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ORIGINAL ARTICLE

Effect of One Session of Muscle Blood Flow Restriction Training Versus Normal Training on Blood Lactate Level

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Objectives: Blood flow restriction training (BFRT) is useful for improving muscle strength. However, it involves a long training time and is unsuitable for vigorous exercise. Muscle blood flow restriction training (MBFRT), which uses multiple parallel pneumatic cuffs (MPCs) to compress large areas of the extremities and restrict blood flow, was subsequently developed to address these issues. This study compared the effects of MBFRT with normal training (NT). **Methods:** Ten healthy adults underwent low-intensity MBFRT. MPC pressure was increased to 200 mmHg just before training. The exercise was a bodyweight half-squat. Three sets of 30 squats were performed. Two weeks later, the participants underwent NT with the same exercise. Blood lactate levels were measured before the start of training and at 1 and 5 min after training. The Borg index was also measured at the end of the training. **Results:** The blood lactate level was elevated at 1 min after MBFRT and NT. The elevated blood lactate level was maintained at 5 min after MBFRT, whereas the lactate level was significantly decreased at 5 min after NT. The Borg index at the end of the training was significantly higher in MBFRT than in NT. **Conclusions:** Lactic acid accumulates in the muscles during low-intensity MBFRT, thereby initiating type II fiber activity.

Key Words: blood lactate level; multiple parallel pneumatic cuffs; muscle; muscle blood flow restriction training

INTRODUCTION

Age-related muscular atrophy, predominantly caused by the loss of type II fibers, starts at approximately 25 years of age and increases thereafter.[1] Type II fibers must be activated to stop this loss, which requires intense exercise at 60%–70% of a single-repetition maximum load or exercise that exhausts type I fibers.[2] However, not everyone can complete this kind of training. Conversely, type II fibers can be recruited during the early phase of low-intensity exercise training because type I fibers cannot be activated when the muscle is hypoxic.[3] As a potential substitute for high-intensity resistance training, Shinohara et al.[4] discovered that an innovative tourniquet ischemia procedure resulted in significant strength improvements. This method is blood flow restriction training (BFRT), where the base of the extremity is compressed with a single cuff or belt (**Fig. 1**). The vascular system progressively becomes compressed during BFRT, and venous blood flow is more constrained than arterial blood flow.[5] Blood is retained in capillaries because of decreased movement of venous blood.[6] Intramuscular pressure increases when muscle contraction occurs with this restricted blood flow.[7] Aerobic exercise of type I fibers consumes oxygen. In addition, capillary blood flow is restricted and the supply of fresh oxygen is limited, making the muscles hypoxic. As type I fibers become inactive, type II fibers are forced to activate. BFRT has been performed on more than 50 patients per day at our hospital for about 10 years since 2004. BFRT is a safe and effective method. However, given that it takes time to achieve hypoxia in the lower limbs with BFRT, the training time is between 5 and 30 min.[8,9] In addition, intense exercise causes increased blood flow, which undermines hypoxia.[9,10]

To solve this problem, I developed muscle blood flow

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Fig. 1. Blood flow restriction training (BFRT). The base of the limb is compressed with a single cuff. The blood flow is restricted throughout the extremity, which restricts blood flow in the muscles.

Fig. 2. Muscle blood flow restriction training (MBFRT). Large extremities are compressed with multiple cuffs. Pressure is increased in the muscle, resulting in restricted blood flow, as in compartment syndrome.

restriction training (MBFRT), which uses multiple parallel pneumatic cuffs (MPCs) to apply uniform pressure over a wide area of the extremities (**Fig. 2**). This study was conducted to test the following hypothesis: when a limb is compressed over a wide area with MPCs, the pressure within the skeletal muscles in that area increases instantaneously, restricting blood flow within the muscles, such that even low-intensity exercise causes the muscles to become hypoxic for a short time, activating type II fibers. To test this hypothesis, post-training blood lactate levels and fatigue level were compared between low-intensity MBFRT and low-intensity normal training (NT) performed by healthy volunteers.[11)]

MATERIALS AND METHODS

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical guidelines for human medical research were followed with the consent of the Fukuta Orthopedic Surgery Ethics Committee (approval number: 3). All participants were informed in advance of the method and purpose of the study, and written informed consent was obtained from the study participants.

