Blood flow restriction: maintaining strength in the deltoid and quadriceps muscle groups during training interruption

Restrição do fluxo sanguíneo: manter a força nos grupos dos músculos deltoide e quadríceps durante a interrupção do treino

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ABSTRACT
Objective: to analyze intervention with pre-conditioning blood flow restriction, conditioning and bodybuilding inining the muscle strength of muscle groups during the interruption of training. Materials and Methods: 15 volunteers (men and women), with an average age of 25,0 ± 5,75 years, body weight 68,36 ± 10,6 kg and height 163,63 ± 8,8 cm, participated in the study. They were randomized and randomized into three groups: G1) was submitted to BFR has proved to be a more effective method, both pre-conditioning and conditioning, inining FM for longer, with intervals in training, in muscle groups, deltoid and quadriceps. Although, bodybuilding is also an option for this maintenance, but at lower levels than BFR, under two conditions that involve more actions and muscle groups when they are at stronger intensities. Various methods can increase and/or maintain muscle strength, including periods of exercise., with strength training, for eight weeks, on alternating days, and three weekly sessions; G2) to traditional strength training (muscle building), with periods and sessions equal to G1; and G3) to preconditioning ischemic training, with times and sessions equivalent to the previous groups. A database was created in Microsoft Excel to verify the Delta variation. Analysis was carried out in the Jeffrey’s Amazing Statistics Program (JASP), version 0.16.3 0 for Windows, which is used to measure the average, standard deviation, minimum and maximum; verify the normality of data by the Shapiro-Wilk test; and the Variance Analysis. (Anova one way). The adopted significance level was p≤0,05. Results: indicate that the muscle strength for the BFR group in the development exercise (p=0.001) and the size of the effect (η2=0.11) in the extender chair (p =0.044) and, effectively (η2.=0.61). Conclusion: BFR proved to be a more effective method, both pre-conditioning and conditioning, inining FM for longer, with intervals between training in the muscle, deltoid and quadriceps groups.

Keywords: restriction of blood flow, destraining, musculation.

RESUMO: restrição do fluxo sanguíneo, destraining, musculação.
10,6 kg e altura de 163,63 ± 8,8 cm, participaram do estudo. Eles foram aleatorizados e randomizados em três grupos: G1) foi submetido ao BFR tem provado ser um método mais eficaz, tanto pré-condicionamento e condicionamento, inining FM por mais tempo, com intervalos de treinamento, em grupos musculares, deltoides e quadríceps. Embora, musculação também é uma opção para esta manutenção, mas em níveis mais baixos do que BFR, sob duas condições que envolvem mais ações e grupos musculares quando estão em intensidades mais fortes. Vários métodos podem aumentar e/ou manter a força muscular, incluindo períodos de exercício., com treinamento de força, por oito semanas, em dias alternados, e três sessões semanais; G2) ao treinamento de força tradicional (construção muscular), com períodos e sessões iguais a G1; e G3) ao treinamento isquêmico de pré-condicionamento, com tempos e sessões equivalentes aos grupos anteriores. Um banco de dados foi criado no Microsoft Excel para verificar a variação Delta. A análise foi realizada no Programa de Estatísticas Incríveis (JASP) de Jeffrey, versão 0.16.3 0 para Windows, que é utilizada para medir a média, o desvio padrão, mínimo e máximo; verificar a normalidade dos dados pelo teste de Shapiro-Wilk; e a Análise de Variância. (Anova one way) (em inglês). O nível de significância adotado foi p≤0,05. Resultados: indica que a força muscular para o grupo BFR no exercício de desenvolvimento (p=0,001) e o tamanho do efeito (η2=0.11) na cadeira extensora (p=0,044) e, efetivamente (η2.=0.61). Conclusão: O BFR mostrou-se um método mais eficaz, tanto pré-condicionamento quanto condicionamento, inining FM por mais tempo, com intervalos entre o treinamento nos grupos muscular, deltoide e quadríceps.

