

Aerobic exercise with different blood flow restriction pressure levels affect the mood state of military? ¿Ejercicio aeróbico con diferentes niveles de presión de restricción del flujo sanguíneo afecta al estado del humor de los militares?

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Abstract. The aim of the study was to analyze the effect of aerobic exercise with different levels of blood flow restriction pressure on mood in military personnel. The sample consisted of 13 military males (age = 20.6 ± 2.2 years; body mass = 68.1 ± 7.7 kg; height = 1.69 ± 0.05 cm). The walking protocols with and without BFR were carried out over 18 minutes, as follows: a) CW+50%BFR - continuous treadmill walking (40% vVO₂max) with 50% BFR; b) CW= continuous treadmill walking without BFR (40% vVO₂max); c) CW+80%BFR= continuous treadmill walking (40% of vVO₂max) with 80% BFR and d) CW+100%BFR= continuous treadmill walking (40% of vVO₂max) with 100%BFR. Mood was measured using the Brunel scale (BRUMS) before exercise, immediately after exercise, 30 and 60 minutes after exercise. There was a significant reduction in the perception of vigor in the exercise protocols with BFR greater than in the CW protocol without BFR immediately after exercise ($p < 0.05$); b) there was a significant reduction in the perception of vigor up to 60 minutes in the exercise protocols with BFR ($p < 0.005$); c) there were significant increases in the perception of fatigue in the exercise protocols with BFR immediately after exercise ($p < 0.005$). We conclude that AE with different levels of BFR increases the perception of muscle fatigue and pain/discomfort immediately post-exercise, and sustains a reduction in the perception of vigor up to 60 minutes post-exercise when compared to the effects perceived with aerobic exercise without BFR.

Keywords: Physical exercise, Military, Mood state, Aerobic training, Perceptual Skills.

Resumen. El objetivo del estudio fue analizar el efecto del ejercicio aeróbico con diferentes niveles de presión de restricción del flujo sanguíneo (RFS) sobre el estado de ánimo en personal militar. La muestra estaba formada por 13 militares (edad = $20,6 \pm 2,2$ años; masa corporal = $68,1 \pm 7,7$ kg; altura = $1,69 \pm 0,05$ cm). Los protocolos de marcha con y sin RFS se realizaron durante 18 minutos, de la siguiente manera: a) MC+50%RFS: marcha continua en cinta rodante (40% de vVO₂máx) con 50%RFS; b) MC= marcha continua en cinta rodante sin RFS (40% de vVO₂máx); c) MC+80%RFS= marcha continua en cinta rodante (40% de vVO₂máx) con 80%RFS y d) MC+100%RFS= marcha continua en cinta rodante (40% de vVO₂máx) con 100%RFS. El estado de ánimo se midió mediante la escala de Brunel (BRUMS) antes del ejercicio, inmediatamente después del ejercicio, 30 y 60 minutos después del ejercicio. Hubo una reducción significativa de la percepción de vigor en los protocolos de ejercicio con RFS mayor que en el protocolo de MC sin RFS inmediatamente después del ejercicio ($p < 0,05$); b) hubo una reducción significativa de lo vigor hasta los 60 minutos en los protocolos de ejercicio con RFS ($p < 0,005$); c) hubo aumentos significativos de la fatiga en los protocolos de ejercicio con RFS inmediatamente después del ejercicio ($p < 0,005$). Concluimos que el EA con diferentes niveles de RFS aumenta la percepción de fatiga muscular y dolor/malestar inmediatamente después del ejercicio, y mantiene una reducción de la percepción de vigor hasta 60 minutos después del ejercicio en comparación con los efectos percibidos con el ejercicio aeróbico sin RFS.

Palabras clave: Ejercicio físico, Militares, Estado de ánimo, Entrenamiento aeróbico, Habilidades perceptivas.

Fecha recepción: 11-03-24. Fecha de aceptación: 14-05-24

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Introduction

A reduction in daily physical activity can have negative effects on the mental and physical health of young and old individuals. Physical exercise is therefore a healthy, cost-effective, non-pharmacological measure that is valid for disease prevention and health promotion (Garber et al., 2011; Gibelli et al., 2024). The specificity of the intensity and setting of these activities can become a enjoyable practice for those who perform it and has the ability to boost the mood of the practitioner (Werneck & Navarro, 2011). However, intense exercise can cause changes in mood (Arruda et al., 2013; Hall et al., 2002; Sakuragi & Sugiyama, 2011), acute feelings of fatigue (Silva et al., 2018) and concentration problems (Meeusen et al., 2006; Nederhof et al., 2008). Moreover, some studies report divergent psychological responses to high-intensity exercise, with benefits (Arent et al., 2007; Tharion et al., 1991), negative effects and even no change in mood (Arruda et al., 2013).

