ORIGINAL ARTICLE

Accuracy of arterial occlusion pressure perception in practical blood flow restriction training after 6 weeks

Ratanyoo Longrak[ABCDE]

Faculty of Sport Science, Burapha University, Chon Buri, Thailand

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: The low-intensity resistance training with blood flow restriction became a popular area of research due to its ability to promote key physiological adaptations. Nevertheless, the standard pneumatic blood flow restriction equipment was expensive and limiting its accessibility. The elastic wrap was proposed to be the effective alternative to standard pneumatic cuffs. However, the estimate occlusion pressure accuracy was questionable. Therefore, this study aimed to investigate the retention of arterial occlusion pressure perception used for practical blood flow restriction training in untrained individuals after 6 weeks following acclimation.

Material and Methods: Eighteen untrained participants (mean age: 21.1 years; height: 174.1 cm; body mass: 68.8 kg) were recruited. Each participant underwent assessment to determine their individual 100% arterial occlusion pressure (100%AOP) for the right leg and arm. Following this familiarization, they acclimated to a 40%AOP. After six weeks, participants returned for a reassessment of their perception of 40%AOP. Paired-samples t-tests were employed to analyze the differences between perceived and actual 40%AOP.

Results: Statistically significant differences were observed between perceived and actual 40%AOP for both the right leg ($p = 0.000$) and the right arm ($p = 0.01$). The 95% confidence intervals for estimated pressure error were 11.6 – 26.5 mm Hg for the right leg and 2.5 – 16.4 mm Hg for the right arm.

Conclusions: This study revealed significant differences between perceived and actual 40%AOP in both the right leg and arm after six weeks following acclimation. However, the perceived 40%AOP remained within the effective range for promoting muscle hypertrophy.

Keywords: arterial occlusion pressure, blood flow restriction, perception, practical BFR, resistance training

Introduction

Recently, low-intensity resistance training has become a popular area of research due to its ability to promote key physiological adaptations, such as increases in muscle size and strength [1]. To further enhance the benefits of low-intensity resistance training, the blood flow restriction (BFR) technique has been introduced as a supplementary method [2]. This technique involves the use of adjustable pneumatic cuffs applied to the proximal region of the upper or lower limbs, restricting blood flow during exercise [3]. The literature demonstrates that when combined with low-intensity resistance training, BFR can amplify hypertrophic adaptations to a greater extent [4].

Mechanistically, BFR operates by partially limiting venous return while reducing arterial inflow, thereby inducing a hypoxic environment within the muscle [5]. This localized hypoxia increases metabolic stress, which triggers several physiological adaptations, including heightened recruitment of fast-twitch muscle fibers [6], enhanced production of growth factors such as insulin-like growth factor-1 [7], and increased muscle protein synthesis [8]. Moreover, the accumulation of metabolites, such as lactate, may further activate anabolic signaling pathways [9]. Consequently, BFR allows for significant muscle adaptations even when low external loads are used, as opposed to traditional high-load resistance training.

In most cases, Pneumatic cuff systems are commonly used to apply pressure for restricting blood flow to muscles [10]. To individualize this pressure, arterial occlusion pressure (AOP) is typically measured using devices such as handheld Dopplers [11] or pulse oximeters [12]. Once an individual's AOP is determined, a specific percentage - such as 40% - is applied for training. Studies have explored various percentages of AOP, such as 40%, 50%, or 80% [11, 13, 14]. However, the primary limitation of this method is the high cost and limited accessibility of standard pneumatic blood flow restriction equipment, making its application in real-world training settings more challenging.

To make BFR training more accessible and reduce the costs associated with equipment, non-pneumatic option such as elastic wrap [11] was used and developed as practical blood flow restriction (pBFR) methods [15]. Research has shown that pBFR is effective in enhancing muscle growth and

doi:10.15561/physcult.2025.0101

strength in both general populations and athletes. For example, a previous study found notable improvements in sprint performance and muscle thickness in active individuals after six weeks of sprinting training with pBFR [16] while the other study reported increased strength and muscle size in football players following a four-week low-load resistance training program using pBFR [17].

