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Acute energy expenditure induced by a 20-minute Lion Fitness stair simulator session in active young adults

Gasto energético agudo induzido por uma sessão de 20 minutos no simulador de escadas Lion Fitness em adultos jovens ativos

Gasto energético agudo inducido por una sesión de 20 minutos en el simulador de escaleras Lion Fitness en adultos jóvenes activos

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Valter Mariano dos Santos Junior
ORCID: https://orcid.org/0000-0002-2650-9441
Universidade de São Paulo, Brazil
Universidade Brasil, Brazil
E-mail: profvaltermariano@gmail.com
Artur Gutierrez Rocha
ORCID: https://orcid.org/0009-0001-7822-5969
Centro Universitário de Votuporanga, Brazil
E-mail: arturrocha@live.com
Jean César Andrade de Souza
ORCID: https://orcid.org/0000-0002-0313-0279
Centro Universitário de Votuporanga, Brazil
E-mail: jeancesar.andrade@gmail.com
Thaisa Silva de Sousa
ORCID: https://orcid.org/0000-0001-6423-7347
Universidade Brasil, Brazil
E-mail: thasfs@gmail.com
Luan Souza do Nascimento
ORCID: https://orcid.org/0000-0001-6829-3258
Universidade Brasil, Brazil
E-mail: jeancesar.andrade@gmail.com
Fernando Ferreira da Silva
ORCID: https://orcid.org/0009-0008-8387-9570
Universidade Brasil, Brazil
E-mail: treinadorpessoalfernando@gmail.com
Reury Frank Pereira Bacurau
ORCID: https://orcid.org/0000-0003-1777-294X
Universidade de São Paulo, Brazil
E-mail: reurybacurau@usp.com.br

Abstract

The development of equipment that simulates functional movement patterns has expanded training options, with stair simulators standing out as tools that demand high metabolic effort while providing low joint impact. However, studies on the acute effects of this modality are still lacking, especially regarding differences between men and women. The aim of this study was to analyze the energy expenditure of a 20-minute session on the Lion Fitness Stair Simulator in physically active young adults. Thirty participants (15 men and 15 women) took part in a protocol consisting of warm-up, a main phase with progressive intensity up to 5 floors/minute, and cooldown. Energy expenditure was measured by direct ergospirometry, and heart rate was continuously monitored. The results showed significantly higher energy expenditure in men (378 ± 20 kcal) compared to women (323 ± 18 kcal; $p = 0.003$). No relevant differences were found in mean heart rate or perceived exertion, suggesting similar relative intensity between sexes. In conclusion, a single session on the stair simulator is effective and safe to induce high caloric expenditure in a short period, approaching daily physical activity recommendations for weight control and cardiovascular health. The equipment shows applicability in conditioning, rehabilitation, and health promotion programs.

Keywords: Stair climbing; Energy metabolism; Endurance training; Exercise.

Resumo

O desenvolvimento de equipamentos que simulam padrões funcionais de movimento tem ampliado as opções de treinamento, em destaque os simuladores de escada são ferramentas de alta demanda metabólica e baixo impacto articular. Contudo, faltam estudos sobre os efeitos agudos dessa modalidade, especialmente considerando diferenças entre homens e mulheres. O objetivo deste estudo foi analisar o gasto energético de uma sessão de 20 minutos no Lion Fitness Stair Simulator em adultos jovens fisicamente ativos. Participaram 30 indivíduos (15 homens e 15 mulheres) submetidos a um protocolo com aquecimento, fase principal em intensidade progressiva até 5 andares/minuto e desaquecimento. O gasto energético foi mensurado por ergoespirometria direta e a frequência cardíaca monitorada continuamente. Os resultados mostraram gasto energético significativamente maior em homens (378 ± 20 kcal) do que em mulheres (323 ± 18 kcal; p = 0,003). Não houve diferenças relevantes na frequência cardíaca média nem na percepção subjetiva de esforço, sugerindo intensidade relativa semelhante entre os sexos. Conclui-se que uma única sessão no simulador de escadas é eficaz e segura para induzir alto gasto calórico em curto período, aproximando-se das recomendações diárias de atividade física para controle de peso e saúde cardiovascular. O equipamento apresenta aplicabilidade em programas de condicionamento, reabilitação e promoção da saúde.

Palavras-chave: Subida em escada**;** Metabolismo energético; Exercício aeróbico; Exercício físico.