**Palavras-chave:** restrição do fluxo sanguíneo, desgaste, musculação.

**1 INTRODUCTION**

Over time, strength and muscle mass are decreasing, which makes it essential to keep them at optimal levels throughout life. (Letieri et al., 2016). One strategy to reverse this framework of muscle hypertrophy is the inclusion in physical training programs with the aim of optimizing and adapting the muscles. (Jambassi Filho et al., 2023). Various protocols can be developed by manipulating different variables such as: volume, intensity, weekly frequency, order of the exercises and intervals between the series and exercise. (Fleck & Kraemer, 2017). The fact of not engaging in physical exercise programmes is one of the ways to consider yourself to be untrained (a), since untraining is defined as the interruption of the practice of physical exercise. (FLECK; KRAEMER, 2017).

The changes in these components can be explained by various factors, such as the decrease in the activation of motor units, the size and losses of muscle fibers, the difficulty of fully activating some muscle groups (FLECK; KRAEMER, 2017). In this way, it is...
crucial to understand the behavior of muscle strength, in the different relationships established in training programs, as well as in the period of untraining. However, this may be possible through a planned exercise program, which reduces the volume and intensity of training due to an injury, which prevents the person from pretending physical exercises. Participation in population training programs (MAY; BRANDNER; WARMINGTON, 2017) can be carried out through low-load and high-intensity training using blood flow restriction. (BFR).

This strategy has been widely used in athletes, hypertensive individuals, obese, elderly, healthy young people among others, to evaluate human performance in terms of physical fitness and health. It has on its basis the external compression around the proximal region of the upper and/or lower limbs, through pneumatic sleeves, knee bandages and elastic strips (ABE et al., 2019; PINTO et al., 2023), which vary according to the body segment. Its application can be in Pre-conditioning Ischemia (IPC) or Pre-Ishemic Conditioning (PCI), which occurs before the execution of the exercise, Conditioning (CON), THAT simultaneously, to the movement and Post-Conditioning Ishemic (IPOC) or Post-Ishemic Conditions (POCI), which is the compression shortly after the end of exercise. (ABE et al., 2019; CIRILO-SOUZA & RODRIGUES NETO et al., 2018). In terms of practical application, BFR can be performed not only with specific equipment (pneumatic cuffs), but also with torniquets and/or alloys that generate compression appropriate to the stimulation of this training technique.

After the removal of the instruments used in compression, reperfusion occurs, which acts as a product with renewable and restorative action, called Reperfusion Ischemic Product. (PIR). PIR is the restoration of blood supply to the tissue that is ischemic due to its normal decrease and comes loaded with metabolite concentrations among other acute positive reactions. (TAKARADA et al., 2000; CIRILO-SOUZA & RODRIGUES NETO, 2018; TEIXEIRA et al., 2019). Thus, it is possible to investigate that interventions with BFR in the destraining of muscle strength can generate comparisons of treatments that allow analyses through networks, which makes more efficient classifications possible. (OWEN et al., 2020). The aim of this article is to analyze
intervention with pre-conditioning blood flow restriction, conditioning and bodybuilding inining the muscle strength of muscle groups during training interruption.

2 MATERIALS AND METHODS

It is a quantitative, experimental and longitudinal research. The sample was made up of men and women between the ages of 20 and 40 (healthy people). Opinion No. 5,328,711, issued on April 4, 2022 approved the study. The sampling was carried out with GPower® 3.1.9.7 software, with a power of 0.80, effect size of 0.5 and a probability of 5%. The total of N=15 volunteers were classified according to the classification: G1) underwent BFR with strength training, for eight weeks, on alternating days, and three weekly sessions; G2) underwent traditional strength training (musculcation) in a period and sessions equal to G1. CIRILO-SOUZA; RODRIGUES NETO, 2018; YASUDA; OGASAWARA; ABE, 2011; LETIERI et al., 2016; Letieri et al, 2018). The exercises carried out were: development (halters) and extender chair. The exercises were carried out in a traditional way and with the technique of BFR, according to the group. The training volume was estimated by the maximum load multiplied by the number of series and repetitions. The load adjustments were made in the fifth week of intervention (FLECK &KRAEMER, 2017).

The following guidelines were recommended to the participants: be in post-prandial state for at least two hours, not ingesting caffeine, chocolate, supplements and alcoholic beverages, sleeping at least eight hours and not performing physical exercise in the hours prior to assessments and also in training sessions. (CIRILO-SOUZA et al., 2017). In addition to the non-execution of work activities that require the use of force and a great effort (physical deterrence), people who work in construction (stoneworkers), with faxina, for example.

