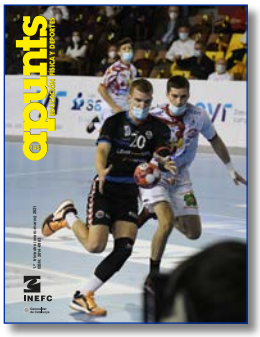
apunts EDUCACIÓN FÍSICA Y DEPORTES

ISSUE 143

Published 01 January 2021
https://doi.org/10.5672/apunts.2014-0983.es.(2021/1).143.09



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Metabolic Comparison During Protocol of Battling Rope Exercise Using Different Implementation Strategies

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Cite this article:
Rodrigues-Barbosa, R., Perrier-Melo, R,J., Brito-Gomes, J.L.,Freitas-Brito A. & Cunha-Costa, M. (2021). Metabolic Comparison During Protocol of Battling Rope Exercise Using Different Implementation Strategies. *Apunts. Educación Física y Deportes*, *143*, 84-89. https://doi.org/10.5672/apunts.2014-0983.es.(2021/1).143.09

Editor:
© Generalitat de Catalunya
Departament de la Presidència
Institut Nacional d'Educació Física de Catalunya (INEFC)

ISSN: 2014-0983

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Section:
Physical Preparation

Original language:
English

Received:
16 January 2020

Accepted:
17 July 2020

Published:
1 January 2021

Cover:
Handball Spain: Ademar León and Liberbank Sinfín play the first match with masks during a Sacyr Asobal league game in October 2020, to comply with the regional regulations of COVID-19. J.Casares/(EPA) EFE/lafototeca.com

Abstract

Introduction: High-intensity interval exercise is a training method that has been popular according to the American College of Sports Medicine. Traditionally, we verified the predominant usage of ergometers (treadmills and cycle ergometer) during interval exercise sessions. However, battle ropes exercise are a alternative to other exercise modalities. *Purpose*: The aim of the study was to compare heart rate (HR) peak and oxygen consumption (VO_2) peak during a sprint interval exercise (SIE) with a battling rope (BRP), using different execution strategies (simultaneous and alternate oscillations). Materials and Methods: Eight college men (24.9 ± 7.0 years, 25.2 ± 3.6 kg/m^2, and 38.9 ± 3.4 ml·kg^{-1}.min^{-1}) having no experience with battling rope exercises completed two different experimental sessions: simultaneous and alternating arms in a random order, and a 4 × 30 s all out (4 min of passive recovery). We used two-way analysis of variance with a significance of $p < .05$ for the analysis between groups. *Results*: The average oxygen consumption peak (VO_2 peak), obtained during the four bouts of alternating and simultaneous arms was 76.52 ± 12.71 % and 79.58 ± 15.58 %, respectively. The average HR peak reached during the four high-intensity bouts was 85.15 ± 7.10 % and 88.29 ± 5.14%, respectively. *Conclusion*: These data show that there is no difference in the acute cardiovascular response of battling rope protocol exercise involving different modes (alternate or simultaneous). These results suggest that the intensity generated during BRP exercise can be sufficient to improve and maintain maximal oxygen uptake in healthy people.

Keywords: physical exercises, performance, high-intensity interval training.

Introduction

High-intensity interval exercise is a training method that has been popular throughout the scientific community and is classified as one of the top fitness trends according to the American College of Sports Medicine (ACSM) (Thompson, 2020; Veiga et al., 2017). The intensity level of the stimulus in high-intensity conditions characterizes the method of training (Buchheit et al., 2013). When the stimulus is applied between 30 s and 4 min duration, in submaximal (>80%) or maximal (100%) intensity, it is referred to as a high-intensity interval exercise session (HIIE). Alternatively, when the said stimulus is given between 10 and 30 s, in supramaximal intensity (>100% or all out), it is called sprint interval exercise (SIE) (Buchheit et al., 2013). Studies have shown that HIIE and SIE protocols are effective for significantly improving physical fitness related to health and athletic performance (Alonso-Férnandez et al., 2017; Bishop et al., 2007; Buckley et al., 2015; Mcrae et al., 2012; Thompson, 2017).

