



Acute adjustments of heart rate and oxygen consumption in an experimental protocol of step training with different combinations of platform height and musical rhythms

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ABSTRACT. The aim of this study was to investigate adaptations acute heart rate (HR) and oxygen consumption (VO_2) in an experimental protocol of step training with different combinations of platform height (15.2, 20.3 and 25.4 cm) and musical rhythms (125, 135 and 145 bpm). Thirty-five women were randomly selected, (mean \pm DP) aged 21.6 ± 1.8 years, body weight of 57.8 ± 8.2 kg, height of 162.6 ± 6.8 cm, body mass index of 21.8 ± 2.5 kg m^{-2} and fat percentage (% Fat) of $24.8 \pm 4.4\%$, with at least six months experience in step training sessions, and a frequency of at least two days a week. Techniques of descriptive and inferential statistics were employed. A significant difference was detected for the HR and VO_2 in relation to the increase in step platform height and in musical rhythm for all the combinations, except for three situations. From the obtained results, we can infer that the cardiovascular and metabolic responses increase or decrease according to the musical rhythm and/or platform height.

Keywords: step training sessions, healthy women, weight loss, physical fitness.

Adaptações agudas da FC e do VO_2 em um protocolo experimental de 'step training' com diferentes combinações de altura de plataforma e ritmos musicais

RESUMO. O objetivo do presente estudo foi verificar adaptações agudas da frequência cardíaca (FC) e do consumo de oxigênio (VO_2) em um protocolo experimental de 'step training' com diferentes combinações de altura de plataforma (15,2, 20,3 e 25,4 cm) e ritmos musicais (125, 135 e 145 bpm). Foram selecionadas aleatoriamente 35 mulheres (média \pm DP) idade de $21,6 \pm 1,8$ anos, peso corporal de $57,8 \pm 8,2$ kg, estatura de $162,6 \pm 6,8$ cm, índice de massa corporal (IMC) de $21,8 \pm 2,5$ kg m^{-2} e percentual de gordura (% G) de $24,8 \pm 4,4\%$, com no mínimo seis meses de experiência nas aulas de 'step training' e com frequência de pelo menos dois dias por semana. Foram aplicadas as técnicas da estatística descritiva e da estatística de inferência. Foi observada diferença significativa para FC e o VO_2 em relação à ocorrência do aumento da altura do 'step' e em relação ao aumento do ritmo musical para todas as combinações, exceto entre três situações. A partir dos achados do presente estudo pode-se inferir que as respostas cardiovasculares e metabólicas aumentam ou diminuem ao se elevar ou atenuar o ritmo musical e/ou a altura da plataforma.

Palavras-chave: sessões de step training, mulheres saudáveis, emagrecimento, aptidão física.

Introduction

The American College of Sports Medicine (ACSM, 2009) suggests the inclusion of aerobic activity three to five days a week, with intensities of 50% to 85% of aerobic consumption of reserve. This recommendation aims the optimal fitness, generating minimum caloric expenditure of 300 kg cal^{-1} per workout. Among aerobic activities used for this purpose are the individual such as walking, running, stationary bike, swimming, or collective activities that can practiced in fitness centers, such as aerobics, step training, jump fit, among others.

The step training (ST) was born in the United States about 20 years ago. The activity consists of step up and down an adjustable platform (10-30 cm height) in varying rhythms, considered an excellent modality for different people and levels of fitness. It is a modality with high intensity and low impact, probably a great method to optimize the levels of fitness (LUCCA et al., 2008).

The achievement of the objectives in the ST sessions depends on the platform height and musical rhythms, closely related with training intensity, and directly influence on the oxygen consumption

(MARTINOVIC et al., 2002; LUCCA et al., 2008; GROSSL et al., 2008). Other variables seem to interfere on the oxygen; LATIN et al., 2001; MARTINOVIC et al., 2002; consumption, such as body weight, height, age, fitness level and body fat percentage (MARTINOVIC et al., 2000; GRIER et al., 2002; ACSM, 2009).