Following the period of the training program, the subjects remained without moderate to vigorous physical exercise, as they were followed by physical assessments and tests to verify changes in the variables: muscle strength, body composition and blood pressure measurement, weekly, to control and identify these variables in the de-training phase and the decrease in strength caused by the time of de-treining. (SANTIAGO et al.,
The sample was released from the detachment phase from the moment the variables returned to the starting point of the study.

In the first week after the intervention, participants underwent anthropometric assessments – measurement of total body mass, height, circumference and skin folds; cardiometabolic measurements – checking systolic and diastolic blood pressure; and evaluation of muscle strength tests – 1 RM (development and extension chair). The sample was released from the detachment phase from the moment the variables returned to the starting point of the study. In the first week after the intervention, participants underwent anthropometric assessments: measurement of total body mass, height, circumference and skin folds; hemodynamic measurements: checking of systolic and diastolic blood pressure and heart rate; and evaluation of muscle strength tests – 1 RM (Closing with bar; direct rosca).

The statistical analysis was carried out in the Statistical Package for the Social Sciences (SPSS) version 22.0, and the interactions between the variables were carried on in the Java Standard Edition (JS2SE) version 5.0, according to table 1. Opinion No. 5.328.711 of April 4, 2022 approved the study.

### 3 RESULTS

Table of 1. Descriptive statistics of the variables of the study (N = 15).

<table>
<thead>
<tr>
<th>Varied</th>
<th>Mean</th>
<th>SD</th>
<th>SW</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>25.0</td>
<td>5.75</td>
<td>0.80</td>
<td>20.00</td>
<td>35.00</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>68.36</td>
<td>10.69</td>
<td>0.893</td>
<td>53.40</td>
<td>93.00</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>163.63</td>
<td>8.87</td>
<td>0.945</td>
<td>152.50</td>
<td>181.00</td>
</tr>
<tr>
<td>SAP (mmHg)</td>
<td>120.46</td>
<td>10.39</td>
<td>0.928</td>
<td>100.00</td>
<td>149.00</td>
</tr>
<tr>
<td>DAP (mmHg)</td>
<td>76.00</td>
<td>11.66</td>
<td>0.966</td>
<td>60.00</td>
<td>100.00</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>71.00</td>
<td>9.56</td>
<td>0.881</td>
<td>49.00</td>
<td>87.00</td>
</tr>
<tr>
<td>ITB (geral)</td>
<td>1.12</td>
<td>0.07</td>
<td>0.984</td>
<td>1.00</td>
<td>1.30</td>
</tr>
<tr>
<td>PF (%)</td>
<td>23.62</td>
<td>9.09</td>
<td>0.961</td>
<td>5.00</td>
<td>33.70</td>
</tr>
<tr>
<td>DEVELOP</td>
<td>31.20</td>
<td>7.77</td>
<td>0.950</td>
<td>22.00</td>
<td>44.00</td>
</tr>
<tr>
<td>EC</td>
<td>32.93</td>
<td>6.79</td>
<td>0.966</td>
<td>20.00</td>
<td>46.00</td>
</tr>
</tbody>
</table>

Legend: SAP= systolic arterial pressure; DAP= diastolic arterial pressure; HR= heart rate; DEVELOP= development; EC= extension chair; M= mean; SD= standard deviation; SW= Shapiro-Wilk. Source: own authorship.
As can be seen in table 2, there is a demonstration of the weekly de-training period by training technique. Statistical differences found in the BFR group were significant when compared to the averages of the MUSC and PCI groups in the dependent variable (dynamic muscle strength) between the exercises. In development – shoulder with bar – (p = 0.001) with reduced effect size ($\eta^2 = 0.11$); and extender chair (p= 0.044) with moderate effect size. In general, the training techniques can vary. The results were expressed in terms of average, standard deviation, significance and magnitude of the effect.

Table of 2. Descriptive characteristics (average ± standard deviation), significance and size of effect of the dependent variables in the depreciation period (N=15).

<table>
<thead>
<tr>
<th>Varied</th>
<th>BFR M ± sd</th>
<th>MUSC M ± sd</th>
<th>IPC M ± sd</th>
<th>P</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEVELOP</td>
<td>5.20 ± 0.44</td>
<td>3.28 ± 0.48</td>
<td>3.66 ± 0.57</td>
<td>0.001*</td>
<td>0.11</td>
</tr>
<tr>
<td>EC</td>
<td>4.60 ± 1.81</td>
<td>2.57 ± 0.53</td>
<td>2.66 ± 1.52</td>
<td>0.044*</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Legend: DEVELOP= development; EC= Extension chair; BFR= blood flow restriction; MUSC= musculation; PCI= pre-conditioned ischemia; M= mean; SD= standard deviation. Source: own authorship.

