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# RESISTED EXERCISE WITH BLOOD FLOW RESTRICTION AFFECTS MOOD STATE AND MUSCLE POWER IN A SIMILAR FASHION TO HIGH LOAD EXERCISE

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## ABSTRACT

The objective of this study was to analyze the acute effect of resistance exercise with and without restrict in of blood flow on the state of mood and muscle power in basketball athletes. The sample was composed by 10 basketball athletes of the Paraíba Team - JP, Who performed two sessions of strength exercise in a randomized way: a) low load resisted exercise with blood flow restriction (LLRE+BFR) and b) high load resisted exercise (HL+RE), with application of BRUMS before, immediately after and 30 minutes after the protocols, as well as the use of vertical jump in both training sessions, performed before, immediately after, 15 and 30 minutes after the exercises. The study indicate dincreases in fatigue after application of both protocols ($p< 0.05$) and a significant reduction in vigor for (LLRE+BFR) immediately after the training session ($p< 0.05$), generating anincrease in the total mood disturbance (TMD) of individuals. However, the iceberg profile initially presented on LLRE+BFR, seemstobere established after 30 minutes of training. Regarding the heigh tof the jump, a significant decrease was observed in both protocol suntil 15 minutes after the exercises ($p< 0.05$). It is concluded that an LLRE+BFR or HLRE session can negatively affect the perception of vigor and fatigue and muscle Power after exercise, however, 30 minutes after the exercises the mood state and neuromuscular performance return to rest levels.



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# INTRODUCTION

An athlete's profile evaluation involves a set of physical, technical and tactical characteristics, in which they must be monitored and improved to achieve the expected sports performance. In this sense, different strength manifestations are characterized as one of the main physical valences requested in a preparation's period of competitive events in most team sports (Vale *et al.,* 2018). Thus, studies indicate high-load resistance exercises with basketball athletes for skeletal muscle adaptations, such as muscle strength and power (Nunes, 2011; Santos, 2012) are essential in the application of the game fundamentals and actions that involve a lot of physical contact, jumps and short runs (Silva, 2018). Association of high intensity physical training (PT) with the athletes' psychophysiological status shows that intense exercises practice can generate mood changes (Moreira, 2009; Hall, 2002; Sakuragi, 2006), causing fatigue and concentration problems (Meussen, 2013; Nederhof, 2008). However, literature evidence reports divergent psychological responses related to high intensity strength exercises, presenting benefits (Tharion, 1991; Arent, 2007) or any changes in mood (Raglin, 1993; Arruda, 2013) realizing, therefore, that repercussions on the athlete's physical performance and behavior depend significantly on how high-load strength exercises are administered during the athletes' physical preparation (Arruda, 2013; Filaire, 2001; Filaire, 2003). In this perspective, low load strength training associated with blood flow restriction (BFR) technique has been used as an alternative to high load training, aiming muscle strength development, hypertrophy and local muscular resistance. This training method differs from high load on conventional strength exercises (≥70% 1RM), adopting low loads (20-40% 1RM), associated with BFR, to induce a high intensity perception similar to high-load training (Loenneke, 2010; Neto, 2016; Vieira, 2015), due to the metabolic stress resulting mainly from metabolites accumulation, especially the $H^+$ ions from LLRE+BFR under hypoxia (Pope, 2013; Patterson *et al.,* 2019). In this sense, a single study investigated the effect of this strength training method on the mood of basketball athletes [4], in which was observed changes in total mood disturbance (TMD) and in mood profile only in preand immediately post-exercise moments, showing a vigor reduction and fatigue after a LLRE+BFR session, however, it is not known whether these mood changes are related to the internal trainingload correspondent to changes in neuromuscular performance of basketball athletes after a LLRE+BFR session. In addition, it appears that many training sessions in basketball throughout the season are initiated by physical trainers using strength exercises with athletes who will immediately undergo tactical-technical training with coaches, in which they jump, perform short high intensity movements, and there is no evidence of the LLRE+BFR impact on neuromuscular performance prior to a technical-tactical training. Thus, the present study aimed to deepen the investigations previously carried out, analyzing the player's behavior, total mood disturbance pre, immediately after and 30 minutes after the resistance training sessions, with and without blood flow restriction in athletes of basketball, as well as the muscle power performance of individuals after the training session for both protocols.