Conversely, the technique of blood flow restriction (BFR), which has been used in combination with aerobic

exercise, has emerged as a method to help individuals who cannot withstand high-intensity efforts due to the high mechanical stress. This training method typically consists of recommends walking at a low intensity (20-40% of VO₂max) and short duration (20 minutes) combined with 50-80% BFR (Patterson et al., 2019). In this sense, there is strong evidence in the literature that aerobic training with restricted blood flow chronically promotes neuromuscular adaptations such as increased strength, localized muscular endurance and hypertrophy (Abe, 2006; Ozaki et al., 2011) and systemic physiological measures such as cardiorespiratory capacity (Oliveira et al., 2015).

Despite the neuromuscular and cardiorespiratory benefits provided by this AE combined with BFR in different populations, the effects of using different blood flow restriction pressures on perceptual responses, such as mood state, ratings perceived exertion (RPE) and ratings of discomfort/pain, are still little known in military men. The lack of information can be explained by the fact that there

is only one study related to mood response after aerobic exercise with BFR (Silva et al., 2019). When reviewing the relevant literature, it can be seen that in the study by Silva et al. (2019) the authors subjected young men to four aerobic exercise protocols with and without BFR and compared the post-exercise mood state responses. In this study, it was observed that the AE protocol combined with 50% BFR promoted decreases in the ratings of vigor and increases in the ratings of fatigue greater than in a session of the same intensity without BFR, and these effects on mood state were similar to an exercise protocol performed at high intensity. Thus, it seems that the amount of pressure used in combination with aerobic exercise has an impact on mood state, which is a variable that has been used to verify changes in the emotional profile of individuals and to analyze the internal training load.

In this context, it can be seen that in most studies carried out with AE+BFR there is no standardization of the pressure used in the inflatable cuffs used to reduce blood flow (Silva et al., 2019), and this is an important variable because the pressure cuff can alter psychophysiological responses during and after the exercise session (Silva et al., 2022; Silva et al., 2018). Thus, it was found that there are gaps in knowledge when reviewing the relevant literature relating aerobic exercise with blood flow restriction with different pressure levels and how this can affect mood states and the ratings perceived exertion and ratings of discomfort/pain in military men.

Finally, the results of this study could be of great relevance, as they could provide support for the current physical training programs that are included in the daily routines of active military men, since these psychometric responses are also related to adherence to physical exercise. Thus, this study aimed to analyze the effect of aerobic exercise with different levels of blood flow restriction pressure in the mood state of military men.

Methods

Participants

Thirteen military men (age = 20.6 ± 2.2 years; body mass = 68.1 ± 7.7 kg; height = 1.69 ± 0.05 cm), volunteered for the current study. Male military soldiers aged between 18 and 25 who were fit for physical activity (PAR-Q) were recruited. The inclusion criteria were: a) men; b) aged between 18 and 35; c) who were systematically performing physical exercise; d) who did not have musculoskeletal injuries in the upper or lower body; e) with a brachial-ankle index (ABI) between 0.90 and 1.30. One volunteer withdrew from the study and was therefore excluded. All experimental procedures and potential risks were explained to the participants before written informed consent was obtained. This study was conducted in accordance with Declaration of Helsinki and approved by the university's institutional review board (protocol number 5.474.173).

The sample size was calculated based on the study by Silva et al. (2019), who evaluated the effects of different EA protocols on the mood state of American soccer players. This study was chosen for the sample calculation due to its similarity to the assessments that were carried out in this study. The sample size was calculated for the repeated measures ANOVA within and between factors using the G*Power 3.1 software. A power of 0.90, $\alpha = 0.05$, a correlation coefficient of 0.5, a non-sphericity correction of 1, and an effect size of 0.7 were used. The actual statistical power was 99.3%. Therefore, the calculations showed the need for an "n" of at least twelve athletes to analyze the post-exercise mood state of military men.

