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Important Methodological Concern Regarding the Article "Effect of Leg Half-Squat Training With Blood Flow Restriction Under Different External Loads on Strength and Vertical Jumping Performance in Well-Trained Volleyball Players": A Letter to the Editor

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We would like to commend Wang et al[1] on their investigation into the 8-week chronic training effects of blood flow restriction (BFR) on trained volleyball players. Novel to the field was the comparison between low-load BFR (30% 1-repetition maximum, RM) and heavy loads (70% 1-RM) (HL) with and without BFR applied at an estimated 50% arterial occlusion pressure (AOP). BFR was prescribed in a commonly recommended fixed scheme (30 repetitions followed by 3 sets of 15)[2] while HL strength training was performed for 4 sets of 8 repetitions. Results indicate that HL strength training with BFR performed better in thigh muscle strength and jumping performance than low-load BFR exercise and in some measures exhibited non-significant improvements over HL strength training. The results are surprising given previous research has indicated no additional benefit with the addition of BFR to HL on muscle strength measures[3] although one study did show improvements of performance in rugby athletes.[4] Nonetheless, the results of this study provide preliminary support for the use of BFR during HL strength training to elicit significant gains in strength and jumping performance—factors thought to be important in improving volleyball performance.

However, we want to highlight a significant methodological limitation that impacts the interpretation of the study. We agree that utilizing a limb circumference equation is an appropriate surrogate for determining AOP when using single-chambered bladder systems capable of achieving full arterial occlusion.[5] However, Wang et al[1] implemented the B-Strong™ cuff (BStrong Training Systems™, Park City, UT, USA), a multi-chambered bladder system,[6] fundamentally reducing the validity of the limb circumference algorithm used in Loenneke et al[5] that was determined using a 5 cm and 13.5 cm wide single-bladder elastic and nylon cuff. Multi-chambered bladder devices are designed to reduce the potential for full arterial occlusion[7] and are not an appropriate device for integrating the AOP equation as it will likely greatly underestimate the applied pressure given its construction is designed to avoid the potential for such personalization of pressure.[8]

Prior research has shown that the multi-chambered bladder system is unable to personalize pressures and has difficulty in modulating resting blood flow—factors that are likely important to inducing some of the beneficial effects of BFR exercise. Citherlet et al[7] showed that femoral blood flow was unaltered from resting conditions with pressures as high as 300 mmHg, a pressure that is almost double to that used in the current study (180 mmHg).[1] In addition, Citherlet et al[7] applied arbitrary pressures in lieu of %AOP because the B-Strong™ cuff could not apply enough pressure to determine AOP in any of the participants, prohibiting a relative pressure assessment on resting blood flow. This is important as there appears to be a minimum amount of applied pressure (~50% AOP) needed to induce fatigue accumulation during BFR exercise.[9] As fatigue is thought to be a primary mechanism of action in promoting the beneficial effects of BFR exercise,[10]

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applying a relative pressure of at least 50% AOP in the lower extremities is likely very important to eliciting the effects of BFR exercise. However, that assumes the restrictive cuff can apply 50% AOP. The pressures used in the current study likely did not alter resting blood flow to induce any effect related to the BFR stimulus and therefore the results should be viewed with caution.

For comparison, Citherlet et al[7] was able to determine AOP using a single-chambered bladder research cuff (Hokanson [Hokanson, Bellevue, WA, United States]) of similar width as the cuffs employed in Wang et al[1] and showed that AOP was reached in the lower extremities with cuff pressures between 188–223 mmHg. This pressure is similar to the pressures used in the current study but it should be pointed out that pressures of as little as 40% AOP (75–89 mmHg) were able to modulate blood flow to a significant degree during resting conditions in the Hokanson device, nearly half of the applied pressure used in Wang et al[1] during exercise. While it is convention to assess AOP during resting conditions and apply it during exercise,[2] it is recognized that AOP increases slightly during exercise from resting conditions[11] but that increase is likely not practically meaningful. Thus, due to the low pressure applied in the current study, it is questionable whether any significant effect of the pressure applied was able to induce a BFR-related effect. Unfortunately, the authors of the current study did not report volume load over the course of the intervention, a metric that could have enabled interpretation on the potential impact of the restrictive stimulus provided by the B-Strong™ bands.