Figures 1 and 2 show the types of exercises and methods of intervention. In relation to development (shoulder with bar), after comparing the averages of each experimental condition, the BFR (5.20 ± 0.44); MUSC (3.28 ± 0.48); PCI (3.66 ± 0.57). A significant difference was observed in the BFR group (p=0.001) and a small effect size ($\eta^2=0.11$), as can be seen in Chart 1.
Figure 1. Comparison of the averages in the detrimentation period in the three conditions. Statistical differences occurred in the development exercises for BFR ($p \leq 0.001$).

![Developmente](image)

In the extender chair exercise, when comparing the averages of the experimental conditions, BFR ($4.60 \pm 1.81$); MUSC ($2.57 \pm 0.53$); PCI ($2.66 \pm 1.52$), the results showed significant differences between the BFR and MUSC groups ($p=0.04$) and an average effect size ($\eta^2=0.61$), as shown in Chart 2.

Figure 2. Comparison of averages in the period of depreciation. Statistical difference in the extender chair exercise between the BFR and MUSC ($p \leq 0.044$).

![Extension chair](image)
4 DISCUSSION

The present study was aimed at analyzing intervention with pre-conditioning blood flow restriction, conditioning and bodybuilding in improving the muscle strength of muscle groups during the interruption of training. The analysis of the performance of muscle strength in relation to the deltoid and quadriceps groups allowed the observation of detrimentation over eight weeks. In the comparison between the exercises with BFR and without, in bodybuilding, the decrease in muscle strength was perceived in the development (with bar) exercise and extender chair in the eight-week period of BFR, this fact was corroborated by the studies of Teixeira et al. (2019) that found that training with RFC did not accelerate the loss of muscle force during the de-training (although the authors have analyzed the intervals between training and detraining). They explain that this is due to the fact that BFR increases the recruitment of rapid contraction fibers, which results in the activation of satellite cells and the decrease of genes that are related to protein breakdown.

In a study conducted by Yasuda et al. (2014), six and three-week training and detrimental interventions were made. The researchers identified differences induced by detraining in the transversal area in young men, while FM increased. This is due to the fact that neural and hypertrophic adjustments were generated during training, which resulted in the maintenance of FM during the detrainment period after BFR intervention. The authors explain that the increase in rapid contraction fibers, as well as the expression and activation of satellite cells, increase muscle.

However, in the study of Brandner et al. (2019), the authors looked at muscle adaptations in four groups of young men and women: BFR with sixty percent occluded flow; moderate-weight strength training – seventy percent of 1 RM; twenty percent light load 1RM; and control group, for leg extension exercises, bar squat, leg press 45°, rectangle with bar, sitting hammer and biceps, after eight weeks of training. The researchers found that FM remained for longer in the (moderate) strength training group during de-training.

Thus, Brandner’s research and collaborators differed from the present study, in which the BFR group, in relation to FM, remained for longer than the other groups. These
effects can be explained by the fact that the compression of the BFR group was eighty percent, since this was better than the previous study. In addition, this group took longer to return to the baseline levels. The increase in intensity due to compression (eighty percent) of the flow was sufficient to moderate the loss of FM and, consequently, maintain this variable during detrainment. The authors concluded that training with BFR applied to the arm (proximal part) improves adjustments and increases overall shoulder muscle mass (although at lower intensity), as well as increases FM.

5 LIMITATION OF

Despite the promising effects, this study has as its limitation: no electro-stimulation was used, strength and muscle tone increased, which favoured relevant physiological changes.

6 CONCLUSIONS

BFR has proved to be a more effective method, both pre-conditioning and conditioning, in increasing FM for longer, with intervals in training, in muscle groups, deltoid and quadriceps. Although, bodybuilding is also an option for this maintenance, but at lower levels than BFR, under two conditions that involve more actions and muscle groups when they are at stronger intensities. Various methods can increase and/or maintain muscle strength, including periods of exercise.

CONFLICTS OF INTEREST

If the authors have any conflicts of interest to declare.

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