Experimental design

The ABI, the arterial occlusion pressure for the lower-body and test in the treadmill were performed on the first visit to the laboratory. After completing the vVO_{2max} test and resting for 30 min, participants were familiarized with the aerobic exercise conditions in the treadmill. The familiarization session consisted of walking for 10 min at 40% of the participants' vVO_{2max} with 100%BFR. Following a 48-hour period, participants returned to the laboratory in four separate occasions, with a 7-day washout period between each visit, to perform the 4 exercise trials. The order of the trials was randomly assigned to each participant and consisted of: a) CW+50%BFR - continuous walking (40% of vVO_{2max}) combined with 50% BFR; b) CW= continuous walking without BFR (40% of vVO_{2max}); c) CW+80%BFR= continuous walking (40% of vVO_{2max}) combined with 80% BFR and d) CW+100%BFR= continuous walking (40% of vVO_{2max}) combined with 100%BFR. Participants were instructed to refrain from taking and nutritional supplements, to avoid consuming caffeine and alcohol for at least 24 h before each exercise trial, as well as to abstain from performing any exercise 24 h before any of their visits (da Silva Telles et al., 2023).

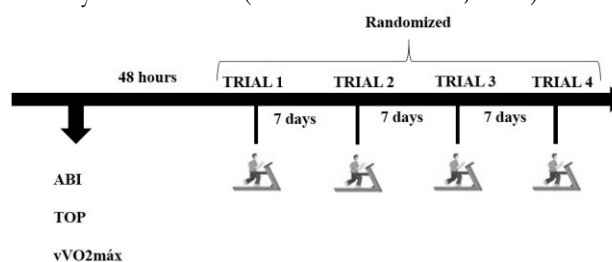


Figura 1. Experimental design.

ABI: Ankle-brachial index; AOP: Arterial occlusion pressure for the lower-body; vVO_{2max} : velocity association maximal oxygen consumption test

Procedures

Determination of the arterial occlusion pressure

The technique used to determine the blood flow restriction point was recommended by Laurentino et al. (2012) and has already been used in previous studies (Silva et al., 2019). The military positioned themselves on a stretcher lying down in a supine position with their arms at their sides. The evaluators attached a pneumatic tourniquet (Riester®, Jungingen, Germany) to the proximal thigh in

the lower limbs. The tourniquet was inflated until the auscultatory pulse of the posterior tibial artery was interrupted, which was established as 100% BFR. A portable vascular Doppler model DV2001 (Medpej, Ribeirão Preto, São Paulo) was used to identify the auscultatory pulse of the posterior tibial artery. For each individual, 50%, 80% and 100% of the total arterial occlusion pressure was calculated as the pressure to be used during the experimental sessions. The average 100% BFR pressure in the right leg was 147.3 ± 18.1 and in the left leg was 134.4 ± 17.9 . The average 80% BFR pressure in the right leg was 118.0 ± 14.4 and the left leg was 107.3 ± 14.1 . The average 50% BFR pressure in the right leg was 73.3 ± 9.2 and the left leg was 67.2 ± 8.9 .

Ankle Brachial Index

Clinical examination of the ankle-brachial index (ABI) was carried out as an inclusion criterion in the study, with the aim of analyzing whether the soldiers were predisposed to having obstructive lower limb arterial disease (Resnick et al., 2004). Thus, if the military had an ABI between 0.90 and 1.30, they were included in the study. All instructions and measurements were carried out as recommended in the literature and in previous studies (Silva et al., 2019; Silva et al., 2018; Dantas et al., 2024). The average ABI on the right side of the body of the military was 1.08 ± 0.1 and the ABI on the left side of the body was 1.09 ± 0.09 .

Perceptual Responses

The verbal analogic pain scale (Nieman et al., 2006; Umbel et al., 2009) was used to analyze the ratings of discomfort/pain before and after the exercise session. The Borg CR10 scale (Borg, 1982), validated by Foster et al. (2001), was used to measure the ratings perceived of exertion before exercise and every three minutes during exercise. The scale instructions and memory anchoring procedures followed the recommendations of Haile et al. (2015). All procedures for familiarizing the Borg scale have been described in previous studies (Silva et al., 2019).

Brunel Mood Scale (BRUMS)

The mood state of the military was measured using the Brunel mood (Terry et al., 2003; Droppleman & McNair, 1971). This questionnaire has 24 adjectives, divided into six subjective and transitory mood domains: [(tension; depression; anger; fatigue; mental confusion (negative factors) and vigor (positive factor)] (Rohlf's, 2006; Rohlf's et al., 2004; Ferreira et al., 2022). The volunteers answered the following question: "How do you feel now?". To analyze total mood disturbance, the formula $TMD = (T+D+A+F+C) - V + 100$ was used, applying the results found in the following domains: Tension (T), Depression (D), Anger (R), Fatigue (F) Mental Confusion (C) and Vigor (V) (Werneck et al., 2012). The military mood state was measured before and after the exercise sessions

(immediately after exercise, 30 minutes and 60 minutes after exercise).