A significant challenge with pBFR is the standardization of its protocols. The use of elastic wrap makes it difficult to accurately measure the applied pressure, which is a major limitation of this method. Previous studies have sought to address this issue. For instance, Wilson and team introduced the perceived pain pressure method, where individuals wrap the elastic wrap until they reach a pain level of 7 out of 10 [15]. More recently, Bell and colleague proposed a method for standardizing pBFR by training individuals to sense the degree of occlusion [18]. This technique involves applying certain pressure such as 40% AOP and releasing pressure in a controlled manner for many intervals of 12 seconds on and 22 seconds off. Results showed that participants could effectively recall the sense of occlusion with an accuracy of less than 5 mmHg 24 hours later [18]. However, the retention of this sense over longer periods, such as weeks, has not yet been studied. Therefore, this study aims to investigate the retention of arterial occlusion pressure perception in untrained individuals after 6 weeks following acclimation.

Materials and Methods

Participants

This study represents the first phase of an investigation into the effects of resistance training on muscle hypertrophy. Sample size was justified by using G*Power version 3.1.9.7 software, based on input parameters from a previous study [19]. The parameters included an effect size of 0.75, $\alpha = 0.05$, and power = 0.80. The total number of participants in the study was 20. All participants met the following inclusion criteria: age under 22 years, no prior resistance training experience, no functional limitations affecting training, and no history of using pharmacological substances, ergogenic aids, performance-enhancing supplements, or anabolic steroids that could influence blood pressure.

Research Design

This study used a within-subject repeated-measures design to evaluate differences between the actual 40% arterial occlusion pressure (AOP) and the retention of perceived 40%AOP in the right leg and right arm at two time points: week 1 and after week 6. At baseline in week 1, participants were measured for both 100%AOP and 40%AOP in the right leg and right arm to allow them to acclimate to the 40%AOP. A re-test of their retention of perception of 40%AOP was conducted after 6 weeks. The study was conducted in accordance with the Declaration of Helsinki, with written informed consent obtained from all participants. The Institutional Review Board of the Burapha University Ethics Committee approved the study (Code: G-HS046/2566(C1)).

Arterial occlusion pressure measurement

To measure arterial occlusion pressure (AOP) for each participant, we used a pneumatic cuff (H+CUFF, USA) applied to the upper right leg or right arm in a random order. The cuff pressure was gradually increased by approximately 10 mmHg increments until blood flow could no longer be detected using a vascular Doppler (EDAN SD3, USA), indicating complete occlusion (100%AOP) (Figure 1) [1]. Once 100%AOP was established, we followed a previous protocol by reducing the pressure to 40%AOP without informing participants of the exact value. Participants then underwent an acclimation process, with alternating pressure cycles: 12 seconds with pressure on and 22 seconds with pressure off, all at their individual 40%AOP [18]. This cycle was repeated 15-20 times until participants became accustomed to the 40%AOP. Six weeks after, participants returned to the laboratory for follow-up measurements. The pneumatic cuff was re-applied to the same areas (upper right leg or right arm, in random order). This time, the pressure was increased by about 10 mmHg every 2 seconds, and participants were instructed to inform the researcher when they perceived the tightness to match their previous 40%AOP.

Statistical Analysis

For the statistical analysis, descriptive statistics were used to calculate the mean, standard deviation (SD), minimum and maximum for participants' baseline characteristics, and 100%AOP of right leg and right arm. Paired-samples t-tests were conducted to compare participants' perceived 40%AOP with their actual 40%AOP for both the right leg and right arm. All analyses were performed using IBM SPSS Statistics software version 20. Statistical significance was set at $p < 0.05$.

Results

Out of a total of 20 participants, 2 participants withdrew. The final analysis included 18 participants (Table 1).

The average 100%AOP for the right leg was 254 ± 32.7 mm Hg, while for the right arm it was 143.8 ± 17.9 mm Hg. From 100%AOP, the average 40%AOP for the right leg was 101.5 ± 13.1 mm Hg, and for the right arm, it was 57.5 ± 7.2 mm Hg.

After 6 weeks following acclimation, participants reported a perception of 40%AOP at 120.6 ± 14.3 mm Hg for the right leg, significantly different from actual 40%AOP (CI95% = 11.6–26.5 mm Hg, $p = 0.000$). Similarly, participants reported a perception

Figure 1. A pneumatic cuff (Left) and a vascular Doppler (Right)

Table 1. Baseline characteristics of participants

Measurement	Mean (n =18)	SD	Minimum	Maximum
Age (years)	21.1	0.5	20	22
Height (cm)	174.1	5.3	165	180
Body mass (kg)	68.8	11.3	56	94
100%AOP leg (mm Hg)	254	32.7	180	300
100%AOP arm (mm Hg)	143.8	17.9	120	180

Note: SD - Standard deviation; AOP -Arterial occlusion pressure.

