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# EFFECTS OF DIFFERENT TYPES OF CUFFS FOR TRAINING WITH RESTRICTION OF BLOOD FLOW: A SYSTEMATIC REVIEW

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**ABSTRACT**

Training with blood flow restriction shows positive results when associated with low training loads and similar when compared to high loads. There is still a gap in the literature regarding the influence of cuff sizes used in training, smaller cuffs require lower blood pressure levels to restrict blood flow in relation to larger cuffs, such a divergence can directly impact strength gains and hypertrophy. The aim of this study is to review in the scientific literature as the varied cuff widths can influence training, since establishing protocols can accelerate strength gains and hypertrophy, thus contributing to the results of the technique. This is a systematic review of the literature. This study is a subproject of a main research entitled "Physiotherapeutic approach in orthopedic and sports injuries", which was sent and approved by the Ethics and Research Committee of Faculdade Independente do Nordeste (CEP / FAINOR) through the opinion: 2,418,872. Both groups of cuffs showed beneficial results for gains in dynamic strength and muscle cross-sectional area. Based on the premise of the results obtained in this review, regardless of the width of the cuffs used in training with blood flow restriction, they produced similar increases in hypertrophy and strength gains.



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## INTRODUCTION

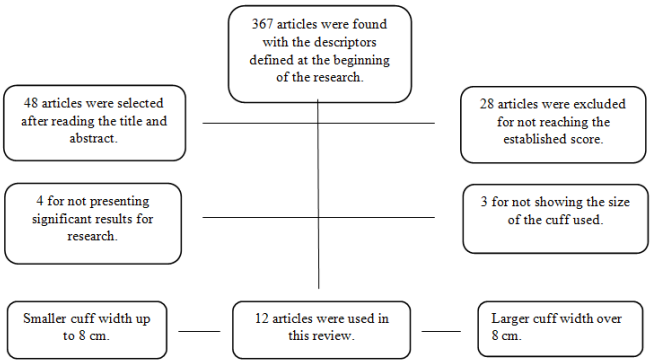
Training with blood flow restriction (TRFS) has been used and studied more frequently, Bryk et al. (2016) in their recent study demonstrated similar results when associated with low-load exercises (20% -50%) of 1RM (1 maximum repetition) in relation to muscle strength with those who did training with high loads 70% -80% of 1RM. The partial occlusion is made from a pressure cuff or tourniquet placed in the proximal region of the limb to be worked, thus offering an external pressure partially limiting the arterial blood flow and decreasing the venous return (SCOTT, 2015). The partial occlusion of blood flow physiologically generates an increase in metabolic stress, decreasing the oxygen supply causing muscle hypoxia, diverting the oxidative energy metabolism to glycolytic, stimulating the afferent group III and IV causing an inhibitory reflex effect on the alpha motor neuron, increasing the recruitment of type II fibers that are fibers of strength and low resistance (YOW, 2017). Despite the beneficial physiological results found in the literature, there is still a divergence between studies where there are questions when it comes to different cuff widths with similar pressures or not used in training. The literature presents several types of pressures to be applied in training, however, some studies are not concerned with the size of the cuff that can impact the perception of effort, with high pressure levels may be associated with a greater feeling of discomfort (SPITZ, 2019). The width of the *cuff* is an important factor to be considered, it was found that *cuff* wider require lower pressures to restrict the blood flow compared to the narrower, however, both cuffs

similar effects on the size of the cross-sectional area of muscle worked and strength, this can be related to the volume of equivalent training and the same pressure levels (LAURENTINO, 2016). In this context, the importance of this review in the scientific literature is observed in investigating and understanding how the varied cuff widths can influence training, since, establishing protocols can accelerate the gains in strength and hypertrophy, thus contributing to the results of the technique.