Evaluation of the maximum speed test on the treadmill

A maximal aerobic test was carried out on the treadmill to determine the velocity associated with the maximum oxygen consumption of the soldiers (Prado et al., 2015). All the measurement procedures and interruption criteria for the maximal exercise test were carried out in previous studies (Silva et al., 2019). The average vVO_{2max} of the volunteers was 12.2 ± 1.1 Km/h.

Protocols

All the experimental sessions were randomized using on the website <https://www.randomizer.org/>, (Urbaniak & Plous, 2013) into four sessions 7 days apart. Each experimental session lasted a total of 83 minutes for all study protocols. The walking protocols with and without BFR were performed in 18 minutes, as follows: a) CW+50%BFR - continuous walking (40% of vVO_{2max}) combined with 50% BFR; b) CW= continuous walking without BFR (40% of vVO_{2max}); c) CW+80%BFR= continuous walking (40% of vVO_{2max}) combined with 80% BFR and d) CW+100%BFR= continuous walking (40% of vVO_{2max}) combined with 100%BFR. In the experimental sessions involving the use of the BFR technique, the pressure cuff positioned on the most proximal part of the thigh and kept inflated during the 18 minutes of exercise.

Statistical analysis

Data was analyzed using the Statistical Package for Social Sciences software version 25.0. An initial exploratory analysis was carried out to verify data normality (Shapiro-Wilk's test) and homogeneity (Levene's test). As data displayed normal distribution, a two-way repeated measures ANOVA (condition {4} by time {4}) was used to test for significant condition and time main effects as well as for significant condition by time interactions. Bonferroni post hoc test was used to control for familywise error rate in all pairwise comparisons. Percent changes ($\Delta\%$) were calculated for each scale domain whenever a significant condition by time interaction was detected. For each dependent variable, we presented values for the magnitude of differences (F), significance (p), and effect size estimate (η^2) using cutoffs of 0.2, 0.5, and 0.8 to represent small, medium, and large effect sizes, respectively (Cohen, 1988). Data are presented as Mean \pm SD and the alpha levels was set at $p < .05$.

Results

Comparative analysis of anger ratings showed no significant interaction effect between Protocols x time ($F = 0,19$; $n^2 = 0,009$; $p = 0,009$), no significant main effect for Protocols ($F = 1,56$; $n^2 = 0,018$; $p = 0,328$) and no significant main effect for Time ($F = 1,062$; $n^2 = 0,016$; $p = 0,366$). Regarding comparative analysis of the participants' ratings of men-

tal confusion, there was no significant interaction effect between Protocols x time ($F= 0,52$; $n^2= 0,024$; $p= 0,855$), no significant main effect for Protocols ($F= 1,47$; $n^2= 0,023$; $p= 0,222$) and no significant main effect for Time ($F= 1,59$; $n^2=0,024$; $p= 0,193$). Comparative analysis of tension ratings showed no significant interaction effect between Protocols x Time ($F= 0,750$; $n^2= 0,034$; $p= 0,663$), no significant main effect for Protocols ($F= 0,325$; $n^2= 0,005$; $p= 0,807$) and no significant main effect for Time ($F= 0,846$; $n^2=0,013$; $p= 0,471$). Regarding comparative analysis of the participants' ratings depression, there was no significant interaction effect between Protocols x time ($F= 0,250$; $n^2= 0,012$; $p= 0,986$), no significant main effect for protocols ($F= 0,658$; $n^2= 0,010$; $p= 0,579$) and no significant interaction effect for time ($F= 0,150$; $n^2=0,002$; $p= 0,930$).

Comparative analysis of vigor ratings showed significant interaction between Protocols x time ($F= 1,15$; $n^2= 0,052$; $p< 0,001$), significant main effect for Protocols ($F= 7,68$; $n^2= 0,107$; $p< 0,001$) and significant main effect for Time ($F= 14,71$; $n^2=0,187$; $p< 0,001$). In the protocol interaction, there was a significant difference immediately after exercise between the protocol CW vs. CW+50%BFR ($p= 0.001$); CW vs. CW+80%BFR ($p= 0.028$) and CW vs. CW+100%BFR ($p= 0.002$) and 60 minutes after exercise between the protocol CW vs. CW+50%BFR ($p= 0.007$); CW vs. CW+80%BFR ($p= 0.001$) and CW vs. CW+100%BFR ($p= 0.005$). In the time interaction, it was observed that in the CW+50%BFR protocol there was a significant reduction in the perception of vigor between pre-exercise vs. immediately post-exercise ($p< 0.001$; $\Delta\% = -52,8$; $ES= -6,6$), pre-exercise vs. 30 minutes' post-exercise ($p< 0.001$; $\Delta\% = -43,3$; $ES= -5,4$) and pre-exercise vs. 60 minutes' post-exercise ($p= 0.001$; $\Delta\% = -36,7$; $ES=$