Martinovic et al. (2002) evaluated cardiovascular and metabolic responses during continuous movements of choreographed exercises of step training at 15.2 and 20.3 platform heights with a musical cadence of 132 bpm. Grier et al. (2002) studied cardiovascular and metabolic responses of step training with choreographed movements of legs and arms at 15.2 and 20.3 cm heights and cadences of 125 and 130 bpm. Skelly et al. (2003) compared the physiological and biomechanical responses of high school-age women, on three different surfaces, during three different movements of step training. Vianna et al. (2005) related the HRmax and VO₂max obtained in choreographed exercises of step training with cyclical activities, using a 18 cm-platform height in a cadence of 135 bpm of music speed.

Lucca et al. (2008) analyzed cardiovascular responses during step training choreographed in 10 cm-platforms height (ST10) in musical rhythm of 135 bpm and the effects caused by ST10 in aerobic power of young college women. Zaletel et al. (2009) compared possible differences between HR values and maximum blood lactate concentration evaluated during a 30 min.-session of step training choreographed at three different platform heights (20, 25 and 30 cm) in a 135 bpm musical rhythm.

However, by reviewing the literature no researcher compared the heart rate and oxygen consumption using more than two platform heights and more than two musical rhythms. Thus, the present study examined acute adjustments of heart rate (HR) and oxygen consumption (VO₂) in an experimental protocol of step training with different combinations of platform height (15.2, 20.3 and 25.4 cm) and musical rhythms.

Material and methods

Sample

It was selected at random 35 women (mean \pm SD) aged 21.6 ± 1.8 years, body weight 57.8 ± 8.2 kg, height 162.6 ± 6.8 cm, BMI 21.8 ± 2.5 kg m⁻² and body fat percentage (% Fat) $24.8 \pm 4.4\%$. As inclusion criterion, the practitioners should have at least six months experience in ST sessions, and a frequency of at least two days a week. As exclusion

criterion, it was not allowed to take part of this study those individuals with ergogenic resources, or those with any type of joint limitation or osteomioarticular problem that could influence the performance of proposed exercises.

Before data gathering, the volunteers responded to the questionnaire PAR-Q (SHEPHARD, 1998) and signed the Consent Form, according to Resolution 196/96 of the National Council of Health.

Proceedings

The study had met the standards to accomplish studies with human beings of the National Council of Health, Resolution 196/96 from 10/10/1996. The project was approved by the Research Ethics Committee involving human beings of the University of Castelo Branco, under the protocol no. 0048/2008.

The collection of data was made in the Motor Assessment Laboratory (MAL) of the Faculty of Physical Education of the Federal University of Juiz de Fora (UFJF). The volunteers were instructed to abstain from caffeine and alcohol for 24h, and all food, drink and nicotine for 2h before the tests. Additionally, the participants were instructed to not perform any sort of physical activity for 48h before the tests. Initially, they attended the laboratory to evaluate their anthropometric measurements (height and body mass), to verify the body composition (fat percentage) and to perform the step test, aiming to determine metabolic and cardiorespiratory responses.

First, it was recorded a music CD with 15 min. duration containing three musical rhythms, 125 bpm, 135 bpm and 145 bpm (R125, R135 and R145), 5 min. of music for each musical rhythm. This CD was used in the experimental protocol of the step test with three heights of step platform: 15.2 cm, 20.3 cm and 25.4 cm (A15, A20 and A25). At the end of each step height (A15, A20 and A25), a 5 min.-interval was given for the participants to rest, drink water and for the teacher change the platform height.

Tests

Height was measured using a stadiometer (Sanny®) accurate to 0.1 cm. The body mass was determined in a scale (Filizola®; Brazil) accurate to 100 g. The BMI was obtained by dividing body weight by height squared (kg m⁻²). The body fat percentage was measured with a scientific adipometer (Lange®; USA) as described by Lohman et al. (1984). The relative body fat was determined by the equation of Siri et al. (1961), from an estimate of body density determined by the protocol of Pollock and Wilmore (1993).