Resumen

El desarrollo de equipos que simulan patrones funcionales de movimiento ha ampliado las opciones de entrenamiento, destacándose los simuladores de escaleras como herramientas que generan alta demanda metabólica con bajo impacto articular. Sin embargo, todavía faltan estudios sobre los efectos agudos de esta modalidad, especialmente en lo que respecta a las diferencias entre hombres y mujeres. El objetivo de este estudio fue analizar el gasto energético de una sesión de 20 minutos en el Lion Fitness Stair Simulator en adultos jóvenes físicamente activos. Participaron 30 individuos (15 hombres y 15 mujeres) sometidos a un protocolo que incluyó calentamiento, fase principal con intensidad progresiva hasta 5 pisos/minuto y enfriamiento. El gasto energético fue evaluado mediante ergoespirometría directa y la frecuencia cardíaca fue monitoreada de forma continua. Los resultados mostraron un gasto energético significativamente mayor en hombres (378 ± 20 kcal) en comparación con las mujeres (323 ± 18 kcal; p = 0,003). No se observaron diferencias relevantes en la frecuencia cardíaca media ni en la percepción subjetiva del esfuerzo, lo que sugiere una intensidad relativa similar entre los sexos. En conclusión, una sola sesión en el simulador de escaleras es eficaz y segura para inducir un alto gasto calórico en un corto período, acercándose a las recomendaciones diarias de actividad física para el control del peso y la salud cardiovascular. El equipo presenta aplicabilidad en programas de acondicionamiento, rehabilitación y promoción de la salud.

Palabras clave: Subida de escaleras; Metabolismo energético; Entrenamiento aeróbico; Ejercicio físico.

1. Introduction

The growing digitalization of tools for physical exercise has encouraged the development of equipment that simulates functional movement patterns, with stair simulators standing out and gaining ground in gyms and in training and evaluation protocols (Teixeira et al., 2021). These devices allow for more precise control of exercise intensity and, by involving large muscle groups, are considered effective for cardiorespiratory conditioning and increased energy expenditure (Swift et al., 2023).

Energy expenditure during physical exercise is an important marker for both body weight control and interventions aimed at cardiovascular and metabolic health (ACSM, 2022). Accurately estimating this variable in different exercise modalities is essential for appropriate exercise prescription, especially in contexts where energy efficiency and physiological response need to be individualized (Westerterp, 2013). In this sense, studies involving ergospirometry analysis and heart rate monitoring are methodologically robust for evaluating the intensity and actual energy cost of training protocols (Pimentel et al., 2021).

Stair simulators have the advantage of mimicking a daily activity—climbing stairs—which has high metabolic demand without the joint impacts present in other modalities such as running (Costa et al., 2011). Moreover, they can be safely used by physically active individuals, offering different levels of intensity controlled by speed and movement cadence.

Despite their growing popularity, there is still a lack of studies investigating the acute effect of a single stair simulator session on caloric expenditure, especially in physically active individuals with different sex and body composition

characteristics. Furthermore, metabolic responses between men and women may vary due to hormonal factors, muscle mass, and mechanical efficiency (Miranda et al., 2020), justifying the importance of sex-specific analyses.

Therefore, this study aimed to analyze the energy expenditure of a 20-minute exercise session on the Lion Fitness Stair Simulator in physically active men and women aged 18 to 35 years, using ergospirometry and heart rate monitoring. It is expected that the results will contribute to expanding the knowledge on the energy cost of practicing functional equipment-based exercises, guiding more accurate practices in exercise prescription with a focus on caloric expenditure and performance.

2. Methods

2.1 Study disign

This was a crossover-type experimental clinical trial, conducted to analyze the acute energy expenditure during a single 20-minute session of exercise on a stair simulator in a quantitative study (Pereira et al., 2018) using simple descriptive statistics using mean and standard deviation values (Shitsuka et al., 2014) and statistical analysis (Vieira, 2021). The study was carried out in an exercise physiology laboratory, with controlled temperature between 22°C and 24°C, and was approved by a Human Research Ethics Committee, in accordance with the principles of the Declaration of Helsinki (protocol number: 6.550.022; CAAE: 75019223.5.0000.0078).

2.2 Participants

The sample consisted of 30 physically active individuals, including 15 men (aged 18 to 32 years) and 15 women (aged 18 to 35 years), recruited through university announcements.The inclusion criteria were:

- classification as “active” or “very active” according to the short version of the International Physical Activity Questionnaire (IPAQ);
- prior familiarity with the Lion Fitness Stair Simulator.

2.3 Participants were excluded if they had

- musculoskeletal or joint injuries that could compromise the execution of the exercise;
- a history of uncontrolled cardiovascular or metabolic diseases;
- use of medications that could alter cardiovascular response.