$-4,6$). In addition, it was found that in the CW+80%BFR protocol there was a significant reduction in the perception of vigor between pre-exercise vs. immediately post-exercise ($p= 0.010$; $\Delta\% = -32,9$; $ES= -3,7$), pre-exercise vs. 30 minutes' post-exercise ($p= 0.028$; $\Delta\% = -27,6$; $ES= -3,1$) and pre-exercise vs. 60 minutes' post-exercise ($p= 0.004$; $\Delta\% = -36,1$; $ES= -4,0$). It was found that in the CW+100%BFR protocol there was a significant reduction in the perception of vigor between the pre-exercise vs. immediately post exercise ($p= 0.010$; $\Delta\% = -46,3$; $ES= -5,3$), pre exercise vs. 30 minutes' post exercise ($p= 0.024$; $\Delta\% = -27,8$; $ES= -3,2$) and pre exercise vs. 60 minutes' post exercise ($p= 0.008$; $\Delta\% = -31,9$; $ES= -3,7$).

Regarding the comparative analysis of the participant's ratings of fatigue, there was a significant interaction effect between Protocols x Time ($F= 1,15$; $n^2= 0,052$; $p< 0,001$), significant main effect for Protocols ($F= 7,68$; $n^2= 0,107$; $p< 0,001$) and significant interaction effect for Time ($F= 14,71$; $n^2=0,187$; $p< 0,001$). In the Protocol interaction, there was a significant difference immediately after exercise between the CW protocol vs. CW+50%BFR ($p= 0.012$); CW vs. CW+80%BFR ($p= 0.016$) and CW vs. CW+100%BFR ($p= 0.002$). In the time interaction, it was observed that in the CW+50%BFR protocol there was a significant reduction in the perception of fatigue from pre-exercise and immediately post-exercise ($p< 0.001$; $\Delta\% = 500$; $ES= 7,5$). In addition, in the CW+80%BFR protocol there was a significant reduction in the perception of fatigue from pre-exercise to immediately post-exercise ($p< 0.001$; $\Delta\% = 400$; $ES= 7,0$), and in the CW+100%BFR protocol there was a significant reduction in the perception of fatigue from pre-exercise to immediately post-exercise ($p< 0.001$; $\Delta\% = 875$; $ES= 8,5$), as shown in figure 2.