In the experimental protocol of the step test, it was registered the VO₂ and HR, between the combinations

of the different variations of platform height: 15.2 cm (A15); 20.3 cm (A20) and 25.4 cm (A25), and of musical rhythms: 125 bpm (R125), 135 bpm (R135) and 145 bpm (R145). The step used in the test was of 'Reebok®' brand. The exhaled air was measured using the metabolic analyzer Aerosport TEEM 100 (Aerosport, Ann Arbor, MI). it was registered the average of 20 s of oxygen consumption (VO_2). A prior investigation showed that Aerosport TEEM 100 is a validated instrument to measure VO_2 (WIDEMAN, et al., 1995). The heart rate (HR) was monitored with a heart monitor (Polar® Accurex) at the end of each 5 min. of test. The mean value of the last 2 min. in each rhythm and height of the experimental protocol was used for calculating averages HR and VO_2 .

Familiarization of the experimental protocol of the step test

The experimental protocol of the step test was developed to maintain the characteristics of the class and the choreography was tested twice a week, for two months, to better familiarize the choreographic movements by the volunteers.

The choreographic structure of the step session was composed of three crossed blocks of choreography, although in the choreography test it was used the pre-step, the intermediate and final steps, the pre-step and the intermediate step were not used in the trial. Since it was chosen, for this study, the final choreography, i.e., the crossing of the three choreographic blocks (final step).

The stages below describe the final step of each block. They were described only to the right side. It was repeated the same choreography to the left side, where (I) means an eight musical. (Table 1)

Block 1

I – two inverted horses (1 to the right (R) and one to the left (L)).

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I – basic middle (up) (R) + two kicks to the side (R + L) and down (R).

I – three lifting alternate knees frontally. E.g. R (step) L (floor) R (step).

Block 2

I – one basic cross (R) + knee high (R).

I – basic middle (up) (L) on the step side + one mambo (L) on the floor, as if walking, using the step and the floor, stepping back behind the step (L) and down the step with a backward mambo (L), like a setback.

I – basic middle (L) (up) two frontal mambo on the floor (L + R).

I – two backward mambo on the floor (L + R) and basic middle (L) (down).

Block 3

I – three lateral kicks on the floor (R + L + R), and the last, besides kicking with the (R) also makes a knee high (R) simultaneously. Repeat to the other side, i.e., three lateral kicks on the floor (L + R + L), the last, besides kicking with the (L) also makes a knee high (L) simultaneously.

I – step with the (L) front (step), side (floor), back (floor) + one knee (L).

I – basic middle upward laterally on the step (R) and jumps laterally alternating the step and the floor four times (R L R L), and in the last, jump with the (L) and make a knee high (L) simultaneously.

I – one mambo (L) on the floor + setback and shortly thereafter, repeat for the other side one mambo (R) on the floor + setback.

Table 1. Choreography design.

1 st Block	R	L	R	L	-	L	R	L	R
	I	I	I	I		I	I	I	I
2 nd Block	R	L	R	L	-	L	R	L	R
	I	I	I	I		I	I	I	I
3 rd Block	R	L	R	L	-	L	R	L	R
	I	I	I	I		I	I	I	I

Obs. The letters D and E above the symbols I mean that this musical eight begins with the right leg (R) or left leg (L), alternately.

The blocks were performed in a crossed way, as shown in Figure 1.

Starting from the 1st block on the right side, followed by the 2nd block on the left side, passing to the 3rd block on the right side, extending to the 1st block on the left, 2nd block on the right, and finally the 3rd block on the left.

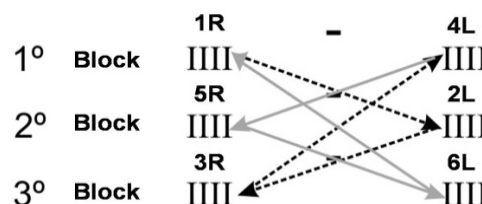


Figure 1. Order of blocks execution.