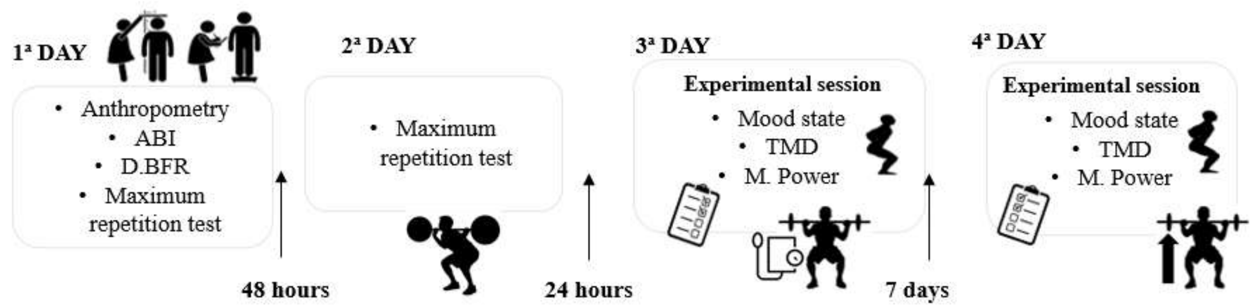
# MATERIALS AND METHODS

**Participants:** Ten male athletes from the Basquete Paraíba club participated in the study, competing in regional and national championships, aged 21.5 years ± 3.5 years. The study included basketball athletes who: a) belonged to the age group between 18 and 25 years; b) male athletes; c) did not have a history of cardiovascular or pulmonary diseases; d) who presented normal risk in the Ankle Brachial Index with values between >0.90 and <1.30; e) were not affected by musculoskeletal injuries. After explaining the possible risks and benefits of the research, the athletes signed a free and informed consent form prepared in accordance with the requirements of the National Health Council (NHC- 466/12). This study was approved by the ethics committee with protocol number 3.450.988.

arterial disease of the lower limbs (Resnick, 2004). The subjects received previous instructions to perform this clinical examination, such as: 1) not to drink caffeinated beverage; 2) not smoking; 3) empty bladder and 4) he does not exercise 24 hours before the exam. With the individuals lying in the supine position, the systolic blood pressure of the right and left arms (brachial artery) and of the right and left ankles (posterior tibial artery) were measured using the Korotkoffauscultatory method, and the measurements were verified in a rotational manner using a Portable Vascular Doppler, model DV2001 (Medpej, RibeirãoPreto, São Paulo) and an aneroid sphygmomanometer (PREMIUM; GLICOMED®; São Paulo, Brazil).

***Blood flow restriction determination:*** The BFR determination pressure was carried out according to a study proposed by Laurentino et al. (2008) in which the subjects were positioned in supine while a pneumatic tourniquet (Riester®, Jungingen, Germany) was fixed in the thigh proximal region with 100 mm and 540 mm in the lower limbs with a reading of up to 700 mmHg. The tourniquet was inflated to the point that the auscultatory pulse of the posterior tibial artery (lower limbs) was interrupted, being established as 100% of BFR. The auscultatory pulse of the posterior tibial artery was verified using a Portable Doppler Vascular device, model DV2001 (Medpej, RibeirãoPreto, São Paulo), in which the equipment transducer was placed on the skin, using coupling gel, in the tibialartery path with an inclination of approximately 60º in relation to the longitudinal axis of the blood vessel. For each individual, 50% of the mean found in the BFR was determined as the mmHg pressure value applied in the experimental sessions. The average pressure used in the athletes' right leg was 64.3 ± 3.8 mmHg and in the left leg 63.8 ± 4.1 mmHg.