2.4 Experimental protocol

Before the main session, all participants performed a standardized warm-up lasting 3 minutes at 2.5 floors per minute. The main 20-minute session on the Lion Fitness Stair Simulator was structured as follows:

- Minutes 1 to 10: started at 3 floors per minute, with increments of 0.5 floors every 2 minutes, reaching 5 floors per minute by the end of the tenth minute;
- Minutes 11 to 18: maintained intensity at 5 floors per minute;
- Minutes 19 to 20: cooldown, reducing speed to 2 floors per minute.

Throughout the session, participants were encouraged to maintain the proposed pace, without verbal communication beyond standard encouragement. Perceived exertion was measured using the CR-10 Borg Scale at the end of every two-minute block.

2.5 Energy expenditure assessment

Total energy expenditure was estimated through direct ergospirometry, using a properly calibrated VO2000 metabolic gas analyzer (MedGraphics). The following parameters were collected:

- Oxygen consumption (VO_2);
- Carbon dioxide production (VCO_2);
- Respiratory quotient (RQ).

Heart rate (HR) was continuously monitored via a portable HW electrocardiogram, synchronized with the gas analyzer.

Caloric expenditure was automatically calculated by the system software based on the traditional metabolic equation (Weir, 1949), validated for acute aerobic exercise studies.

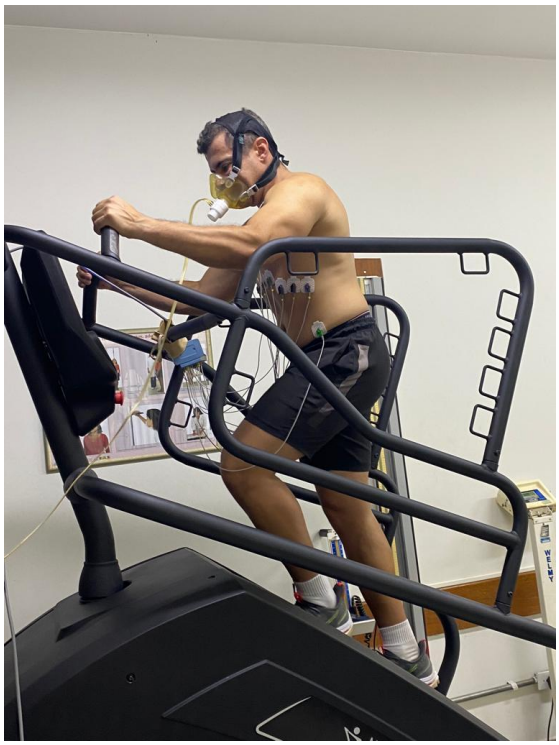
2.6 Statistical analysis

Data were organized in spreadsheets and analyzed using SPSS version 25.0. Descriptive statistics (mean and standard deviation) were applied to physiological variables. To compare energy expenditure between sexes, the independent Student's t-test was used, with a significance level of $p < 0.05$. Normality of data was verified using the Shapiro-Wilk test.

3. Results

All 30 participants completed the experimental protocol without incident. Descriptive analysis indicated that men showed a mean energy expenditure of 378 ± 20 kcal, while women had a mean of 323 ± 18 kcal at the end of the 20-minute session on the Lion Fitness stair simulator (Figure 1).

Figure 1 - Lion Fitness Stair Simulator.



Source: Authors.

The comparison between groups revealed a statistically significant difference in total energy expenditure between sexes (p = 0.003), with men showing a higher caloric demand during the exercise session.

Furthermore, the average heart rate during the main phase of the exercise was 162 ± 9 bpm for men and 158 ± 11 bpm for women, with no statistically significant difference (p = 0.19), although both groups remained within moderate to vigorous aerobic training zones, according to ACSM classification (2022).

The Rating of Perceived Exertion (RPE), assessed at the end of the session, averaged 7.8 ± 1.1 points for men and 7.4 ± 1.0 for women, with no statistically significant difference (p = 0.27).

Table 1 – Comparison between men and women in the assessed parameters.

Variable	Men (n = 15)	Women (n = 15)	p-Valeu
Caloric Expenditure (Kcal)	378 ± 20	323 ± 18	0.003 **
Heart rate	162 ± 9	158 ± 11	0.19
RPE (Borg Scale)	7.8 ± 1.1	7,4 ± 1.0	0.27

Source: Authors.

4. Discussion

The present study investigated the acute effects of a 20-minute session on the Lion Fitness Stair Simulator on energy expenditure in physically active men and women aged between 18 and 35 years. The results showed that the exercise was effective in promoting high energy demand in both sexes, with an average of 378 kcal for men and 323 kcal for women, with a statistically significant difference between groups (p = 0.003).