## MATERIALS AND METHODS

This study is a systematic review which follows the recommendation criteria of PRISMA (Main Item for Reporting Systematic Reviews and Meta Analysis). Bibliographic in character, this study searched controlled and randomized clinical trials in the literature that presented the profile established for inclusion in the study. Systematic review is a form of research that uses the literature on a given topic as a source of data. The study provides a summary of the evidence related to specific intervention strategies through the application of clear and systematic research, key assessment and methods of information integration chosen. Systematic reviews can be particularly useful for integrating information from a series of studies conducted separately for specific therapies / interventions, which may have conflicting and / or consistent results, and for identifying topics that require evidence, which can help guide future research. (SAMPAIO, 2007). Systematic literature search was carried out, without publication language restrictions, the articles were selected with publication date between 2015 and 2020. *US National Library of Medicine National Institutesof Heath* PUBMED was the database chosen for the search of the articles. The following keywords were used alone: "Blood flow restriction", "Blood pressure cuff", "Muscle strength", "Hypertrophy", or in combination: ["BLOOD FLOW RESTRICTION" OR "blood pressure cuff"] AND ["Muscle strength "OR“ Hypertrophy ”].

Articles with insufficient data or that did not present the cuff size used in the protocol were not included. Studies involving participants over 18 years of age, active or sedentary, post-operative of the lower limb or who had some pathology were included, studies that compared or combined training with restricted blood flow with other techniques were also included. The most relevant data extracted was the configuration of the cuff used in training, such as width and length. The results for research considered were muscle strength and hypertrophy, the data extracted for strength included isokinetic and / or manual dynamometer. For hypertrophy, the extracted data included limb circumference and / or transverse area. The eligibility criteria were based on the PEDro platform score above 5/10. The study selections, analysis and data collection were made separately and independently by two reviewers (CMAE and LFS), if there was no consensus the differences would be evaluated by a third reviewer (KTS). The reviewers first read the subsequent titles and abstracts according to the qualification criteria to independently judge the relevance of the research. Then, they carefully read and analyzed the full text of all articles whose summary may qualify or add points relevant to the project. During the search, 367 articles were found with the descriptors used in the research, after reading the title and abstracts, 48 articles were selected. The evaluation of the quality of the studies was carried out by two evaluators independently. The risk of bias was considered high if the methodological procedure was not described in detail, low if the procedure was described in detail, and unclear whether the description was partially described. 35 articles were removed, 28 for not reaching the proposed score, 4 for not presenting significant results for research, 3 for not presenting the cuff size used in the protocol. For research purposes , two groups were divided, cuffs up to 8 cm (41.6%), and another group was composed of cuffs over 8 cm (58.3%).




## RESULTS

The acquired results were tabulated according to the imposed specifications: author / year of publication / study title / published journal / cuff size used in the protocol / main results. Both groups of cuffs showed beneficial results for gains in 1RM, dynamic strength and muscle cross-sectional area. The 12 selected articles are available in the table below.

## DISCUSSION

The present study sought to review in the scientific literature the influence of the varied cuff widths used in training with blood flow restriction for strength gains and hypertrophy. After analyzing the studies, the main findings of this review were that regardless of the width of the cuffs, there were beneficial results in gains in strength and hypertrophy. Despite presenting similarity, we can highlight that there was no uniformity in relation to the width of the cuffs used in training, but a band corresponding to smaller and larger cuffs, in addition to the pressures that are not similar for both sizes, thus influencing the training volume, perception of discomfort and the respective gains, in this way it is necessary to standardize the width to be used. Thus, a more reliable prescription of which restriction pressure is more effective for each cuff is necessary, the studies show a diversification of pressures used in their protocols, as a result of which Loenneke et al. (2012) brought in their study that wider cuffs restrict blood flow with lower pressures compared to shorter ones and that the pressures used must be based on the width of the cuffs.

It is noted that the result of this review is consistent with the study by Laurentino et al. (2016) who compared the influence of different cuff sizes (5cm and 10cm) on muscle strength in patients undergoing low load training (20% of 1RM), inflated to 80% of blood pressure, and found that both groups obtained beneficial and similar responses after 12 weeks with 24 sessions in relation to 1RM and the cross-sectional area of the muscle, however, there was no significant difference regarding pain in the groups. The relationship between gains in both cuffs is physiologically proven with factors that generate strength and hypertrophy.