***Maximum dynamic force rating (1RM):*** To perform the maximum repetition test (1RM) in the squat exercise, the Smith Machine equipment (Life Fitness® - USA) was used. The test took place according to the recommendations of the American Society of Exercise Physiologists (Brown, 2001), starting with a local muscles warm-up of 5-10 repetitions with a load equivalent to 40% of estimated 1RM.




B.A.I = BrachialAnkle Index; D.BFR = blood flowrestriction determination; Test 1 RM= Test maximal dynamic force rating; M. State. = Moodstate; M. Power = Muscular Power Assessment; TMD= Total mood disturbance.

**Figure 1. Description of the experimental design**

***Experimental design:*** The BAI (Brachial Ankle Index), the auscultatoryblood flow restriction point, anthropometric measures and maximum repetition test were measured on the first visit to the laboratory. After 48 hours the subjects returned and performed the maximum repetitiontest for data reproducibility and exercise prescription. After these visits, the athletes returned to the laboratory on two different occasions, separated by an interval of seven days (Wash out), to carry out two exercise protocols in a randomized order (designer cross over). They were instructed to abstain from eating nutritional supplements, caffeine and alcoholic beverages during and after exercise sessions and to eat a light diet 2 to 4 hours before the session and not to exercise 24 hours before the sessions.

**Procedures**

**Brachial Ankle Index (BAI):** The clinical measurement of the ankle brachial index was performed as a pre-participation criterion in the study, to verify whether individuals were predisposed to obstructive

After two minutes the athletes performed 3-5 repetitions with 60-80% of the estimated 1RM load. Subsequently, after three minutes the subjects started the maximum repetition test (1RM), with 3-5 repetitions with progressive loads, each with 3-5 minutes intervals each. No pauses were allowed between the repetitions concentric and eccentric phases of the warm-up.

***Brunel MoodScale (BRUMS):*** The athletes' mood states were assessed using the Brunel Humor scale (BRUMS) (Terry, 2003). The BRUMS scale was developed to quickly measure the moods of individuals, being adapted from the Profile of Mood States (POMS) (Mcnair, 2020) translated into Portuguese (Rohlfs, 2006; Rohlfs, 2008) and validated by Rohlfs (2006) with reliability coefficients ranging from 0.76 to 0.90. This questionnaire has 24 adjectives, distributed in six subjective and transient mood domains: (a) tension - reflects a high tension in the skeletal muscles (b) depression - indicates a state of depressed mood and a feeling of functional incapacity and futility; (c) anger - reflects an irritation in mood and hostility towards others, in addition to rebellion and bad mood (d) fatigue - represents inertia, fatigue and low energy levels; (e) confusion - reflects the state of mood characterized by mental confusion (negative factors) and (f) vigor - indicates a state of mood characterized by high physical energy (positive factor). The athletes rated the adjectives on a five-point scale (0=absolutely not; 1=a little; 2=moderately; 3=quite; 4=extremely) to describe their current mood. The instrument was applied with the athletes before, immediately after the exercise and in thirty minutes after the exercise, in which they answered the following question: “How do you feel now?”. With the measured data of the BRUMS scale, the total mood disturbance (TMD) was calculated using the formula: TMD = (T + D + A + F + C) - V + 100, applying the results found in the domains: Tension (T), Depression (D), Anger (R), Fatigue (F) Mental Confusion (C) and Vigor (V). In this way, the mood profile that presents high vigor value and low values for the other variables is called “iceberg profile”, positively characterizing the individual's mental health (Werneck, 2012).