Statistical analysis

It was applied the techniques of descriptive statistics to characterize the studied sample, and the inference statistics, in which are presented the analytical data of the tests. An analysis of variance for repeated measures was employed, followed by Tukey's test, adopting $p \leq 0.05$. These analyses were made using the software SigmaStat 3.0.

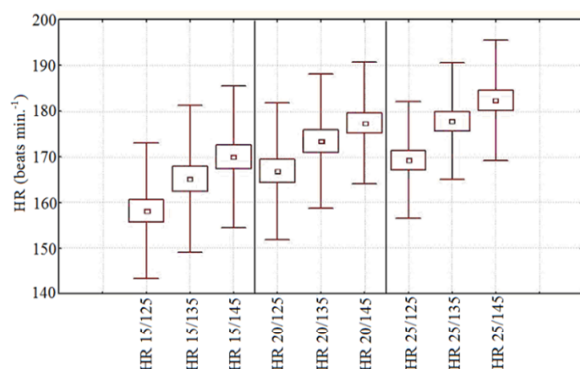
Results

The Table 2 lists the data of HR, VO_2 in the different combinations of height and rhythms.

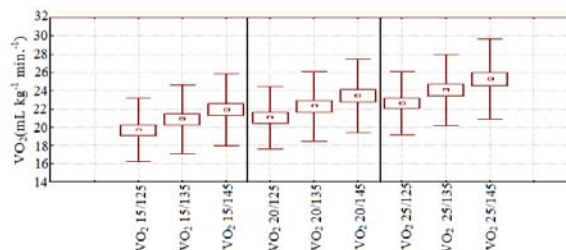
Table 2. Heart rate and oxygen consumption obtained with different combinations of height and musical rhythms.

Heart rate (HR)	(bpm)		Oxygen consumption (VO ₂)	(mL kg ⁻¹ min. ⁻¹)	
	Mean	SD		Mean	SD
HR A15/R125	158	15	VO ₂ A15/R125	19.7	3.5
HR A15/R135	165	16	VO ₂ A15/R135	20.9	3.8
HR A15/R145	170	16	VO ₂ A15/R145	21.9	3.9
HR A20/R125	167	15	VO ₂ A20/R125	21.0	3.4
HR A20/R135	173	15	VO ₂ A20/R135	22.3	3.8
HR A20/R145	177	13	VO ₂ A20/R145	23.5	4.0
HR A25/R125	169	13	VO ₂ A25/R125	22.6	3.5
HR A25/R135	178	13	VO ₂ A25/R135	24.0	3.9
HR A25/R145	182	13	VO ₂ A25/R145	25.3	4.4

The Figure 2 shows, through analysis of variance and Tukey's test, the significant difference ($p < 0.05$) for HR with increasing height of the platform (A15, A20, A25) and in relation to the increase in musical rhythm (R125, R135, R145), except in three situations: a) HR A15/R135 x HR A20/R125; b) HR A15/R145 x HR A20/R135, and c) HR A20/R135 x HR A25/R125. These values were: a) 165 bpm x 167 bpm; b) 170 bpm x 173 bpm; and c) 173 bpm x 169 bpm, respectively. The cardiovascular responses in relation to HR seem to be similar between these heights and rhythms.

**Figure 2.** Heart rate in different heights (A15, A20, A25) and musical rhythms (R125, R135, R145).

The figure 3 pointed out, through the analysis of variance and Tukey's test, a significant difference ($p < 0.05$) for the VO₂ with increasing height of the platform (A15, A20, A25) and increased musical rhythm (R125, R135, R145), except for three situations: a) VO₂ A15/R135 x VO₂ A20/R125; b) VO₂ A15/R145 x VO₂ A20/R135, and c) VO₂ A20/R135 x VO₂ A25/R125. These values were: a) 20.9 mL kg⁻¹ min.⁻¹ x 21.0 mL kg⁻¹ min.⁻¹; b) 21.9 mL kg⁻¹ min.⁻¹ x 22.3 mL kg⁻¹ min.⁻¹ and c) 22.3 mL kg⁻¹ min.⁻¹ x 22.6 mL kg⁻¹ min.⁻¹, respectively. The metabolic responses in relation to VO₂ appear to be similar between these heights and rhythms.