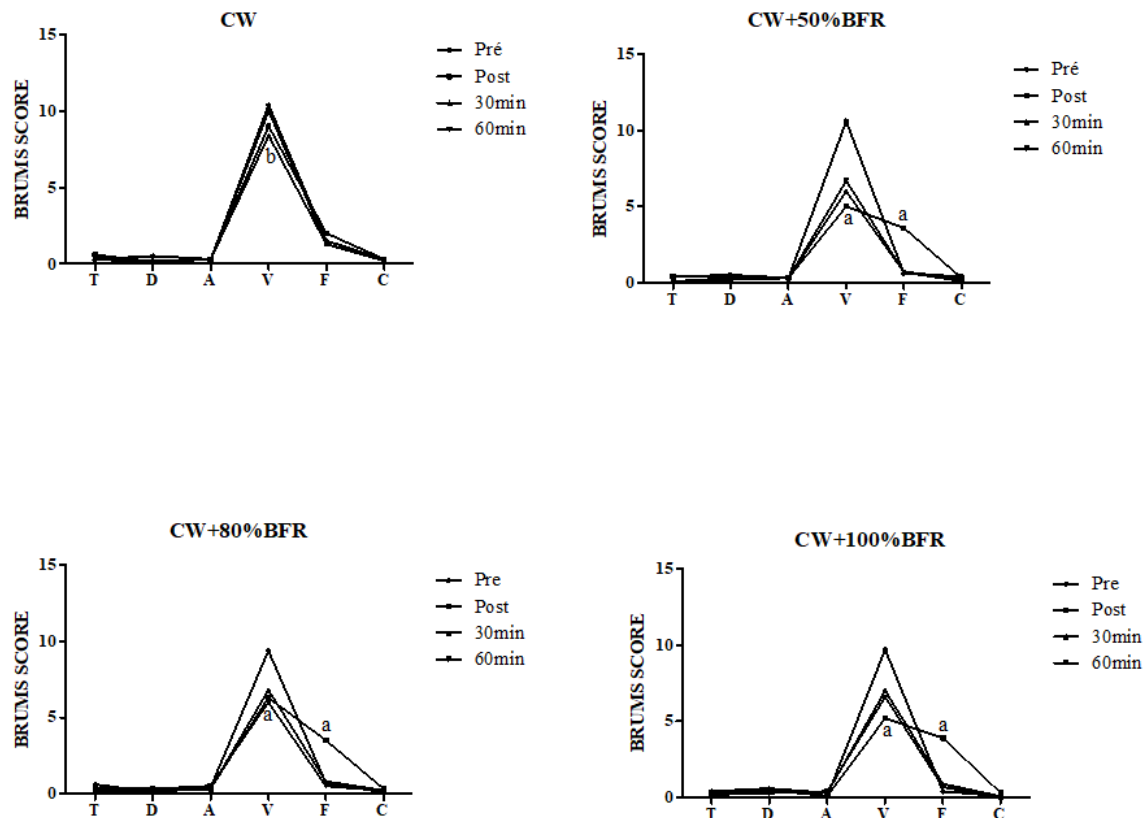


Figura 2. Comparison of the changes in the mood state domains over time for all testing conditions.

Legend: T: tension; D: depression; A: anger; V: vigor; F: fatigue; C: confusion mental; CW- walking continuous; CW+50%BFR- walking continuous with 50% of blood flow restriction; CW+80%BFR- walking continuous with 80% of blood flow restriction; CW+100%BFR- walking continuous with 100% of blood flow restriction; a- significantly different from rest in the protocols with BFR; b- significantly different of all protocols with BFR.

Comparative analysis of total mood disturbance (TMD) showed no significant interaction effect between Protocols \times Time ($F= 1,35$; $n^2= 0,213$; $p= 0,060$) and no significant main effect for Protocols ($F= 0,312$; $n^2= 0,005$; $p= 0,816$), however there was a significant main effect for Time ($F= 8,84$; $n^2=0,121$; $p< 0,001$). In the time interaction, it was observed that in the CW+50%BFR protocol there was a significant increase in TMD pre-exercise vs. immediately post-exercise ($p= 0.018$); a similar fact in the CW+80%BFR protocol in which there was a significant increase in TMD pre-exercise vs. immediately post-exercise ($p= 0.005$) and in the CW+100%BFR protocol there was a significant increase in TMD pre-exercise vs. immediately post-exercise ($p= 0.001$), as shown in figure 3.

In the comparative analysis of the ratings of discomfort (RD), there was a significant difference immediately after exercise between the CW vs. CW+50%BFR protocol ($p< 0.01$); CW vs. CW+80%BFR ($p< 0.01$) and CW vs. CW+100%BFR ($p< 0.01$). However, there was a significant increase in RD in the CW+50%BFR protocol between pre-exercise and immediately post-exercise ($p= 0.13$), which was similar to the CW+80%BFR and CW+100%BFR protocols in which there was a significant increase in RD between pre-exercise and immediately post-exercise ($p= 0.003$).

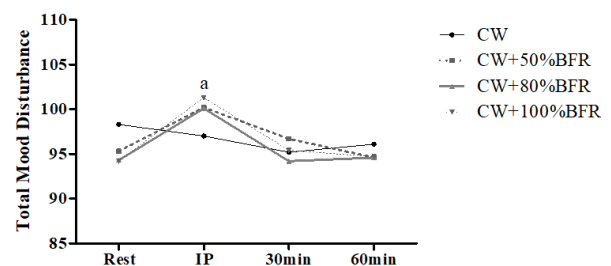


Figura 3. Comparison of the changes in the total mood disturbance over time for all testing conditions.

Legend: Rest – baseline levels; IP- immediately after exercise; TMD- total mood disturbance; CW- continuous walking; CW+50%BFR- continuous walking with 50% blood flow restriction; CW+80%BFR- continuous walking with 80% blood flow restriction pressure; CW+100%BFR- continuous walking with 100% blood flow restriction pressure; a- significantly different from the resting moment in protocols with BFR.