The study included ten healthy adults (four men, six women; mean age 33 ± 10 years). The medical histories and results of physical examinations, laboratory tests, and liver and renal function tests of all the participants were reviewed. The participants were physically active but were not undergoing exercise training at the time of the study.

The MPCs comprised three parallel pneumatic cuffs connected to each other. The cuffs had individual widths of 6 cm and were spaced 1 cm apart, giving a total MPC width of 20 cm. The MPCs were connected to a pump and a pressure-regulating airbag (**Fig. 3**). MPCs were worn on both thighs with the knees flexed at 90°. The inferior edge of the MPCs was placed 5 cm proximal to the superior edge of the patella. The exercise performed for this research was a bodyweight-loaded half-squat with knee flexion at 90° (**Fig. 4**). Each position (knee extension and knee flexion) was held for 1 s.

All participants performed the MBFRT squat first. The pressure of the MPCs was increased to 200 mmHg just before training. The maximum number of squats was 30, and three sets were performed with a 5-s rest in between. After completing the three sets, the pressure was lowered to 0 mmHg.

Blood lactate levels were measured before MBFRT and 1 and 5 min after MBFRT with a Lactate Pro 2 blood lactate meter (Arkray, Kyoto, Japan). Blood was drawn from a finger. After 2 weeks, all participants undertook NT. Meals, sleep, and activities until the start of NT were the same as those used during MBFRT. Blood lactate levels were measured three times in the same manner as described for MBFRT. During each exercise, the physical activity intensity of the participant was measured using the Borg scale of perceived

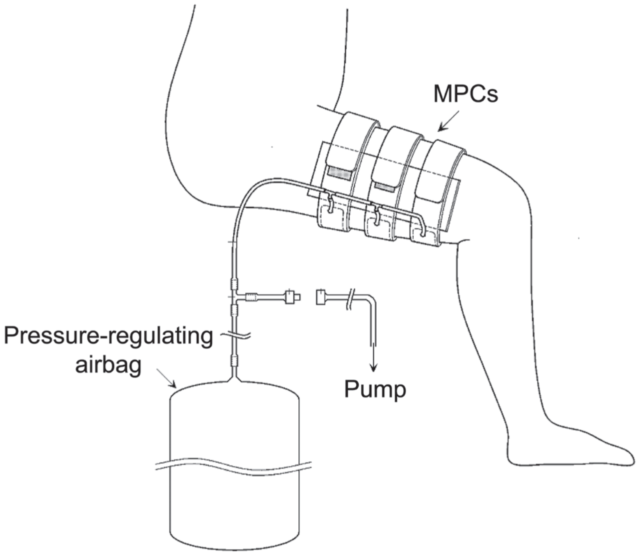

Fig. 3. Multiple parallel pneumatic cuffs (MPCs) comprise three parallel pneumatic cuffs connected to each other across a total width of 20 cm. The MPCs are connected to a pump and a pressure-regulating airbag.

exertion.[12] Stata version 15 (Stata, College Station, TX, USA) was used for statistical analysis, and P<0.05 indicated significance.

RESULTS

All participants performed 30 squats in the first set of MBFRT. However, the average number decreased to 25.3 ± 8.4 in the second set and 13.3 ± 12.1 in the third set. Participants performed the same number of squats in NT as in MBFRT.

The mean blood lactate levels for MBFRT were 1.5 ± 0.3 mmol/L before training, 4.9 ± 1.9 mmol/L at 1 min after training, and 5.1 ± 2.0 mmol/L at 5 min after training. In contrast, the respective blood lactate levels for NT were 1.4 ± 0.5, 3.3 ± 1.5, and 2.5 ± 1.6 mmol/L (**Table 1**).