**Figure 3.** Oxygen consumption in different heights (A15, A20, A25) and musical rhythms (R125, R135, R145).

The results of the present study indicated significant difference for HR and VO₂ when it was increased the height of the platform and the musical rhythm for all combinations, except for three situations: a) 165 bpm x 167 bpm; b) 170 bpm x 173 bpm; and c) 173 bpm x 169 bpm; and a) 20.9 mL kg⁻¹ min.⁻¹ x 21.0 mL kg⁻¹ min.⁻¹; b) 21.9 mL kg⁻¹ min.⁻¹ x 22.3 mL kg⁻¹ min.⁻¹ and c) 22.3 mL kg⁻¹ min.⁻¹ x 22.6 mL kg⁻¹ min.⁻¹. A drawback of our study was related to the collection of the experimental protocol, which had occurred in the same day due to the difficulty to collect the data of each one of the individuals of the sampling group ($n = 30$).

Discussion

The present study verified acute adjustments of heart rate (HR) and oxygen consumption (VO₂) in an experimental protocol of step training with different combinations of platform height (15.2, 20.3 and 25.4 cm) and musical rhythms (125, 135 and 145 bpm).

Lucca et al. (2008) evaluated cardiovascular responses (aerobic power) during step training choreographed on platforms with 10cm height and musical rhythm of 135 bpm in young college women. The results showed that the average consumption of O₂ was 18.9 ± 0.41 mL kg⁻¹ min.⁻¹, with mean HR of 134.89 ± 1.83 bpm. The study performed by Martinovic et al. (2002) examined cardiovascular and metabolic responses during continuous movements of choreographed exercises of step training at 15.2 and 20.3 platform heights with a musical cadence of 132 bpm. Their results of HR and VO₂ were lower for the platform of 15.2 cm, in relation to that with 20.3 cm, i.e., mean HR of 138.33 bpm to A15.2; and 152.37 bpm to A20.3 with average VO₂ of 26.0 mL kg⁻¹ min.⁻¹ and 29.93 mL kg⁻¹ min.⁻¹, respectively. Comparing the results of VO₂ from Lucca et al. (2008) and HR and VO₂ from Martinovic et al. (2002) with our results, it can be noticed that both variables HR and VO₂, in the three studies, at lower platforms, had lower responses in relation to those with greater height.

The study carried out by Grier et al. (2002) analyzed metabolic and cardiovascular responses of step training choreographed with movements of legs and arms at 15.2 and 20.3 cm heights and cadences of 125 and 130 bpm. Their results were: for the combination A15.2 x R125, a mean HR of 153.6 bpm and average VO_2 of $22.9 \text{ mL kg}^{-1} \text{ min}^{-1}$; A20.3 x R125, a mean HR of 165.4 bpm and average VO_2 of $27.0 \text{ mL kg}^{-1} \text{ min}^{-1}$; A15.2 x R130, a mean HR of 156.9 bpm and average VO_2 of $24.0 \text{ mL kg}^{-1} \text{ min}^{-1}$; A20.3 x R130, a mean HR of 165.1 bpm and average VO_2 of $26.0 \text{ mL kg}^{-1} \text{ min}^{-1}$. In the present study, we found higher values for HR and VO_2 in the height 20.3 cm, in relation to 15.2 cm, but it was not registered significant difference for these variables between the rhythms of 125 bpm and 130 bpm. The authors have concluded that the rhythm had no influence on the oxygen consumption, but the step height was able to influence it significantly. Comparing our results, we can infer that both studies found higher responses of HR and VO_2 in the greater heights of the platforms, even when considering the upper limbs movements in the choreography.