**Chart 1. Results of the articles according to the methodological parameter**

| Author / Year of publication / Title | Magazine | Cuff size | Main results |
|---|---|---|---|
| Hughes et al. 2019<br>Comparing the Effectiveness of Blood Flow Restriction and Traditional Heavy Load Resistance Training in the Post-Surgery Rehabilitation of Anterior Cruciate Ligament Reconstruction Patients: A UK National Health Service Randomized Controlled Trial. | Sports Med. | 11.5 cm wide | Training with restricted blood flow and resistance training with high loads observed comparable increases in skeletal muscle hypertrophy and strength; Training with restricted blood flow resulted in greater improvements in physical function and ROM;<br>Training with restricted blood flow resulted in a greater reduction in pain and effusion; There were no adverse events or effects on the laxity of the knee joint with any intervention. |
| Centner et al. 2019<br>Effects of Blood Flow Restriction Training with Protein Supplementation on Muscle Mass And Strength in Older Men. | J Sports Sci Med. | 12 cm wide | The main finding was that the transverse thigh area increased significantly after training training with restricted blood flow with and without ingestion of collagen hydrolyzate. Although not statistically significant, the percentage gain in the transverse muscle area after training was greater when collagen hydrolyzate was consumed compared to the training group with restricted blood flow - placebo. Muscle strength did not show significant adaptations between all groups. |
| Slysz et al. 2018<br>The Effects of Blood Flow Restricted Electrostimulation on Strength and Hypertrophy. | J Sport Rehabil. | 10.2 cm wide | The combination of training with blood flow restriction and low intensity neuromuscular electrostimulation stimuli led to strength gains that were significantly better in the control group. The training groups with isolated blood flow restriction and isolated neuromuscular electrostimulation were not significantly different from each other, or from any other group. |
| Ferraz et al. 2018<br>Benefits of Resistance Training with Blood Flow Restriction in Knee Osteoarthritis. | Med Sci Sports Exerc. | 17.5 cm wide | The main conclusions of this study are that training with blood flow restriction was similar and widely effective as resistance training with high loads in increasing the dynamic strength of lower limbs, quadriceps transverse area and functionality in patients with knee osteoarthritis. In addition, both training methods were able to improve the WOMAC physical function subscale, while blood flow restriction training significantly improved pain and stiffness subscales. |
| Gavanda et al. 2020<br>Low-intensity blood flow restriction calf muscle training leads to similar functional and structural adaptations than conventional low-load strength training: A randomized controlled trial. | PLoS One. | 7 cm wide | The training with blood flow restriction led to the increase to improvements compared to me 1RM equivalent to an average increase of 40 kg, and the thickness of the muscle an average increase of 0.07 cm |
| Cook et al. 2017<br>Blood flow restricted resistance training in older adults at risk of mobility limitations. | Exp Gerontol. | 6 cm wide | Training with blood flow restriction increased strength in the flexor chair, leg press, 1-RM and transverse muscle area in 6 weeks and at the conclusion of the training, changes in leg press, 1-RM and transverse muscle area were of extension similar to high intensity training. |
| Sieljacks et al. 2019<br>Non-failure blood flow restricted exercise induces similar muscle adaptations and less discomfort than failure protocols. | Scand J Med Sci Sports. | 14 cm wide | The training with blood flow restriction to failure and training with blood flow restriction without fail, increased muscle size and muscle function in similar degree , and that training with blood flow restriction without fail reduced perceived exertion, discomfort and late pain compared to training with restricted blood flow to failure. |
| Farup et al. 2015<br>Blood flow restricted and traditional resistance training performed to fatigue produce equal muscle hypertrophy. | Scand J Med Sci Sports. | 8 cm wide | Since performed until voluntary failure, training with restricted blood flow and resistance training with low loads are also capable of inducing hypertrophy that transient increases induced by exercise in relation to muscle thickness and that accumulated do not produce persistent changes in water retention in muscle. |
| Centner et al. 2020<br>Effects of Whole-Body Vibration Training and Blood Flow Restriction on Muscle Adaptations in Women: A Randomized Controlled Trial. | J Strength Cond Res. | 12 cm wide | The present study showed that the whole body vibration training group associated with training with blood flow restriction increased the transverse area of the vastus lateralis muscle. The assessment of muscle strength and jumping performance did not reveal significant differences between groups. |
| Cardoso et al. 2019<br>Intradialytic exercise with blood flow restriction is more effective than conventional exercise in improving walking endurance in hemodialysis patients: a randomized controlled trial. | Clin Rehabil. | 6 cm wide | The present clinical trial found a significant increase in walking resistance in patients undergoing 12 weeks of low / moderate intensity aerobic training associated with blood flow restriction training. No change in muscle strength was found after any condition of exercise. |
| Dankel et al. 2017<br>The acute muscular response to two distinct blood flow restriction protocols. | Physiol Int | Elastic cuff 3 cm wide<br>Nylon cuff 5 cm wide | The main findings of this article were that EMG amplitude, acute muscle thickness and post-exercise muscle strength produce similar acute responses in both cuffs. Regarding the perception of effort and discomfort at rest, there was no difference, however, the perception of effort was greater in the first series with the elastic cuff, and also resulted in greater discomfort after exercise. |
| Rodrigues et al. 2020<br>Low-Load Resistance Training With Blood-Flow Restriction in Relation to Muscle Function, Mass, and Functionality in Women With Rheumatoid Arthritis. | Arthritis Care Res (Hoboken) | 17.5 cm wide | The training blood flow restriction is effective for increasing the maximum dynamic force of the lower end area transverse quadriceps and functionality in patients with rheumatoid arthritis. In addition, training with blood flow restriction was able to improve HAQ and SF-36 due to physical and bodily pain. |