The blood lactate level was significantly increased at 1 min after MBFRT (P<0.001, paired *t*-test) and was maintained at 5 min after training. In NT, the blood lactate level was significantly increased at 1 min after the end of training (P=0.004, paired *t*-test) but decreased significantly at 5 min after training ended (P=0.009, paired *t*-test). In comparing blood lactate levels at 5 min after training, the levels were significantly higher after MBFRT than after NT (P=0.005, unpaired *t*-test) (**Fig. 5**). The mean Borg scale of perceived exertion was 17.6 ± 1.35 during MBFRT, which was significantly higher than the Borg scale during NT (12.8 ± 1.75; P<0.001, unpaired *t*-test).

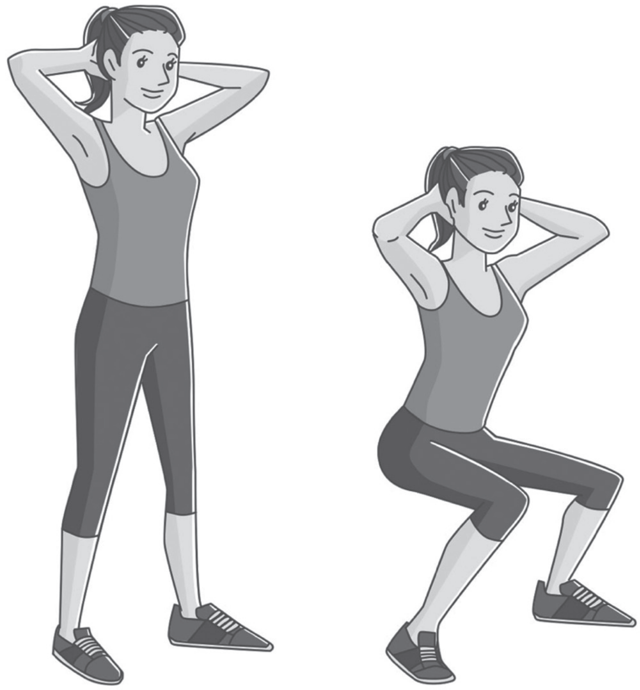

Fig. 4. Bodyweight half-squat exercise performed in this study. The participants held knee extensions and 90° knee flexions for 1 s each.

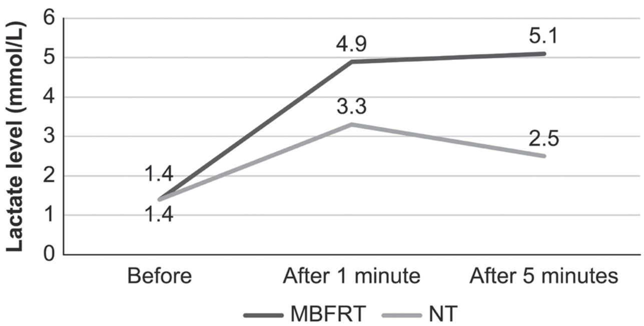

Fig. 5. Mean blood lactate levels (n=10) before and soon after NT and MBFRT.

DISCUSSION

During MBFRT in this study, blood lactate levels were significantly increased at 1 min after training and were maintained 5 min after training. In contrast, in NT, the blood lactate level was increased at 1 min after training but then showed significant decline at 5 min after training. Five minutes after MBFRT ceased, the blood lactate level

Table 1. Participant characteristics, number of squats, blood lactate levels, and Borg scale readings

	Participants										Mean±SD
Age, years	29	31	31	54	42	32	24	22	46	23	33.4±11.6
Sex	M	F	M	F	F	M	F	M	M	M	
MBFRT											
Number of squats											
Set 1	30	30	30	30	30	30	30	30	30	30	30±0
Set 2	23	10	30	30	10	30	30	30	30	30	25.3±8.4
Set 3	7	6	1	5	4	30	15	30	30	5	13.3±12.1
BL, mmol/L											
Before	1.2	1.2	2.1	1.2	1.3	1.3	1.8	1.4	1.2	1.7	1.4±0.3
After 1 min	3.2	3	4.1	4.3	3.6	7.8	2.9	7.8	6.4	6.3	4.9±1.9
After 5 min	3.1	2.7	4.6	5.6	3.1	7	3.6	8.7	5.8	7	5.1±2
Borg scale	19	19	17	19	19	17	17	17	15	17	17.6±1.35
NT											
BL, mmol/L											
Before	1.7	1.6	0.8	0.8	1.8	1.4	1.8	1.3	1.1	1.4	1.4±0.4
After 1 min	3.6	2	1.8	3.1	2.2	3.3	1.8	6.2	4.6	4.8	3.3±1.5
After 5 min	1.9	1.7	1.3	2	1.8	2.9	1.1	6.1	1.9	4.3	2.5±1.6
Borg scale	15	15	15	13	11	11	13	11	11	13	12.8±1.75