Skelly et al. (2003) compared physiological and biomechanical responses of high school aged women, on three different surfaces, during three different movements of step training. The result found for HR for the combination A20 x R124 was 170 bpm, and in our study was 167 bpm, for the combination A20 x R125. In relation to VO_2 , Skelly et al. (2003) registered an average value of $25.6 \text{ mL kg}^{-1} \text{ min}^{-1}$, higher than the average VO_2 in the present study ($21.0 \text{ mL kg}^{-1} \text{ min}^{-1}$). The likely factors that may have influenced these differences were that the study of Skelly et al. (2003) used three exercises with basic movements with duration of 2 min. for each movement without choreography, while in the present study we used a complex choreography from a typical session of step training performed in fitness centers. Other factors that might have influenced this result were the size and the training level between the samples.

The purpose of the study of Vianna et al. (2005) was to relate the HR and the VO_2 obtained in choreographed exercises of step training with cyclical activities, using a 18 cm-platform height in a cadence of 135 bpm of music speed. The results were 174.8 ± 13.2 bpm of HR, and $21.8 \pm 3.1 \text{ mL kg}^{-1} \text{ min}^{-1}$ of VO_2 . Our study found for the combination A20 / R135 a HR of 173 ± 15 bpm and VO_2 of $22.3 \pm 3.8 \text{ mL kg}^{-1} \text{ min}^{-1}$, evidencing a high similarity with the results of the study above. This

similarity may have occurred due to the very close characteristics of the samples, as the place of the experiment, average age, gender, and complexity of the experimental protocol.

The VO_2 results for the different combinations were $21.37 \pm 5.92 \text{ mL kg}^{-1} \text{ min}^{-1}$ for A15.2 x R128; $23.10 \pm 5.98 \text{ mL kg}^{-1} \text{ min}^{-1}$ for A15.2 x R134; $29.83 \pm 6.66 \text{ mL kg}^{-1} \text{ min}^{-1}$ for A25.4 x R128 and $29.64 \pm 9.54 \text{ mL kg}^{-1} \text{ min}^{-1}$ for A25.4 x R134. It was found significant difference as for the variation in platform height, but not between musical rhythms for the same height. In turn, in our study, the VO_2 results for the different combinations were $19.7 \pm 3.5 \text{ mL kg}^{-1} \text{ min}^{-1}$ for A15 x R130; $20.9 \pm 3.8 \text{ mL kg}^{-1} \text{ min}^{-1}$ for A15 x R135; $22.6 \pm 3.5 \text{ mL kg}^{-1} \text{ min}^{-1}$ for A25 x R130; $24.0 \pm 3.9 \text{ mL kg}^{-1} \text{ min}^{-1}$ for A25 x R135. We found significant differences between all these combinations of platform height and musical rhythm in VO_2 values. The study had met the recommendations of ACSM (2009) in relation to HR and VO_2 , which suggest 20 to 30 daily minutes of continuous or intermittent aerobic exercise at intensity between 60% and 90% of HRmax, or 50% and 85% of $\text{VO}_{2\text{max}}$ three to five days a week.

Moreover, Zaletel et al. (2009) sought to establish possible differences between FC values and maximum blood lactate concentration evaluated during a 30 min.-session of step training choreographed at three different platform heights (20, 25 and 30 cm) in a 135 bpm musical rhythm. Their results were: for the HR 164 ± 1.17 bpm for A20 x R135; 166.8 ± 1.65 bpm for A25 x R135 and 175.4 ± 1.59 bpm for A30 x R135. It was found a significant difference in the mean values of HR between different heights for the same musical rhythm. In the same way, in the present study it was also found a significant difference in mean HR as for the increase in platform height for the same musical rhythm, corroborating the findings of Zaletel et al. (2009).

Conclusion

In summary, there were significant differences ($p \leq 0.05$) in the mean values of HR and VO_2 , for all combinations of rhythm and height of the step, except for the followings: a) A15/R135 x A20/R125; b) A15/R145 x A20/R135 and c) A20/R135 x A25/R125. Therefore, it can be inferred that cardiovascular and metabolic responses increase or decrease when elevating or attenuating the musical rhythm and/or platform height.

Regarding the application of these results, in practice, the professional can choose to change the

platform height and/or musical rhythm to reach higher workout intensity, as a function of the biological activity of each student.

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