Our opinion is that the results align closer with supporting the benefits of limb compression on athletic performance rather than BFR *per se*. As prior research has shown that limb compression enhances maximal strength to a greater degree than when performed without,[12] it is plausible to hypothesize that the bilateral stimulus applied to the legs during exercise enhanced some form of stretch reflex in the working muscles beyond that of HL strength training alone. For example, powerlifters have long applied compression sleeves to the knees during squatting to augment muscle strength and improve acute concentric muscle contraction velocity.[13] The applied BFR stimulus may have contributed to augmenting the compression of the musculature underneath the cuff application in the hip region, acting in a similar capacity to compressive therapy applied to the knees. Unfortunately, as muscle activation and concentric contraction velocity[14] were not measured in this study,[1] it leaves many questions unanswered as to the acute performance responses of the HL BFR group. As BFR continues to gain more popularity, it is important to understand device features and that may impact the BFR stimulus. We hope that highlighting this important methodological concern shapes future research endeavors on the topic.

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References

1. Wang J, Fu H, QiangZhang, Zhang M, Fan Y. Effect of leg half-squat training with blood flow restriction under different external loads on strength and vertical jumping performance in well-trained volleyball players. *Dose Response*. 2022;20(3):15593258221123672.
2. Patterson SD, Hughes L, Warmington S, et al. Blood flow restriction exercise position stand: Considerations of methodology, application, and safety. *Front Physiol*. 2019;10(MAY):533. doi:10.3389/fphys.2019.00533
3. Laurentino G, Ugrinowitsch C, Aihara AY, et al. Effects of strength training and vascular occlusion. *Int J Sports Med*. 2008; 29(8):664-667.
4. Cook CJ, Kilduff LP, Beaven CM. Improving strength and power in trained athletes with 3 weeks of occlusion training. *Int J Sports Physiol Perform*. 2014;9(1):166-172.
5. Loenneke JP, Thiebaud RS, Fahs CA, Rossow LM, Abe T, Bemben MG. Effect of cuff type on arterial occlusion. *Clin Physiol Funct Imaging*. 2013;33(4):325-327.
6. Rolnick N, Cerqueira MS. Comparison of blood flow restriction devices and their effect on quadriceps muscle activation: Letter to the editor. *Phys Ther Sport*. 2021;49:227-228. doi:10.1016/j.ptsp.2021.03.006
7. Citherlet T, Willis SJ, Chaperon A, Millet GP. Differences in the limb blood flow between two types of blood flow restriction cuffs: A pilot study. *Front Physiol*. 2022;13. 931270. doi:10.3389/fphys.2022.931270
8. Rolnick N, Kimbrell K, de Queiros V. Beneath the cuff: Often overlooked and under-reported blood flow restriction device features and their potential impact on practice. *Front Physiol*. 2023:14;1089065. doi:10.3389/fphys.2023.1089065
9. Cerqueira MS, Lira M, Mendonça Barboza JA, et al. Repetition failure occurs earlier during low-load resistance exercise with high but not low blood flow restriction pressures: A systematic review and meta-analysis. *J Strength Cond Res*. 2021; Publish Ahead of Print. doi:10.1519/JSC.0000000000004093
10. Jessee MB, Mattocks KT, Buckner SL, et al. Mechanisms of blood flow restriction: The new testament. *Tech Orthop*. 2018;33(2):72-79.
11. Crossley KW, Porter DA, Ellsworth J, et al. Effect of cuff pressure on blood flow during blood flow-restricted rest and exercise. *Med Sci Sports Exerc*. 2020;52(3):746-753.
12. Baum JT, Carter RP, Neufeld EV, Dolezal BA. Donning a novel lower-limb restrictive compression garment during training augments muscle power and strength. *Int J Exerc Sci*. 2020;13(3):890-899.
13. Lake JP, Carden PJC, Shorter KA. Wearing knee wraps affects mechanical output and performance characteristics of back squat exercise. *J Strength Cond Res*. 2012;26(10): 2844-2849.
14. Sánchez-Medina L, González-Badillo JJ. Velocity loss as an indicator of neuromuscular fatigue during resistance training. *Med Sci Sports Exerc*. 2011;43(9):1725-1734.