SD, standard deviation; BL, blood lactate concentration.

was significantly higher than 5 min after NT. These findings suggest that lactate accumulated in the muscle during MBFRT and was released from the muscle immediately after decompression of the MPCs.

Several studies have supported Brooks' lactate shuttle hypothesis, in which lactate moves between and within tissues.[13,14] Lactate produced in the muscles is released outside the muscles and used as a carbohydrate source.[15,16] Previously, it was considered that all lactate produced in skeletal muscles was released outside the muscles. However, intramuscular lactate shuttling by monocarboxylate transporter (MCT) is now recognized.[17–19] Lactate is produced in glycolytic muscle cells, released by MCT4, and taken up by oxidative muscle cells by MCT1 in the same muscle. Considering lactate metabolism in skeletal muscle, type II fiber activity promotes glycolysis and produces lactic acid. The lactate produced is transported from the muscle into the bloodstream or is consumed by muscle activity in type I fibers.[20] Therefore, for lactate to accumulate, type II fibers must be activated first. In addition, restricted blood flow and inactivity of type I fibers are required. In this study, MBFRT activated type II fibers, deactivated type I fibers, and restricted intramuscular blood flow, which resulted in lactic acid accumulation within the muscles. Type II fibers are preferentially active in MBFRT.

In this study, a high Borg index (17.6 ± 1.35) was observed during MBFRT. Given that the relationship between perceived exertion and blood lactate concentration is recognized,[21] the high Borg scale[12] observed during MBFRT in this study indicates lactic acid accumulation. Lactate produced during exercise can stimulate growth hormone production by acidification of the skeletal muscle sarcoplasm, leading to skeletal muscle hypertrophy and hyperplasia through the activity of insulin-like growth factors.[22–24]

In addition to the perceived benefits of MBFRT, the safety implications of the training method also require consideration. In performing MBFRT in this study, the maximum duration of training was about 190 s (2 s × 30 reps × 3 sets + 5 s × 2 rests). Even during limb surgery, the limb may be compressed using a pneumatic tourniquet. There are several reports on problems caused by this approach.[25–28] Reportedly, muscle changes occur after a tourniquet is left in place for 15 min.[29] However, there are no reports of any damage caused by a tourniquet left in place for 3 min. In contrast, in ischemic conditioning, which provides temporary ischemia and reperfusion to the limb, blood flow is stopped for approximately 5 min using a tourniquet.[30,31] Ischemic conditioning is performed on the upper and lower limbs.[32,33] In addition, it is performed for cases with vascular disease.[34,35] When applied to the lower extremities, the tourniquet is

13.5–33 cm wide and compresses a wide area of the extremity.[36] This width is similar to that being compressed by MPCs in MBFRT. Given that there have been no reports of adverse effects of ischemic conditioning, it is reasonable to suggest that MBFRT lasting up to 5 min is safe. Furthermore, to reduce risks, the following procedures are recommended:

- Start with a low pressure (approximately 150 mmHg or below) and gradually increase it. Do not exceed 300 mmHg.
- Start with a short duration (approximately 1 min) and gradually increase the time. Do not exceed 5 min.
- Instruct the subject to exercise without the cuff before performing MBFRT. Start MBFRT after confirming that the exercise will not cause any problems.
- If the subject experiences unexpected pain during MBFRT, the muscle may have been torn and is causing internal bleeding. Continuing MBFRT while applying pressure using the cuff may cause massive internal bleeding. Immediately lower the pressure or remove the cuff and discontinue MBFRT. Therefore, MBFRT should not be performed in subjects with severe dementia, those who lack the ability to feel pain (because of paralysis), or other subjects who cannot complain of discomfort.