These findings are consistent with previous evidence that aerobic exercise involving large muscle groups, such as stair climbing, promotes high oxygen consumption and, consequently, greater caloric expenditure (Miranda, 2020). The difference observed between sexes in our study can be primarily explained by men's greater absolute muscle mass, a factor that directly influences metabolic rate during exercise (Miranda, 2020).

The average heart rate during the session remained within the moderate to vigorous aerobic training zone for both groups, according to the criteria of the American College of Sports Medicine (ACSM, 2022). The absence of a significant difference in heart rate and the Rating of Perceived Exertion (RPE) between men and women suggests that the relative intensity of effort was similar between sexes, despite the absolute difference in caloric expenditure.

The use of a stair simulator, in this context, proves advantageous by offering a cyclic, functional activity with low joint impact, favoring its application in diverse populations and in both performance and rehabilitation contexts (Boreham et. al., 2000; Teixeira et al., 2021). Furthermore, equipment like the Lion Fitness allows precise intensity control through cadence, which is useful in both scientific studies and clinical or sports practice.

A study by Prieto-González et al. (2024) examined oxygen consumption, heart rate, and energy expenditure on a stair-climbing simulator (STAIR) and reported that this modality induced high values of VO_2, HR, and energy expenditure, especially at increasing load levels of the device. This reinforces that simulated stair-climbing exercise is a feasible option to generate significant stimuli to the cardiorespiratory system, confirming the relevance of the equipment used in our study.

In a review on stair interventions, Ghosal et al. (2023) pointed out that stair climbing improves cardiometabolic parameters, energy expenditure, and vascular functions, which reinforces the practical applicability of stair-based modalities for public health promotion. Thus, our results strengthen the translational aspect: the simulator can be incorporated into training and health programs to generate important metabolic adaptations.

The finding that men showed higher absolute energy expenditure in the protocol can be partially explained by the greater lean mass volume typical of males and their higher basal metabolic rate (BMR), which is already recognized in the literature. Recent studies such as Archacki et al. (2024) have shown differences in total energy expenditure and in the contributions of energy systems between men and women during acute efforts. Other research reports that, after strength training protocols, men maintain higher absolute expenditures than women even at equal relative intensities (Del-Cuerpo et al., 2023).

However, recent works relativize or challenge the idea that there will always be disparities in acute metabolism between sexes. For example, Ramírez-Vélez et al. (2025) reported that, in the context of a sprint interval training (SIT) protocol, no significant differences were found in systemic metabolic responses between men and women. This suggests that in very intense and short modalities, the basal difference may be mitigated—and raises the hypothesis that if our protocol were even more intense or involved interval variants, the results could be closer between groups.

In addition, in post-SIT recovery studies, it was observed that men showed higher rates of lipid oxidation and post-exercise energy expenditure (EPOC) than women, although when normalized to lean mass, some differences are attenuated. This reinforces the importance of, in future studies, quantifying lean mass and expressing relative energy expenditure (kcal per kg of lean mass) to allow better comparisons between sexes (Forsyth et al., 2019).

It is important to highlight that, even in a single session, the caloric expenditure observed approaches the minimum daily recommendations for weight control and health promotion, especially when combined with appropriate nutritional strategies (Allison, 2016; Swift et al., 2018; Teixeira et al., 2021). This reinforces the potential of stair simulators as efficient tools in fitness training programs focused on energy expenditure.

Among the limitations of this study, it should be noted that the sample consisted exclusively of young, physically active individuals, which limits the generalizability of the results to sedentary, elderly, or clinically compromised populations. Furthermore, no detailed hormonal or anthropometric variables were analyzed, which could influence individual energy response.

Finally, future studies are recommended to investigate the effects of continuous protocols using the stair simulator over several weeks, as well as its effectiveness compared to other aerobic exercise modalities, such as treadmill running or cycling.

5. Conclusion

A single 20-minute exercise session on the Lion Fitness Stair Simulator was effective in promoting significant energy expenditure in physically active men and women, with mean values of 378 kcal and 323 kcal, respectively. The difference between sexes was statistically significant and is likely explained by physiological factors such as greater muscle mass in men.

The effort intensity, assessed by heart rate and perceived exertion, remained within the moderate to vigorous aerobic training zone for both groups, demonstrating that the adopted protocol was safe, applicable, and sufficiently demanding to promote metabolic adaptations.

These results highlight the potential of the stair simulator as an efficient tool for increasing caloric expenditure in physical training programs, with applicability in both conditioning contexts and body weight control strategies. The use of this equipment may represent a practical, functional, and low joint-impact alternative for Physical Education professionals and related fields.

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