In the comparative RPE analysis, there was a significant difference from 9 minutes into the exercise between the CW protocol and all the BFR protocols exercise ($p< 0.05$). In the analysis of the time interaction, there were significant increases in RPE for the CW+50%BFR and CW+80%BFR protocols from 9 minutes of exercise ($p< 0.005$), in the CC protocol there were significant increases from 15 minutes of exercise ($p< 0.05$) and in the CW+100%BFR protocol

there were significant increases from 6 minutes of exercise ($p < 0.05$).

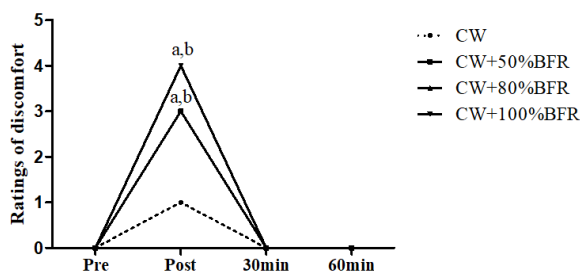


Figure 4. Ratings of discomfort averaged for each testing condition.

Legend: CW- Walking continuous; CW+50%BFR- walking continuous with 50% of blood flow restriction; CW+80%BFR- walking continuous with 80% of blood flow restriction; CW+100%BFR- walking continuous with 100% of blood flow restriction; a- significantly different of all protocols with BFR. b- significantly different from rest in the protocols with BFR

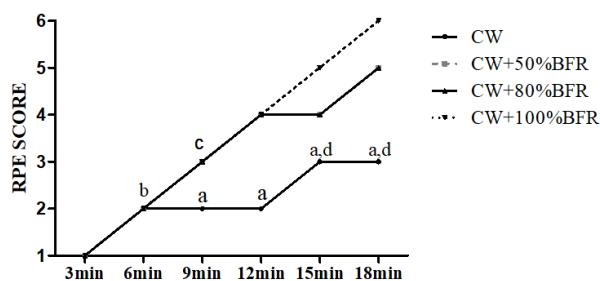


Figure 5. Ratings of perceived exertion over time during exercise for all experimental conditions.

Legend: CW- walking continuous; CW+50%BFR- walking continuous with 50% of blood flow restriction; CW+80%BFR- walking continuous with 80% of blood flow restriction; CW+100%BFR- walking continuous with 100% of blood flow restriction; a- significantly different of all protocols with BFR. b- significantly different from rest in the protocols CW+100%BFR; c- significantly different from rest in the protocols CW+50%BFR and CW+80%BFR; d- significantly different from rest in the protocols CW.

Discussion

The aim of the study was to analyze the effect of aerobic exercise with different levels of blood flow restriction pressure on the mood state of military men. The main findings of the study were: a) a significant reduction in the perception of vigor in the exercise protocols with BFR greater than in the CW protocol without BFR immediately after exercise; b) a significant reduction in the perception of vigor up to 60 minutes in the exercise protocols with BFR; c) increases in the perception of fatigue in the exercise protocols with BFR at the time immediately after exercise; d) the subjective perceptions of pain and discomfort were higher in the exercise protocols with BFR than in the exercise protocol without BFR immediately after exercise; and e) the RPE in the exercise protocols with BFR were significantly higher from 9 minutes after exercise when compared to the exercise protocol without BFR.

Thus, it is clear that in the aerobic exercise protocols with BFR, although there is no significant interaction between the different pressure levels on mood states, there is a difference between performing aerobic exercise with

and without blood flow restriction. In this study, there was an increase in the rating of fatigue immediately after exercise and a reduction in the perception of sustained vigor up to 60 minutes after the exercise protocols performed with BFR. From this perspective, muscle fatigue can be defined as the inability of the muscle to maintain a certain power, or a decrease in the levels of sustained performance during physical exercise (Santos et al., 2003). In this study, this increase in the rating of fatigue in exercise with BFR may have occurred due to additional metabolic stress and greater recruitment in skeletal muscle, especially type II muscle fibers (fast twitch) (Silva et al., 2018).

In fact, this high metabolic stress caused by AE+BFR, such as phosphocreatine depletion, increased inorganic phosphate accumulation, decreased intramuscular pH and lactate accumulation, causes an increase in muscle acidosis and this, in addition to increasing the perception of post-exercise fatigue, justifies the significant increase in the levels of subjective perception of pain and discomfort observed in the AE+BFR condition when compared to AE after the session. However, this physiological effect provided by this training method has been suggested as potent stimuli for obtaining the neuromuscular and systemic effects of AE with BFR (Patterson et al., 2019).