There are cases where MBFPT should not be performed. First, there are some areas of the body that should not be compressed with MPCs:

- Parts other than the arms and legs (neck, waist, chest).
- Joints (elbows, knees).
- Areas containing plastic or silicone, such as artificial blood vessels.
- Areas where it is inappropriate to apply pressure, including areas affected by severe edema, severe varicose veins, skin disease, infection or inflammation, skin injury (wound), muscle injury (muscle tear), or acute internal bleeding.

Furthermore, limbs affected by the following conditions should not be subjected to MBFRT:

- Internal bleeding after acute trauma or surgery (bleeding may increase).
- Infection (suppuration, cellulitis), severe inflammation, or severe dermatitis.
- Severe blood circulation disorder, severe sensory impairment, or severe paralysis.
- Severe edema.
- Recently worsened edema and swelling (suspected in the acute phase of deep vein thrombosis).

CONCLUSION

The results of this study suggest that MBFRT causes an accumulation of lactic acid in muscles, thereby activating type II muscle fibers. To fully demonstrate the usefulness of MBFRT, it should be compared with regular training and other training methods that are known to be effective, including BFRT. These research topics should be investigated in future studies.

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CONFLICTS OF INTEREST

The author declares no conflict of interest.

REFERENCES

1. Lexell J, Taylor CC, Sjöström M: What is the cause of the ageing atrophy? Total number, size and proportion of different fiber types studied in whole vastus lateralis muscle from 15- to 83-year-old men. J Neurol Sci 1988;84:275–294. https://doi.org/10.1016/0022-510X(88)90132-3, PMID:3379447
2. Henneman E, Somjen G, Carpenter DO: Functional significance of cell size in spinal motoneurons. J Neurophysiol 1965;28:560–580. https://doi.org/10.1152/jn.1965.28.3.560, PMID:14328454
3. Ishihara A, Itoh K, Itoh M, Hirofuji C: Effect of hypobaric hypoxia on rat soleus muscle fibers and their innervating motoneurons: a review. Jpn J Physiol 2000;50:561–568. https://doi.org/10.2170/jjphysiol.50.561, PMID:11173551
4. Shinohara M, Kouzaki M, Yoshihisa T, Fukunaga T: Efficacy of tourniquet ischemia for strength training with low resistance. Eur J Appl Physiol Occup Physiol 1997;77:189–191. https://doi.org/10.1007/s004210050319, PMID:9459541