Traditionally, we verified the predominant usage of ergometers (treadmills and cycle ergometer) during HIIE and SIE sessions. However, research has established that at least eight different devices or sporting modalities can be used. These approaches include different ergometers (rowing, elliptical) (Buckley et al., 2015; Fex et al., 2015), calisthenic exercises (burpee, squatting, jumping, jumping jacks) (Blackwell et al., 2017; Mcrae et al., 2012), sporting modalities (swimming) (Bishop et al., 2007), and implements (boxing bag, battling rope). Among these, the latter has gained scientific popularity, given its considerable advantage in practicality, low impact on joints, and low cost compared to traditional models (Brewer et al., 2018; Chen et al., 2018).

Previous investigations have analyzed the cardiometabolic response during a session of SIE with battling rope in different postures (sitting, standing, jumping) (Brewer et al., 2018) and execution strategies of movement (both simultaneous and alternate oscillations) (Ratamess et al., 2015a, 2015b). Overall, the results show that the metabolic response reached during the battling rope protocol (BRP) is similar to, or greater than, that of many traditional exercises (Ratamess et al., 2015). Nonetheless, up to the present moment, the studies that analyzed metabolic response during a BRP investigated the execution of one movement (e.g., simultaneous) or the sum of movements (simultaneous plus alternate). Therefore, we do not know if there are differences in the metabolic response during one session with different execution strategies (simultaneous vs. alternate) using battling rope exercise. Thus, the aim of the study was to compare the HR peak and VO_2 peak during an SIE with a battling rope, using different execution strategies (simultaneous vs. alternate oscillations).

Methodology

Participants

The *posteriori* sample size calculation was performed using V02 peak ANOVA-values and was based on power (1–β) .9 and an alpha error of.05. Power analyses were computed by the G*Power 3.1.9.21 (Franz Faul, Universität Kiel, Germany) for four repeated measures (correlation among the measures; r=.45), and a minimum of 8 participants were necessary to carry out the study. Eight healthy, habitually active men (24.9±7 years, 38.9±3.4 mL/kg/min) participated in this study (Table 1). Participants were recruited from the university campus, via personal or printed invitations in a university setting, and online social networks. Participants were healthy, exercised regularly before initiating the study, and none were taking any medications or supplements known to affect performance. There were no recent cases (within 12 months) of osteomyoarticular injuries, and all had negative answers to the Physical Activity Readiness Questionnaire.

We dismissed participants who were unable to complete any one of the sessions, or who started another exercise intervention. All participants were informed of the experimental procedures and signed the informed consent. The study was approved by the research ethics committee with human beings (55357016.1.0000.5192; nº033418/2016) of the local university and followed all the norms of resolution 466/12 of the Health National Board.

Procedures

We randomly selected volunteers for exercise sessions that included simultaneous arms (simultaneous) and alternating arms (alternate), in an SIE protocol with 4 × 30 s all out: 4 min of passive recovery, with 48- and 72-hour intervals between sessions. Random numbers taken from the website *www.randomizer.org* defined session randomization. Before the BRP, the volunteers rested for 5 min to analyze their resting heart rate (Polar, FT4 model, Finland) and blood pressure (OMRON DALIAN®, HEM 7113 model, China) to obtain base values at the onset of the activities. We measured the variables HR and VO_2 during the sprints (30 s) and during every minute of recovery (4 min) in all conditions.

Measurements

Initially, we measured the volunteers' body masses and height for the computation of body mass index, using a scale (Filizola, Brazil, 100g precision) and a stadiometer, following the recommendations of the *International Society for the Advancement of Kinantropometry*. To determine

the oxygen peak consumption (VO_2 peak), we used the Buckley protocol (Buckley et al., 2015) with a treadmill (Super ATL, Inbrasport, USA) and a Cortex metabolic computerized analyzer (QUARK COSMED CPET, Italy) in the mode breath by breath and Hans Rudolph Linc masks (USA). Thus, participants underwent one 2-min session of familiarization, focused on performing the exercise in BRP (both simultaneous and alternate). Following familiarization, they were asked to return to the lab between 48 and 72 hours later for the sessions.

Battling rope protocol

The volunteers completed two experimental sessions (25 min each), separated between 48 and 72 hours. Before the BRP, the participants rested for 5 min for the analysis of resting heart rate - HR and blood pressure to obtain safe values to start the efforts. Following this, they had a standard 5-min warm-up and BRP. During the BRP (simultaneous and alternate), the volunteers were instructed to perform the most repetitions in 30 s (receiving verbal conventional encouragement "go, go"), followed by a 4-min passive recovery. The stimulus: recovery (1:8) was repeated four times, totaling 18 min [4x (30 s all out, 4 min recovery)]. In the simultaneous arms session, the participants performed the repetitions simultaneously, while in the alternating arms, they alternated. The rope used was nylon, with a 9.7 m length, 11.4 kg weight, and a circumference of 17 cm, and was fastened to a rod in the ground. The volunteers held approximately 4.85 m of rope in each hand.