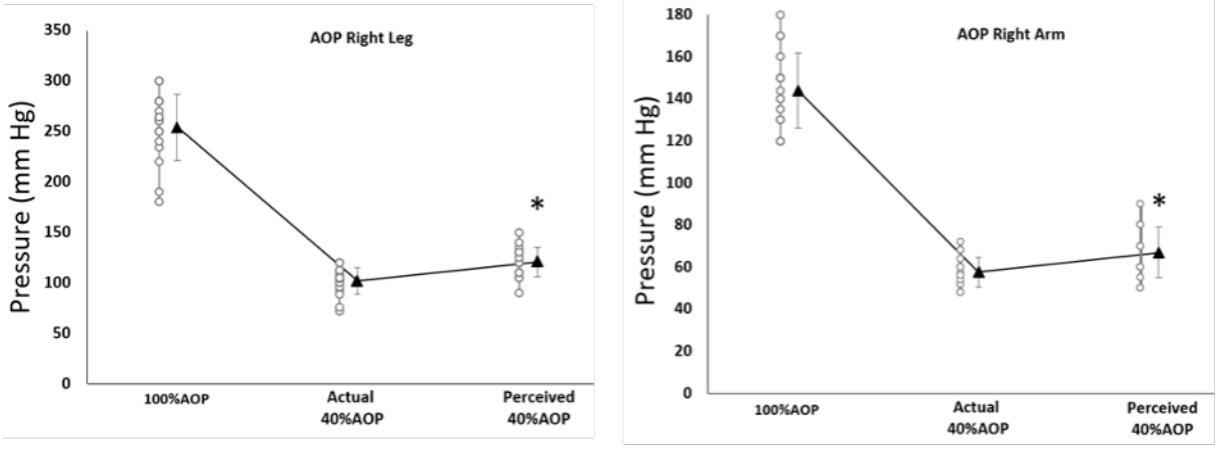

Figure 2. The average AOP for the right leg (Left) and the right arm (Right) at 100%AOP, actual 40%AOP, and perceived 40%AOP, with individual analyses: AOP - Arterial occlusion pressure; * indicates significant different from Actual 40%AOP.

of 40%AOP at 66.9 ± 12 mm Hg for the right arm, significantly different from actual 40%AOP (CI95% = 2.5–16.4 mm Hg, p = 0.01) (Figure 2).

Discussion

To the best of our knowledge, this was the first study to investigate the perception of arterial occlusion pressure after a 6-week period. Our findings indicated that, following an extended time after the familiarization session, participants' perception of arterial occlusion pressure changed significantly. Our finding did not support the use of practical blood flow restriction with elastic wraps that standardizing protocol by familiarizing practitioners to percentage of arterial occlusion pressure only in the first session [18].

A previous study reported that following a brief familiarization period of 5 minutes, the error in estimating AOP was just minimal, with participants achieving a target pressure close to the desired value (57 vs. 53 mm Hg). Even after 24 hours, the error remained small (57 vs. 54 mm Hg) [18]. Similarly, a recent study by Song and team demonstrated that individuals could learn to sense target pressures, although this ability diminishes over time [20]. Their study explored participants' perception of 40% AOP and found that after familiarization, the participants reported pressure estimations which were just slightly higher than target pressure, with deviations of 7.9 mm Hg at 5 minutes and 2.9 mm Hg at 30 minutes [20]. Our current findings extended the current literature by showing the

ability to accurately perceive AOP diminished more substantially over longer periods, such as after 6 weeks, which contrasted with previous studies indicating minimal error following short-term familiarization.

From a practical standpoint, the utilization of BFR to enhance low-intensity resistance training for inducing muscle hypertrophy had been suggested to be effective within an AOP range of 40-80% [2]. Although our study showed that participants were unable to accurately recall the exact perception of 40%AOP after 6 weeks, their perceived occlusion pressures were still approximately 48% for the right leg and 47% for the right arm. These values remained within the effective range for BFR, making it a viable approach for promoting hypertrophy. Furthermore, we proposed that regularly training the perception of occlusion pressure, such as by using an elastic wrap each week, might enhance the retention of the feeling of AOP after learning the actual 40%AOP from a pneumatic cuff [11].