Since the accumulation of these metabolites during exercise influences muscle fatigue, gradually decreasing contractile capacity, as well as the rating of effort, they can consequently negatively alter mood states, which on the other hand, fatigue can be associated with tiredness, apathy and low energy levels, acutely impairing exercise performance (Silva et al., 2019; Suga et al., 2009) all these factors may have contributed to a decrease in the perception of vigor after performing aerobic exercise with BFR.

These results related to the ratings of fatigue and vigor after exercise were similar to the study by (Silva et al., 2019) in which the author found that CW with 40% BFR provided changes in the perception of fatigue and vigor similar to an aerobic exercise performed at high intensity and greater than a walking session at the same intensity without BFR. However, it was evident in the present study that there were no significant changes in the negative domains (tension, depression, anger and mental confusion) which are factors related to the emotional profile of the sample, a fact that did not occur in the study by Silva et al. (2019) in which these authors observed that there was a change after aerobic exercise with BFR in the athletes' perception of tension, and this may have occurred due to the difference in the samples, since in the present study military men participated who are subjected to various adverse psychological situations and it seems that they are more able to withstand performing exercises with high intensity characteristics.

It is clear that although there was no significant difference between the aerobic exercise protocols with BFR in mood states and RPE, it can be seen that the CW+100%BFR protocol caused a greater perception of fatigue and contributed to a faster increase in RPE than the other CW protocols with and without BFR. It was clear that

the CW+100%BFR protocol led to an increase in RPE from the 6th minute of exercise, while the walking protocols with 50 and 80% BFR only led to an increase in RPE from the 9th minute of exercise, while all the exercise protocols with BFR led to an increase in RPE from the 9th minute of exercise when compared to the exercise protocol without BFR. A similar fact occurred in the study by Mendonca et al. (2014) in which the authors found that BFR combined with walking induced a greater RPE compared to a walking protocol without BFR at the same relative exercise intensity. In the study by Silva et al. (2019), these authors compared different aerobic exercise protocols with and without BFR and found that walking at 40%VO₂max combined with 50% BFR promoted greater increases in RPE and RPP than walking at the same intensity without BFR. In the study by Karabulut & Garcia (2017), the authors found that RPE responses were compared after obese men and women were subjected to cycling exercise using different restrictive pressures (~40 or ~60mmHg) and a session without exercise (CON). The results indicated that the RPE during cycling exercise was higher with BFR when compared to the BFR control without any exercise (CON), and that there was a difference in the RPE between the sessions with ~60mmHg, ~40mmHg and CON. However, the RPE found in all participants indicated that the perceived effort during exercise was considered low, ranging from "easy" to "quite light" on the Borg scale. The results found in this study indicate that the different levels of pressure can interfere in the individual's fatigue and vigor domains, when compared to the same activity without the restriction, and it is worth noting that these factors show that AE+BFR appears to be a high-intensity exercise. However, it should be noted that these results represent an observation at an acute level, observed only up to one hour after exercise; the chronic effects of this technique in assessing different mood states remain undefined. However, it can be used as an alternative method of military training, given that the changes in mood are comparable to high-intensity aerobic training without BFR. Although this represents only a short-term response observed post-exercise, aerobic exercise with BFR chronically promotes cardiorespiratory and neuromuscular adaptations in young non-athletic individuals (Silva et al., 2019; Silva et al., 2018). Considering the discussions presented, this study is not without its limitations. Firstly, the results obtained would be applicable to the population studied and not extrapolated to the military population in general. In addition, no variables related to metabolic responses to exercise, such as blood lactate and pH, were checked in the current investigation. These variables would be useful to provide additional relevant information when interpreting and discussing our findings.

Conclusion

We conclude that AE with different levels of BFR increases the perception of muscle fatigue and pain/discomfort immediately post-exercise, and sustains a reduction in the perception of vigor up to 60-minute post-exercise when

compared to the effects perceived with aerobic exercise without BFR. In addition, it was evident that the use of higher BFR pressures can affect negatively the RPE of military men individuals during exercise. It is suggested that future studies investigate the different levels of BFR pressure in other types of aerobic exercise with male and female military, and include the assessment of metabolic variables during AE combined with different levels of BFR.

Author contributions

Júlio César, Lucas and Gilmário Ricarte wrote the paper and Kalinne, Pâmela, Júlio César, Ezequiel, Jhonatan collected the data. All authors approved the final submission.

Supporting agencies

No funding agencies were reported by the authors.

Disclosure statement

No potential conflict of interest were reported by the authors

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