5. Wernbom M, Augustsson J, Raastad T: Ischemic strength training: a low-load alternative to heavy resistance exercise? Scand J Med Sci Sports 2008;18:401–416. https://doi.org/10.1111/j.1600-0838.2008.00788.x, PMID:18466185
6. Kawada S, Ishii N: Changes in skeletal muscle size, fibre-type composition and capillary supply after chronic venous occlusion in rats. Acta Physiol (Oxf) 2008;192:541–549. https://doi.org/10.1111/j.1748-1716.2007.01761.x, PMID:17970825
7. Manini TM, Clark BC: Blood flow restricted exercise and skeletal muscle health. Exerc Sport Sci Rev 2009;37:78–85. https://doi.org/10.1097/JES.0b013e31819c2e5c, PMID:19305199
8. Cerqueira MS, Costa EC, Santos Oliveira R, Pereira R, Brito Vieira WH: Blood flow restriction training: to adjust or not adjust the cuff pressure over an intervention period? Front Physiol 2021;12:678407. https://doi.org/10.3389/fphys.2021.678407, PMID:34262476
9. Patterson SD, Hughes L, Warmington S, Burr J, Scott BR, Owens J, Abe T, Nielsen JL, Libardi CA, Laurentino G, Neto GR, Brandner C, Martin-Hernandez J, Loenneke J: Blood flow restriction exercise: considerations of methodology, application, and safety. Front Physiol 2019;10:533. https://doi.org/10.3389/fphys.2019.00533, PMID:31156448
10. Lixandrão ME, Ugrinowitsch C, Laurentino G, Libardi CA, Aihara AY, Cardoso FN, Tricoli V, Roschel H: Effects of exercise intensity and occlusion pressure after 12 weeks of resistance training with blood-flow restriction. Eur J Appl Physiol 2015;115:2471–2480. https://doi.org/10.1007/s00421-015-3253-2, PMID:26323350
11. Kamiya K, Fukuta H: Effect of a plural parallel cuff system on anaerobic metabolism during low-intensity exercise training. J Exerc Physiol Online 2019;22:21–29.
12. Borg E, Kaijser L: A comparison between three rating scales for perceived exertion and two different work tests. Scand J Med Sci Sports 2006;16:57–69. https://doi.org/10.1111/j.1600-0838.2005.00448.x, PMID:16430682
13. Brooks GA: The lactate shuttle during exercise and recovery. Med Sci Sports Exerc 1986;18:360–368. https://doi.org/10.1249/00005768-198606000-00019, PMID:3523107
14. Brooks GA: Intra- and extra-cellular lactate shuttles. Med Sci Sports Exerc 2000;32:790–799. https://doi.org/10.1097/00005768-200004000-00011, PMID:10776898
15. van Hall G, Jensen-Urstad M, Rosdahl H, Holmberg HC, Saltin B, Calbet JA: Leg and arm lactate and substrate kinetics during exercise. Am J Physiol Endocrinol Metab 2003;284:E193–E205. https://doi.org/10.1152/ajpendo.00273.2002, PMID:12388120
16. Gladden LB: A lactatic perspective on metabolism. Med Sci Sports Exerc 2008;40:477–485. https://doi.org/10.1249/MSS.0b013e31815fa580, PMID:18379210
17. Garcia CK, Goldstein JL, Pathak RK, Anderson RG, Brown MS: Molecular characterization of a membrane transporter for lactate, pyruvate, and other monocarboxylates: implications for the Cori cycle. Cell 1994;76:865–873. https://doi.org/10.1016/0092-8674(94)90361-1, PMID:8124722
18. Bonen A: The expression of lactate transporters (MCT1 and MCT4) in heart and muscle. Eur J Appl Physiol 2001;86:6–11. https://doi.org/10.1007/s004210100516, PMID:11820324
19. Kitaoka Y, Hoshino D, Hatta H: Monocarboxylate transporter and lactate metabolism. J Phys Fit Sports Med 2012;1:247–252. https://doi.org/10.7600/jpfsm.1.247
20. Juel C, Halestrap AP: Lactate transport in skeletal muscle—role and regulation of the monocarboxylate transporter. J Physiol 1999;517:633–642. https://doi.org/10.1111/j.1469-7793.1999.0633s.x, PMID:10358105
21. Abe D, Yoshida T, Ueoka H, Sugiyama K, Fukuoka Y: Relationship between perceived exertion and blood lactate concentrations during incremental running test in young females. BMC Sports Sci Med Rehabil 2015;7:5. https://doi.org/10.1186/2052-1847-7-5, PMID:25973209
22. Godfrey RJ, Madgwick Z, Whyte GP: The exercise-induced growth hormone response in athletes. Sports Med 2003;33:599–613. https://doi.org/10.2165/00007256-200333080-00005, PMID:12797841
23. Godfrey RJ, Whyte GP, Buckley J, Quinlivan R: The role of lactate in the exercise-induced human growth hormone response: evidence from McArdle disease. Br J Sports Med 2009;43:521–525. https://doi.org/10.1136/bjsm.2007.041970, PMID:18184755