Moreover, comparing to other practical applications of blood flow restriction, such as the widely-used method of perceived tightness of 7 out of 10 [15], the familiarization approach offered some greater precision and consistency. The subjective nature of the 7/10 method introduced variability, as individuals' perceptions of tightness could fluctuate based on factors like discomfort tolerance and prior experience. In contrast, this method, which was based on familiarization with a specific percentage of pressure, provides a more objective and measurable way to ensure that the occlusion pressure remained within the effective range for training. This reduced the risk of under- or overestimating the pressure, which can impact training efficacy and safety.

This study was not without limitations. The main limitation was the relatively short investigation period and the small number of participants, which could have been considered insufficient for standardizing the protocol. Therefore, we encouraged future studies to investigate the retention of perception over longer periods, such as 8–12 weeks, with a larger sample size.

Conclusions

In conclusion, this study was the first to investigate the retention of perception of arterial occlusion pressure over a 6-week period, revealing significant difference between perceived and actual 40%AOP for both the right leg and arm. Despite these differences, the perceived pressures remained within the effective range for inducing muscle hypertrophy. For practical application, we recommend tightening the elastic wrap slightly beyond perceived 40%AOP to maintain effective training pressures for hypertrophy.

Conflict of interests

The authors declare that there is no conflict of interests.

References

1. Dinyer TK, Byrd MT, Garver MJ, Rickard AJ, Miller WM, Burns S, et al. Low-Load vs. High-Load Resistance Training to Failure on One Repetition Maximum Strength and Body Composition in Untrained Women. *Journal of Strength and Conditioning Research*, 2019;33(7): 1737–1744. https://doi.org/10.1519/JSC.0000000000003194
2. Patterson SD, Hughes L, Warmington S, Burr J, Scott BR, Owens J, et al. Blood Flow Restriction Exercise: Considerations of Methodology, Application, and Safety. *Frontiers in Physiology*, 2019;10: 533. https://doi.org/10.3389/fphys.2019.00533
3. Perera E, Zhu XM, Horner NS, Bedi A, Ayeni OR, Khan M. Effects of Blood Flow Restriction Therapy for Muscular Strength, Hypertrophy, and Endurance in Healthy and Special Populations: A Systematic Review and Meta-Analysis. *Clinical Journal of Sport Medicine*, 2022;32(5): 531–545. https://doi.org/10.1097/JSM.0000000000000991
4. Loenneke JP, Wilson JM, Marín PJ, Zourdos MC, Bemben MG. Low intensity blood flow restriction training: a meta-analysis. *European Journal of Applied Physiology*, 2012;112(5): 1849–1859. https://doi.org/10.1007/s00421-011-2167-x
5. Törpel A, Herold F, Hamacher D, Müller NG, Schega L. Strengthening the Brain—Is Resistance Training with Blood Flow Restriction an Effective Strategy for Cognitive Improvement? *Journal of Clinical Medicine*, 2018;7(10):337.https://doi.org/10.3390/jcm7100337
6. Burd NA, Mitchell CJ, Churchward-Venne TA, Phillips SM. Bigger weights may not beget bigger muscles: evidence from acute muscle protein synthetic responses after resistance exercise. *Applied Physiology, Nutrition, and Metabolism*, 2012;37(3): 551–554. https://doi.org/10.1139/h2012-022
7. Aram S, Khodaei K, Zolfaghar Didani M. The effect of low-intensity suspension training with blood flow restriction on GH , IGF -1, and their association with physical fitness in young women. *Physiological Reports*, 2024;12(15): e16154. https://doi.org/10.14814/phy2.16154
8. Burd NA, West DWD, Staples AW, Atherton PJ, Baker JM, Moore DR, et al. Low-Load High Volume Resistance Exercise Stimulates Muscle Protein Synthesis More Than High-Load Low Volume Resistance Exercise in Young Men. Lucia A (ed.) *PLoS ONE*, 2010;5(8): e12033. https://doi.org/10.1371/journal.pone.0012033
9. Lawson D, Vann C, Schoenfeld BJ, Haun C. Beyond Mechanical Tension: A Review of Resistance Exercise-Induced Lactate Responses & Muscle Hypertrophy.