***Muscle power assessment:*** Athletes' jump height data (CMJ) were collected using the mobile device application “my jump test 2” which was developed and validated to measure the height of vertical and horizontal jumps. Concurrent validation between My Jump app and a force platform was performed, with a reliability value of r=0.99 (Balsalobre-Fernadéz, 2015). The athlete stood up with his hands at the hip level, knees slightly bent (approximately 90 degrees) and shortly after wards the impulse with tidy lower limbs, executing a maximum explosive movement (Rodrigues, 2011). The highest jump height obtained after two jumps was recorded with an interval of 60 seconds between each jump.

**Statistical Analysis:** The data were analyzed using the Statistical Package for the Social Science (SPSS) version 21.0. Initially, an exploratory analysis was performed to verify the data normality (Shapiro-Wilk test) and homogeneity (Levene’s test). As the data met the normality assumptions, they were used in the Two-Way Analysis of Variance test, [2 (protocols: LLRE + BFR vs. HLRE) x 3 (time: pre-test vs. immediately after exercise vs. 30 minutes after exercise for mood state) and 4x (time: pre-test vs. immediately after exercise vs. 15 and 30 minutes after exercise for jump test)] followed by Bonferroni's post hoc test to analyze the effects of exercise in all dependent variables. The percentage variation (Δ%) was used in the time interaction for the mood states domains and muscle power. Data were presented as means and standard deviations. The significance level was set at p <0.05. For each dependent variable, the differences’ magnitude value (F), significance (p) and the effect size estimate using cutoff points (trivial <0.35, small 0.35-0.80, moderate 0, 80-1.50 and large> 1.5) (Rhea, 2004).

# RESULTS

Comparative analysis of tension, there was no significant interaction effect between Protocols and Time: ($F$= 0.170; $n^2$= 0.008; p= 0.844); no significant interaction main effect for Protocols ($F$= 4.25; $n^2$= 0.092; p= 0.054) and no significant interaction main effect for Time ($F$= 0.511; $n^2$= 0.024; p= 0.604). Regarding comparative analysis of the participants’ ratings depressed mood, there was no significant interaction effect between Protocols and Time: ($F$= 0.059; $n^2$= 0.056; p= 0.298); no significant interaction main effect for Protocols ($F$= 0.949; $n^2$= 0.022; p= 0.336) and no significant interaction main effect for Time ($F$= 1.24; $n^2$= 0.024; p= 0.604).

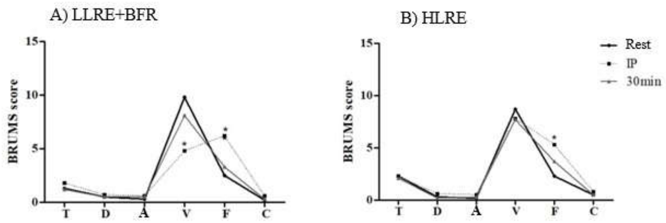
**Table 1. Comparison of the changes in the mood state domains over time for alltesting conditions**

| Mood State Domains | LLRE+BFR | | | HLRE | | |
|---|---|---|---|---|---|---|
| | Rest | IP | 30min | Rest | IP | 30min |
| Tension | 1.3 ± 1.0 | 1.8 ± 1.6 | 1.2 ± 1.1 | 2.3 ± 1.5 | 2.3 ± 1.5 | 2.1 ± 1.3 |
| Depression | 0.5 ± 0.4 | 0.7 ± 0.7 | 0.5 ± 0.3 | 0.3 ± 0.1 | 0.6 ± 0.5 | 0.2 ± 0.4 |
| Anger | 0.3 ± 0.1 | 0.6 ± 0.5 | 0.5 ± 0.5 | 0.2 ± 0.4 | 0.5 ± 0.5 | 0.3 ± 0.5 |
| Vigor | 9.8 ± 3.5 | 4.8 ± 1.8* | 8.1 ± 2.7 | 8.7 ± 2.9 | 7.8 ± 0.6 | 7.7 ± 1.9 |
| Fatigue | 2.5 ± 1.8 | 6.2 ± 1.3* | 3.3 ± 1.6 | 2.3 ± 1.3 | 5.3 ± 2.3* | 3.7 ± 2.1 |
| Confusion | 0.2 ± 0.4 | 0.6 ± 0.5 | 0.3 ± 0.5 | 0.5 ± 0.2 | 0.8 ± 1.3 | 0.5 ± 0.5 |

Rest: Baseline levels, IP: immediately post exercise, 30min: 30 minutes post exercise LL+BFR: Low load resistance exercise with blood flow restriction; HLRE: High Load resistance exercise; *significantly different from rest.

