobics experiment was carried out. Each subject was required to complete bench step test on two bench heights (6 inch and 8 inch) i.e. two conditions per day between 0930 hrs to 1300 hrs, with at least 90 min rest in between trials. The rest was necessary to eliminate fatigue effect and allow the subject for full recovery. Subjects wore the same dress as during  $VO_{2max}$  test.

**Figure-1:** Step test is being performed on Reebok bench



**Physiological parameters:** During bench step aerobics experiment heart rate (HR), oxygen consumption ( $VO_2.kg^{-1}$ ), energy expenditure (EE) of each individual were recorded by breath by breath gas analysis using K4b<sup>2</sup> system (Cosmed S.r.l, Italy). The accuracy of the K4b<sup>2</sup> system in measuring the respiratory gases is already established [13]. The same system was used to measure  $VO_{2max}$  as well.

The system was calibrated with room air and standard gas mixture (16% O<sub>2</sub> and 5% CO<sub>2</sub>) at the beginning of each day's work. The subjects were asked to breath normally at rest and during exercise. Average of last five minutes of 30 minutes exercise trial was considered as individual value. Relative work load (%VO<sub>2max</sub>) was calculated from the VO<sub>2</sub> value as percentage of VO<sub>2max</sub> of each subject. Maximum HR of each subject was assumed by the age predicted method [14]. Percentage of maximum HR was calculated from the age predicted maximum HR.

**Statistics:** Student's 't' (paired) tests was applied as same subjects were used in both the step heights to see the level of significance across the conditions. For the entire test statistical significance were verified at p< 0.05.

**Results**

Parameters	Mean	SD
Age (years)	19.7	2.3
Height (cm)	156.2	6.5
Weight (kg)	51.2	7.9
BMI (kg/ m <sup>2</sup> )	21.1	2.3
VO <sub>2max</sub> (ml.min <sup>-1</sup> .kg <sup>-1</sup> )	35.7	4.8
Age predicted HR <sub>max</sub> (beats. min <sup>-1</sup> )	200.2	2.2

Parameters	Bench heights (Inch)		% increase	P value
	6	8		
VO <sub>2</sub> (ml.min <sup>-1</sup> .kg <sup>-1</sup> )	18.7±3.5	20.9±4.0	12.1*	0.01
HR (beats.min <sup>-1</sup> )	160.4±8.7	172.3±9.7	4.4*	0.00
EE (kcal. min <sup>-1</sup> )	4.9±1.1	5.5±0.8	11.9*	0.01
%VO <sub>2max</sub>	53.3±7.1	58.7±11.8	8.8*	0.04
% of predicted HR <sub>max</sub>	86±4.9	89.7±4.2	4.4*	0.00

\* P<0.05, EE- Energy Expenditure

The mean (SD) age, height, weight, BMI and age predicted maximum heart rate of the subjects

were 19.7 (2.3) yrs, 156.2 (6.5) cm, 51.2 (7.9) kg, 21.1 (2.3) kg.m<sup>-2</sup> and 200.3 (2.2) beats.min<sup>-1</sup> respectively (table-1). A descriptive statistics in the form of mean and standard deviation is presented in table- 2 for various cardio respiratory parameters eg. VO<sub>2</sub>, HR, EE, %VO<sub>2max</sub> and % of predicted HR<sub>max</sub> during aerobic bench test at two step height (6 inch and 8 inch). Students't' test (paired) revealed significant (p<0.05) effect of bench height on all parameters (VO<sub>2</sub>, HR, EE, %VO<sub>2max</sub>). It has been observed that response of all the cardiorespiratory parameters except %VO<sub>2max</sub> showed an increasing trend with increasing step height. These parameters increased from 6 inch step height to 8 inch step height from 18.7 to 20.9 ml.min<sup>-1</sup>.kg<sup>-1</sup> (VO<sub>2</sub>), 160.4 to 172.3 beats.min<sup>-1</sup> (HR), 4.9 to 5.5 kcal. min<sup>-1</sup> (EE), 53.3 to 58.7 % of VO<sub>2max</sub> and 86.0 to 89.7 % of age predicted HR<sub>max</sub> respectively. Table-3 shows a comparison of % of age predicted HR<sub>max</sub> and %VO<sub>2max</sub> between the present study and ACSM recommendations.

Parameters	ACSM recommendations	Observed in present study	
		6 inch step height	8 inch step height
% of age predicted HR <sub>max</sub>	70% - 85%	86.0%	89.7%
%VO <sub>2max</sub>	50% - 85%	53.3	58.7

**Discussion**

The linear increase in HR and VO<sub>2</sub> with increasing bench height has been observed during bench step aerobics [7, 15-16]. In the present study we found similar changes in the cardiorespiratory responses. Grier et al. [17] conducted aerobic bench stepping exercise with varying bench height and cadences on women (n=30) to find out metabolic and cardiovascular responses. They observed significant differences in physiological responses (HR and VO<sub>2</sub>) between two bench heights (6 and 8 inch). They also reported that on an average 2 inch increase in bench height,

HR and  $VO_2$  increased by 10  $\text{beats}\cdot\text{min}^{-1}$  and  $3.09 \text{ ml}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$  respectively. Stanforth et al. [6] stated that during bench stepping exercise in females,  $VO_2$  significantly increased with increasing bench height. Similarly, in the present study a significant change in HR and  $VO_2$  were observed while stepping on 6 and 8 inch benches. HR and  $VO_2$  increased by 12  $\text{beats}\cdot\text{min}^{-1}$  and  $2.2 \text{ ml}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$  respectively in 8 inch bench when compared to 6 inch bench. Sutherland et al. [18] conducted aerobic step exercise on female population using 6, 8 and 10 inches bench height to evaluate exercise intensity. They reported that the mean intensities were 45.6%, 51.6% and 56.2% of  $VO_{2\text{max}}$  for the 6, 8 and 10 inch steps, respectively. In the present study, it is observed that exercise intensity increased from 53.3% to 58.7% of  $VO_{2\text{max}}$  from 6 to 8 inch step height.

According to ACSM [19] the exercise intensity is measured by using  $VO_2$  and HR responses during exercise. The guidelines state that exercise at 50- 85% of  $VO_{2\text{max}}$  and 70- 85% of  $HR_{\text{max}}$  are sufficient to bring about improvement in cardiorespiratory fitness when combined with an appropriate frequency and duration of exercise. It

was observed in the present study that aerobic step test with 6 inch and 8 inch bench height demanded 53.3% and 58.7% of  $VO_{2\text{max}}$  and 86.0 % and 89.7 % of age predicted  $HR_{\text{max}}$  respectively. The relative work load demand in both bench heights were well within the ACSM recommendations (50-85% of  $VO_{2\text{max}}$ ). But HR response with 6 inch step height was almost within the limit (85% of age predicted  $HR_{\text{max}}$ ).

This study demonstrated that aerobic stepping on 6 inch bench height for 30 minutes with a cadence of  $120 \text{ beats}\cdot\text{min}^{-1}$  may be useful exercise module to improve cardio respiratory fitness for Indian young females as per the international standard [19]. Present study qualifies in identifying for the first time a suitable bench stepping height for Indian young women population for safely maintaining cardiorespiratory fitness.

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