Journal of Functional Morphology and Kinesiology, 2022;7(4): 81. https://doi.org/10.3390/jfmk7040081
10. Ladlow P, Coppack RJ, Dharm-Datta S, Conway D, Sellon E, Patterson SD, et al. Low-Load Resistance Training With Blood Flow Restriction Improves Clinical Outcomes in Musculoskeletal Rehabilitation: A Single-Blind Randomized Controlled Trial. *Frontiers in Physiology*, 2018;9: 1269. https://doi.org/10.3389/fphys.2018.01269
11. Thiebaud RS, Abe T, Loenneke JP, Garcia T, Shirazi Y, McArthur R. Acute Muscular Responses to Practical Low-Load Blood Flow Restriction Exercise Versus Traditional Low-Load Blood Flow Restriction and High-/Low-Load Exercise. *Journal of Sport Rehabilitation*, 2020;29(7): 984–992. https://doi.org/10.1123/jsr.2019-0217
12. Hill EC, Housh TJ, Keller JL, Smith CM, Schmidt RJ, Johnson GO. Early phase adaptations in muscle strength and hypertrophy as a result of low-intensity blood flow restriction resistance training. *European Journal of Applied Physiology*, 2018;118(9): 1831–1843. https://doi.org/10.1007/s00421-018-3918-8
13. Santos A, Neves Jr M, Gualano B, Laurentino G, Lancha Jr A, Ugrinowitsch C, et al. Blood flow restricted resistance training attenuates myostatin gene expression in a patient with inclusion body myositis. *Biology of Sport*, 2014;31(2): 121–124. https://doi.org/10.5604/20831862.1097479
14. Laurentino GC, Loenneke JP, Teixeira EL, Nakajima E, Iared W, Tricoli V. The Effect of Cuff Width on Muscle Adaptations after Blood Flow Restriction Training. *Medicine & Science in Sports & Exercise*, 2016;48(5): 920–925. https://doi.org/10.1249/MSS.0000000000000833
15. Wilson JM, Lowery RP, Joy JM, Loenneke JP, Naimo MA. Practical Blood Flow Restriction Training Increases Acute Determinants of Hypertrophy Without Increasing Indices of Muscle Damage. *Journal of Strength and Conditioning Research*, 2013;27(11): 3068–3075. https://doi.org/10.1519/JSC.0b013e31828a1ffa
16. Behringer M, Behlau D, Montag JCK, McCourt ML, Mester J. Low-Intensity Sprint Training With Blood Flow Restriction Improves 100-m Dash. *Journal of Strength and Conditioning Research*, 2017;31(9): 2462–2472. https://doi.org/10.1519/JSC.0000000000001746
17. Yamanaka T, Farley RS, Caputo JL. Occlusion Training Increases Muscular Strength in Division IA Football Players. *Journal of Strength and Conditioning Research*, 2012;26(9): 2523–2529. https://doi.org/10.1519/JSC.0b013e31823f2b0e
18. Bell ZW, Spitz RW, Wong V, Yamada Y, Song JS, Abe T, et al. Can Individuals Be Taught to Sense the Degree of Vascular Occlusion? A Comparison of Methods and Implications for Practical Blood Flow Restriction. *Journal of Strength and Conditioning Research*, 2022;36(12): 3359–3365. https://doi.org/10.1519/JSC.0000000000004151
19. Zaroni RS, Brigatto FA, Schoenfeld BJ, Braz TV, Benvenutti JC, Germano MD, et al. High Resistance-Training Frequency Enhances Muscle Thickness in Resistance-Trained Men. *Journal of Strength and Conditioning Research*, 2019;33(1): S140–S151. https://doi.org/10.1519/JSC.0000000000002643
20. Song JS, Hammert WB, Kataoka R, Yamada Y, Kang A, Loenneke JP. Individuals Can be Taught to Sense the Degree of Vascular Occlusion: Implications for Practical Blood Flow Restriction. *Journal of Strength & Conditioning Research*, 2024;38(8): 1413–1418. https://doi.org/10.1519/JSC.0000000000004807

Information about the author:

Ratanyoo Longrak; https://orcid.org/0000-0001-6117-7617; addmuscleclinicz@gmail.com; Faculty of Sport Science, Burapha University; Chon Buri, Thailand.

Cite this article as:
Longrak R. Accuracy of arterial occlusion pressure perception in practical blood flow restriction training after 6 weeks. *Physical Culture, Recreation and Rehabilitation*, 2025;4(1):4–8.
https://doi.org/10.15561/physcult.2025.0101

Received: 02.12.2024
Accepted: 30.01.2025; Published: 30.06.2025