***Experimental protocols:*** All experimental sessions were randomized as indicated by Urbaniak (2013) the website https://www.randomizer.org/ in two sessions separated by 7 days. Each experimental session lasted a total of ≅40 minutes in all study protocols. In the LLRE + BFR condition, the athletes did the squat exercise with four sets, the first of which waswith 30 repetitions and the remaining three of 15 repetitions, with a load equivalent to 30% of 1RM and 30 seconds of interval between sets combined at 50% of the BFRinduced by an inflatable cuff and a speed execution of 2 seconds for each concentric and eccentric phase, with the BFR being released between sets.The session time was ≅ 36 minutes. In the HLRE condition, the athletes trained with a load corresponding to 75% of 1RM with four sets of 10 repetitions and a two-minute interval between sets and a two-second execution speed for each concentric and eccentric phase. The total session time was ≅ 38 minutes. In addition, in both training sessions, individuals performed two vertical jumps with counter movements (CMJ) separated by a one-minute interval before, immediately after, 15 minutes after and 30 minutes after the exercises. For the two experimental protocols, the athletes arrived at the laboratory during the morning and answered the Brunel mood scale (BRUMS), pre-exercise and started the experimental protocol at the gym. Immediately after the end of the training session and after 30 minutes, they answered the Brunel scale again. The athletes were already familiar with the strength, mood and muscle power tests applied in this study.

Comparative analysis of anger ratings showedno significant interaction effect between Protocols and Time: ($F$= 0.289; $n^2$= 0.014; p= 0.751); no significant interaction main effect for Protocols ($F$= 0.072; $n^2$= 0.002; p= 0.790) and no significant interaction main effect for Time ($F$= 2.02; $n^2$= 0.088; p= 0.145). Comparative analysis of fatigue ratings showedno significant interaction effect between Protocols and Time: ($F$= 0.359; $n^2$= 0.017; p= 0.700) and no significant interaction main effect for Protocols ($F$= 0.339; $n^2$= 0.008; p= 0.564), however, there was a significant main effect for Time: ($F$= 16.2; $n^2$= 0.437; p< 0.001). A significant increase in fatigue occurred from pre- to post-test measurement for protocols LLRE + BFR (p< 0.001; Δ%= 148; SE= 2.0; large) and HL + HI (p= 0.001; Δ%= 130.4; SE= 2.3; large). Comparative analysis of the confusion ratings showed no significant interaction effect between Protocols and Time: ($F$= 0.125; $n^2$= 0.006; p= 0.883); no significant interaction main effect for Protocols ($F$= 0.50; $n^2$= 0.012; p= 0.483) and no significant interaction main effect for Time ($F$= 1.12; $n^2$= 0.051; p= 0.334). Comparative analysis of vigor ratings showed no significant interaction effect between Protocols and Time: ($F$= 3.1; $n^2$= 0.131; p= 0.053) and no significant interaction main effect for Protocols ($F$= 0.491; $n^2$= 0.012; p= 0.487), however, there was a significant main effect for Time: ($F$= 5.6; $n^2$= 0.212; p= 0.007). A significant decreased in vigor occurred from pre- to post-test measurement for protocols LLRE + BFR (p<0.001; Δ%= -51.0; ES= -1.4; large). In the iceberg profile analysis, it was observed that in the pre-exercise classifications in both experimental conditions, the athletes reported high vigor domain but low values for negative mood states of tension, depression, anger, fatigue and mental confusion. However, in the post-exercise classifications, there was a mischaracterization of the athletes' iceberg profile in both conditions due to a significant decrease in vigor in the LLRE + BFR condition and a significant increase in fatigue in both experimental conditions.