Source: *US National Library of Medicine National Institutesof Heath* PUBMED.

These answers are found in the study by Bittar et al. (2018) where he brought that the occlusion generates hypoxia providing an oxidative stress in the muscle fibers, these factors influence the synthesis and increase in the vascular endothelial growth factor and formation of new blood vessels, in addition to the proliferation of satellite cells, with the increase from blood pressure levels there is the release of bone alkaline phosphatase and amino-terminal telopeptides, favoring bone densiometry. This decrease in oxygen levels during training generates a greater dependence on anaerobic metabolism, with this, type I fibers become fatigued early, requiring the prior recruitment of type II fibers. Cerqueira (2016) reported in his study that the increase in lactate production generates fatigue in the limb, making the environment acidic, this intramuscular acidity accumulates hydrogen ions together with other free radicals such as nitrous oxide, which are potent indicators of Muscular hypertrophy.

The assembly of hydrogen stimulates affective metaboreceptors III and IV, which is linked to the hypothalamus and the pituitary by perfirefic signaling, which causes an inhibitory reflex on the motoneuronio alfa that results in a greater recruitment of motor units. Exercise-induced metabolic stress acts on cell hypertrophy through some mechanisms, such as hormonal growth, recruitment of contraction fibers, muscle damage and proliferation of satellite cells, being a major factor in inducing muscle growth, and when found in situations hypoxic or ischemic disorders are more significant, in their review Pearson et al. (2014) brought that the metabolic stress exerts blood lactate concentrations and demonstrated to be greater when the exercise is associated with training with blood flow restriction, which resulted in an increase in the cross sectional area of the muscle. This metabolic profile contributes to the significant increase in plasma concentrations of growth hormone (GH), which is ratified in the study by Kon et al. (2012), showing that acute systemic hypoxia causes greater elevations in GH levels, and the local accumulation of metabolic by-products, such as lactate and hydrogen ions, stimulate the secretion of anabolic hormones from the hypothalamus-pituitary.

It is important to highlight that some studies did not present the participants' sex and others did not homogenize just a group of people, which may interfere in the results, which we know that the body composition of men and women are different. However, it should also be noted that there was no blinding of evaluators and without an intense analysis of dealing with some articles, also that individual pressures for each participant were not used in any article.

**Conclusion**

Based on the premise of the results presented in this independent review of the width of the cuffs used in training with blood flow restriction, they produced similar increases in hypertrophy and strength gains. However, the literature still lacks studies where there are comparisons on the impact of different cuff widths on training results, requiring future studies of high methodological quality in order to elucidate a well-established protocol for which cuff width to use in training. However, in the context of musculoskeletal rehabilitation, there are benefits that can contribute to the clinical improvement of patients who need strength gains and hypertrophy, since both cuffs can mitigate this goal.

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