Statistical Analysis

Initially, we tested the normality and homogeneity *(Shapiro–Wilk and Levene)*. Two-way analysis of variance (ANOVA) with repeated measures was used to measure differences in VO_2 peak and HR peak between both exercise conditions (simultaneous and alternate arms). Tukey's post hoc analysis was used to determine significant differences. The effect size was calculated with the Psychometrica calculator. The values considered were: $\eta^2 < .20$ trivial, 0.20 – 0.59 small, 0.60 – 1.19 moderate, 1.20 – 1.99 large, and > 2.0 very large effect. The significance level was set at $p < .05$.

Results

All participants completed the stages of the study and were included in the analysis. On average, they were eutrophic, with VO_2 peak values comparable to actively trained men. Individual values are shown in Table 1 and did not identify differences in either of the variables between the participants ($p < .05$).

Figure 1 shows the response of VO_2 peak during the four sprint interval bouts. The VO_2 peak averages during each bout were 29.77 ± 5.15 vs 34.77 ± 7.46 ($p = .56$) in bout 1; 30.27 ± 4.99 vs 31.82 ± 7.17 ($p = .99$) in bout 2; 30.68 ± 7.43 vs 27.62 ± 5.95 ($p = .99$) in bout 3 and 28.23 ± 3.65 vs 29.61 ± 6.92 ($p = .99$) $ml.kg^{-1}.min^{-1}$ in bout 4, during alternating and simultaneous conditions, respectively. The session average (relative) was 76.52 ± 12.71% (alternating arms) and 79.58 ± 15.58% (simultaneous arms). The ANOVA repeated measurements showed that there was no significant

Table 1
Characteristics of the participants of the study (n = 8).

Variable	(mean ± SD)	
Age (years)	24.9 ± 7.0	
BMI (kg/m2)	25.2 ± 3.6	
Sistolic Blood Pressure rest (mmHg)	126.5 ± 10.2	
Diastolic Blood Pressure rest (mmHg)	68.8 ± 9.9	
HRrest (bpm)	65.3 ± 12.8	
HRpeak-test (bpm)	188.4 ± 10.7	
VO_2peak-test (ml/kg/min)	38.9 ± 3.4	
Variable	Alternate	Simultaneous
Average HR (bpm)	160.38 ± 16.24	166.25 ± 12.5
% HR	85.15 ± 7.10 %	88.29 ± 5.14 %
Average VO2 (ml.kg-1.min-1)	29.74 ± 5.31	30.96 ± 6.88
% VO_2	76.52 ± 12.71 %	79.58 ± 15.58 %

Note. VO_2 peak = peak oxygen uptake; HR peak: heart rate peak VO_2 peak reached in a session