**Legend** – Domains: Tension (T), Depression (D), Anger (A), Vigor (V), Fatigue (F), Confusion (C); *significant differences of rest

**Figure 2. Iceberg profile of basketball athletes during and after strength exercises with and without blood flow restriction**

In the comparative TMD analysis, there was no significant interaction in the protocol x time ($F$ = 2.62; $n^2$ = 0.111; p = 0.084); in the protocol ($F$ = 0.108; $n^2$ = 0.003; p = 0.744) and in time ($F$ = 9.25; $n^2$ = 0.306; p <0.001). In the interaction time after post hoc analysis, a significant increase in TMD was observed in the LLRE+BFR condition between the pre vs. immediately after (p <0.001; Δ% = 13.7; ES = 2.2; high).

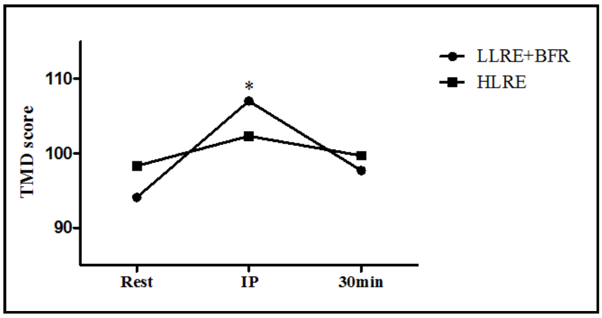



**Figure 3. Total mood disturbance in basketball athletespre- and post-strength exercises with and without blood flow restriction**

In the comparative analysis of the jump height (CMJ), it was observed that there was no significant interaction in the protocol x time (F = 0.96; n2 = 0.003; p = 0.416), however, there was a significant interaction in time ($F$ = 12.4; $n^2$ = 0.471; p <0.001). In the interaction time after post hoc analysis, a significant decrease in the jump height was observed in the LLRE+BFR condition between the pre vs. immediately after (p = 0.042; Δ% = -6.7; ES = 0.5; moderate) and pre vs. 15 minutes after exercise ((p = 0.008; Δ% = -7.4; ES = -0.5; medium), a fact similar to the HLRE in which there was a significant decrease in the jump height between the moments before vs. immediately after (p = 0.005; Δ% = -9.6; ES = -0.6; medium) and the pre vs. 15 minutes post exercise ((p <0.001; Δ% = -11.9; ES = -0.8; high).

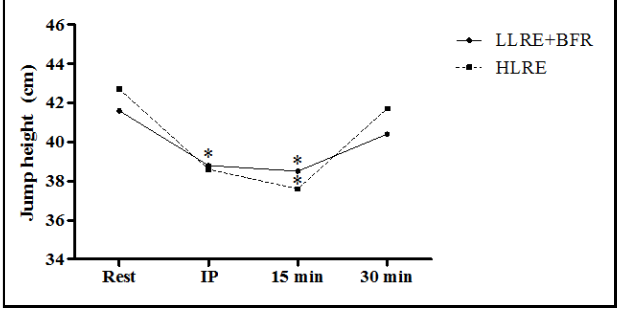



**Figure 4. Jump height (CMJ) of basketball athletes pre- and post-strength exercises with and without blood flow restriction**