24. Ohno Y, Ando K, Ito T, Suda Y, Matsui Y, Oyama A, Kaneko H, Yokoyama S, Egawa T, Goto K: Lactate stimulates a potential for hypertrophy and regeneration of mouse skeletal muscle. Nutrients 2019;11:869. https://doi.org/10.3390/nu11040869, PMID:30999708
25. Chang J, Bhandari L, Messana J, Alkabbaa S, Hamidian Jahromi A, Konofaos P: Management of tourniquet-related nerve injury (TRNI): a systematic review. Cureus 2022;14:e27685. https://doi.org/10.7759/cureus.27685, PMID:36072167
26. Masri BA, Eisen A, Duncan CP, McEwen JA: Tourniquet-induced nerve compression injuries are caused by high pressure levels and gradients—a review of the evidence to guide safe surgical, pre-hospital and blood flow restriction usage. BMC Biomed Eng 2020;2:7. https://doi.org/10.1186/s42490-020-00041-5, PMID:32903342
27. de Carvalho EG, Corsini W, Hermes TA: Severe muscle damage after a short period of ischemia and reperfusion in an animal model. Surgery 2023;174:363–368. https://doi.org/10.1016/j.surg.2023.04.033, PMID:37210237
28. Korth U, Merkel G, Fernandez FF, Jandewerth O, Dogan G, Koch T, van Ackern K, Weichel O, Klein J: Tourniquet-induced changes of energy metabolism in human skeletal muscle monitored by microdialysis. Anesthesiology 2000;93:1407–1412. https://doi.org/10.1097/00000542-200012000-00011, PMID:11149434
29. Appell HJ, Glöser S, Duarte JA, Zellner A, Soares JM: Skeletal muscle damage during tourniquet-induced ischaemia. The initial step towards atrophy after orthopaedic surgery? Eur J Appl Physiol Occup Physiol 1993;67:342–347. https://doi.org/10.1007/BF00357633, PMID:8299602
30. Bøtker HE, Kharbanda R, Schmidt MR, Bøttcher M, Kaltoft AK, Terkelsen CJ, Munk K, Andersen NH, Hansen TM, Trautner S, Lassen JF, Christiansen EH, Krusell LR, Kristensen SD, Thuesen L, Nielsen SS, Rehling M, Sørensen HT, Redington AN, Nielsen TT: Remote ischaemic conditioning before hospital admission, as a complement to angioplasty, and effect on myocardial salvage in patients with acute myocardial infarction: a randomised trial. Lancet 2010;375:727–734. https://doi.org/10.1016/S0140-6736(09)62001-8, PMID:20189026
31. Hoole SP, Heck PM, Sharples L, Khan SN, Duehmke R, Densem CG, Clarke SC, Shapiro LM, Schofield PM, O'Sullivan M, Dutka DP: Cardiac Remote Ischemic Preconditioning in Coronary Stenting (CRISP Stent) study: a prospective, randomized control trial. Circulation 2009;119:820–827. https://doi.org/10.1161/CIRCULATIONAHA.108.809723, PMID:19188504
32. Patterson SD, Bezodis N, Glaister M, Pattison JR: The effect of ischemic preconditioning on repeated sprint cycling performance. Med Sci Sports Exerc 2015;47:1652–1658. https://doi.org/10.1249/MSS.0000000000000576, PMID:25412297
33. Cheng CF, Kuo YH, Hsu WC, Chen C, Pan CH: Local and remote ischemic preconditioning improves sprint interval exercise performance in team sport athletes. Int J Environ Res Public Health 2021;18:10653. https://doi.org/10.3390/ijerph182010653, PMID:34682399
34. Loo RJ, Wohlauer MV, Tarima SS, Weseman E, Nguyen JN, Mansukhani NA, Durand MJ: A pilot study examining the effects of ischemic conditioning on walking capacity and lower extremity muscle performance in patients with claudication. J Vasc Res 2022;59:314–323. https://doi.org/10.1159/000525166, PMID:36067740
35. Hansen CS, Jørgensen ME, Fleischer J, Bøtker HE, Rossing P: Efficacy of long-term remote ischemic conditioning on vascular and neuronal function in type 2 diabetes patients with peripheral arterial disease. J Am Heart Assoc 2019;8:e011779. https://doi.org/10.1161/JAHA.118.011779, PMID:31215299
36. French C, Robbins D, Gernigon M, Gordon D: The effects of lower limb ischaemic preconditioning: a systematic review. Front Physiol 2024;14:1323310. https://doi.org/10.3389/fphys.2023.1323310, PMID:38274048