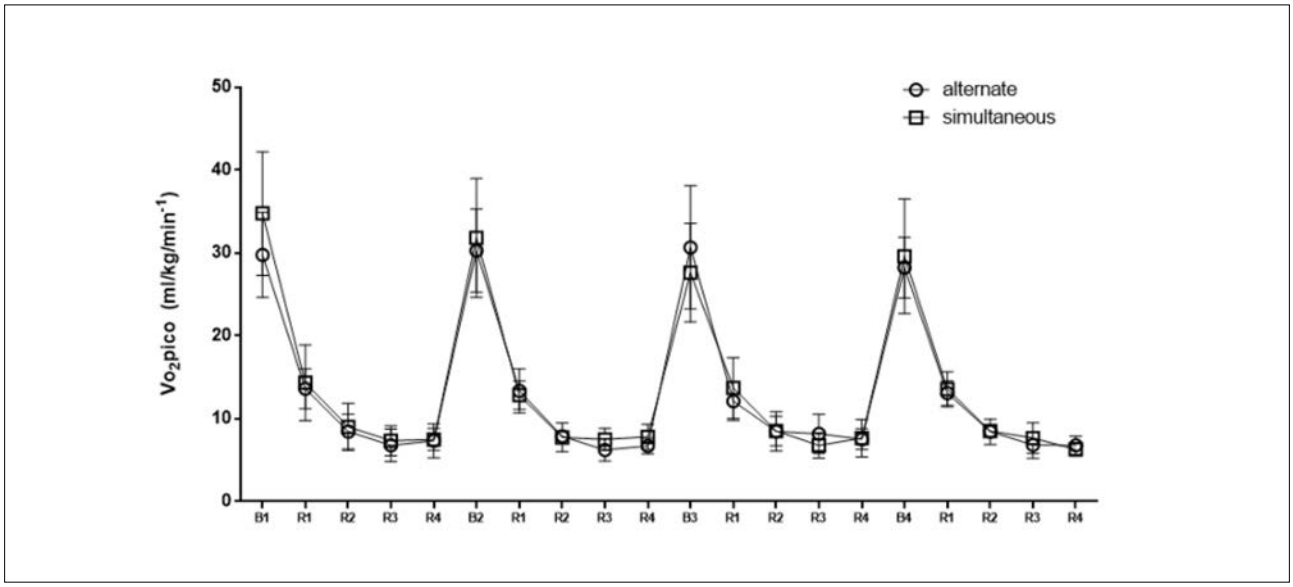

Figure 1
VO_2 peak analysis (direct measurement) during sprints on different battling rope strategies. □ - simultaneous; ☐ – alternate. B – Sprint bout; R – Passive Recovery. HRpeak reached in a session.

difference ($p = .67$) between the strategies and effect size $\eta^2 = .704$, considered moderate

Figure 2 shows the HR peak response reached during the four sprint interval bouts. The HR peak averages during each bout were 156 ± 18.60 vs. 162.37 ± 14.83 bpm ($p > .99$) in bout 1; 159.12 ± 17.70 vs 164.50 ± 12.82 ($p > .99$) in bout 2; 166.25 ± 12.83 vs 168.37 ± 12.18 bpm ($p > .99$) in bout 3, and 166.25 ± 12.83 vs 169.37 ± 12.18 bpm ($p > .99$) in bout 4 during alternating and simultaneous conditions, respectively. The session average was 85.15 ± 7.10% (alternating arms) and 88.29 ± 5.14% (simultaneous arms). The ANOVA repeated measurements showed that there was no significant chronotropic difference between strategies (p = .99) and effect size η^2=1.638, considered large.

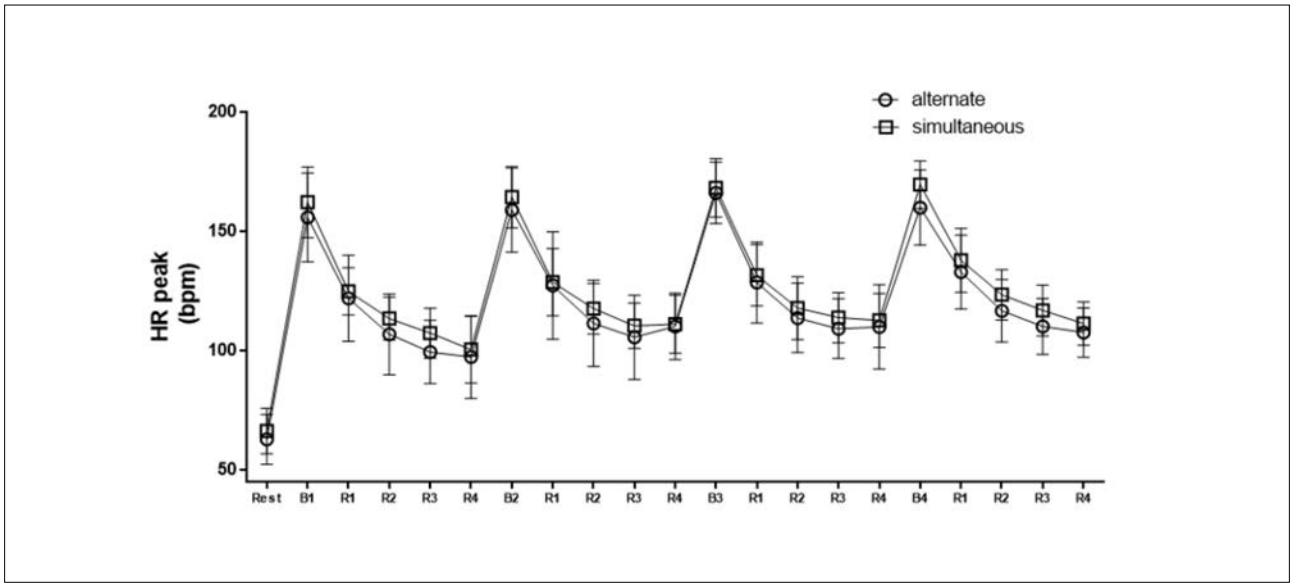

Figure 2
HR analysis during sprints on different battling rope strategies. □ - simultaneous; ☐ – alternate. B – Sprint bout; R – Passive Recovery.