# DISCUSSION

This study analyzed the mood state and muscle power after strength training sessions with and without blood flow restriction, obtaining as main findings a reduction in the vigor perception immediately after the LLRE+BFR and an increase in fatigue immediately after the LLRE+BFR sessions and HLRE, a mischaracterization of the iceberg profile after the experimental conditions, the significant increase in TMD immediately after the LLRE+BFR session and the reduction of the muscular power of the athletes in the LLRE+BFR and HLRE protocols up to 15 minutes after exercise. The significant reduction in vigor perception in the LLRE+BFR session may be due to an increased fatigue feeling after the completion of this training session. This high exhaustion response occurs due to the metabolic stress to which the musculature is subjected in ischemia, since, as described by Pope (2013), the hypoxia condition induces a greater demand for glycolytic fibers, linked to the rapid fatigue of oxidative fibers, which promotes depletion of phosphocreatine (Pcr) and inorganic phosphate (Pi), reduction in intramuscular pH, a phenomenon closely related to the activation of afferent nerve fibers through chemoreceptors found in muscles that induce greater sensitivity to pain. In addition, the concentration of metabolites such as $H^+$ ions seem to contribute to the negative increase in fatigue, since this accumulation can affect the kinetics of calcium and consequently in the actin-myosin interaction (Silva et al., 2019). This understanding justifies the significant TMD change immediately after the LLRE+BFR, which the increase in the result is caused by the exacerbated vigor decrease in and fatigue increase (Ruaro *et al.,* 2020). However, corroborating the studies byWerneck (2012), there is a tendency to reduce the TMD value after a recovery period from the training session, due to thefatigueand vigor perception returning to the rest levels, according to results found 30 minutes after the PT+BFR session in the present study.

The reduction of vertical jump decrease in the time interval presented in the study of both LLRE+BFR and HLRE, can be explained by the fatigue increase linked to the performance of high and moderate intensity exercises, negatively affecting the neuromuscular system. In this sense, muscular exhaustion caused by the effort made, comes from the majority recruitment of type II fibers which, although producing a great amount of strength and power, are little resistant to fatigue (Paulo *et al.,* 2010) in addition to having a lower speed glycogen resynthesis, culminating in an energy supply deficiency. Another determining factor is the changes in nerve-muscle transmissions, in which there is aneural activity reduction and neurotransmitters release derived from biogenic amines and amino acids in their free form, such as Tiptophane, causing failure in the potential action conduction of motor neuron for muscle fiber (Paulo *et al.,* 2010) which, coupled to the environment in hypoxia and metabolic acidosis in which the muscle is found, negatively affect the performance of the athletes. This study has some limitations. A more detailed analysis of the context that causes fatigue would be pertinent to understand which factors are triggering the performance decrease and how it would be possible to delay it. In addition, the present study monitored the effect in just one training session on the mood status, TMD and athletes' muscle power, being important to conduct studies that investigate these profiles alterations and team physical performance within a training program.

# CONCLUSION

It is concluded that the LLRE+BFR negatively affects mood state immediately after the exercise regarding increased fatigue and decreased vigor, causing changes in the athlete's iceberg profile. However, it is clear that 30 minutes after an LLRE+BFR session, TMD tends to decrease its values and the fatigue and vigor domains being restored to pre-exercise levels. Regarding muscle power, there was a reduction in the neuromuscular performance of the athletes, observed by a jump height reduction in the vertical jump up to 15 minutes after the execution of the exercise session, showing the need for an interval greater than 15 minutes after a training session for a metabolic restoration of the athletes' lower limbs, to reestablish the neuromuscular performance before the tactical-technical training.

**Conflict of Interest:** The authors declare thatthey do not have any conflict of interest.

**Author Contributions:** Conceptualization, C.L.C.M; methodology, C.L.C.M. and J.C.G.S.; formal analysis, V.C.A.; data curation, C.L.C.M and J.C.G.S.; writing original draft preparation, C.L.C.M., writing review and editing, K.F.S; V.B.C.T., G.R.N. All authors have read and agreed to the published version of the manuscript.

**Institutional Review Board Statement**: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the UNIFACISA (protocol codes: 3.450.988.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Conflicts of Interest:** The authors declare no conflict of interest.

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