Discussion

The main purpose of this study was to compare the HR and VO_2 responses elicited by a BRP in simultaneous and alternating movements. Our main findings were that HR and VO_2 responses during simultaneous and alternating movements were not different between exercise modes.

The results of the present study demonstrated that HR and VO_2 produced a mean value of 166 ± 12 and 160 ± 16 bpm, which corresponded to 88.29% and 85.1% % HR peak, respectively, and a mean of 30.96 ± 6.88 and 29.74 ± 5.31 $ml.kg^{-1}.min^{-1}$, corresponding to 79.58% and 76.52% of VO_2 peak, respectively, for alternating and simultaneous movements. These behaviors are similar to those of previous studies, showing higher VO_2 and HR in response to BRP exercise. Fountaine and Schmidt (2015) analyzed the mean HR peak and VO_2 peak during a sprint session of battling rope with simultaneous movements (10x15 s all out, 45 s recovery). They found peak HR as a percentage of 94% HR peak (178 bpm) and average VO_2 peak of 35.4 $ml.kg^{-1}.min^{-1}$. A similar finding was reported in a study by Brewer et al. (2018), who analyzed the influence of the simultaneous BRP in seated and standing positions. They found peak HRs as a percentage of the maximum of 93% and 92% and 67% vs. 65% of VO_2 peak, with no significant difference between positions.

Conversely, Ratamess et al. (2015) identified moderate intensities (24.6 $ml.kg^{-1}.min^{-1}$ – 50%VO_2 peak) with the effect of a battling rope session (3 × 30 s/2 min), using different movement techniques (alternate, simultaneous, and simultaneous with jumping) throughout the sprint. In another study by the same authors, Ratamess et al. (2015) compared the metabolic effects of different recovery times (1 min vs. 2 min) during a 30 s stimulus using alternate and simultaneous movements (15 s + 15 s). They found that lower intervals increased the metabolic demand (72 – 75.5% vs. 67.9 – 69.6% VO_2 peak) when compared to the larger ones. Faigenbaun et al. (2018) analyzed the cumulative effect of five different oscillation techniques during a 10-min protocol [5x (2x 30 s all out, 30 s recovery)]. The HR peak and VO_2 peak showed a progressive increase with the level of movement effort, as in our study, and this reached moderate and vigorous intensities, varying between 52.9% – 86.4% (109 – 168.9 bpm) and 21.5 – 67.8% (10.3. 30 $ml.kg^{-1}.min^{-1}$).

As we can see in the results above, there is substantial heterogeneity between the protocols and an apparent association between the lower recovery time (<45 s) and the highest metabolic demand. However, it is possible to identify that the results are independent of the type of protocol or execution condition (alternate or simultaneous). The battling rope exercise facilitates the reach of vigorous and moderate levels of intensity, complying with the recommendations of ACSM, by being capable of important cardiovascular and neuromuscular adaptations to obtain better indices of maximal aerobic power. The potential benefits of battling rope exercise were presented in a recent research paper by Chen et al. (2018). The researchers studied the effect of an 8-week intervention with battling rope and observed significant improvements over core localized muscular resistance, aerobic capacity, and upper body power.

Although our results are exciting, there are some limitations to the present study. First, we did not use a metronome to standardize the repetitions or velocity for each exercise. Second, the participants had only one session in each form, and we did not verify the reproducibility of the results. Finally, we had a reduced number of volunteers and only included young male adults without familiarity of exercise method. Thus, future work is needed to investigate the acute and chronic effects of the movement variation in battling rope for different gender and age groups, controlling the number of movements per stimulus.

Conclusion

This study showed that there is no difference in the acute cardiovascular response of BRP exercise involving different modes (alternated or simultaneous). Moreover, according to ACSM, these results suggest that the intensity generated during BRP exercise can be sufficient to improve and/or maintain maximal oxygen uptake in healthy people.

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Conflict of Interests: No conflict of interest was reported by the authors.