SCIENTIFIC JOURNAL OF SPORT AND PERFORMANCE

REVIEW ARTICLE

Effects of blood flow restriction exercise on muscle adaptations: A review

Hizbullah Bahir . *Education Faculty. Wardak University. Wardak, Afghanistan.*
Mohammad Shafi Sakhizada. *Sports Medicine Department. Faculty of Physical Education and Sports Sciences. Kabul Education University. Afghanistan.*

ABSTRACT

Purpose: This article analyzes the effects of compression or blood flow restriction (BFR) combined with aerobic exercise and resistance exercise on human muscle strength and volume-related indicators through systematic literature search and screening. to evaluate its possible effects on muscles. Methods: Based on the pre-established literature retrieval, screening, entry, and evaluation methods, the relevant literature was retrieved, screened, and evaluated. Results: Compression/blood flow restriction combined with aerobic exercise was better than the control group in terms of quadriceps muscle volume, thigh muscle volume, knee extension strength, and torque (30°/180°) (p < .05); plus The combination of blood pressure or blood flow restriction and resistance exercise was also better than the control group in terms of mid-thigh muscle circumference, joint flexor muscle cross-sectional area, knee extension 1-repetition maximum strength, right knee flexion strength, and left knee extension strength. (p < .05). Conclusion: Systematic compression or blood flow restriction combined with aerobic exercise and resistance exercise can effectively increase muscle size and circumference and optimize muscle strength. Follow-up related research can conduct more detailed discussions in terms of pressurization pressure, method, load, cycle, indicators, time, and safety evaluation.
Keywords: Sport medicine, Compression, Blood flow restriction, Aerobic exercise, Resistance exercise to muscles.

Cite this article as:
Bahir, H., & Sakhizada, M. S. (2025). Effects of blood flow restriction exercise on muscle adaptations: A review. *Scientific Journal of Sport and Performance*, *4*(3), 454-465. https://doi.org/10.55860/WRQM8944

Corresponding author. *Education Faculty. Wardak University. Wardak, Afghanistan.*
E-mail: bahir.hizbullah@hotmail.com
Submitted for publication March 13, 2025.
Accepted for publication April 13, 2025.
Published May 27, 2025.
Scientific Journal of Sport and Performance. ISSN 2794-0586.

doi: https://doi.org/10.55860/WRQM8944

INTRODUCTION

Muscle strength and muscle endurance are components of healthy physical fitness. The American College of Sports Medicine (ACSM) collectively refers to muscle strength, muscle endurance and muscle work ability as "*muscle fitness*" (Genelhu et al., 2009). Good muscle fitness is an important factor in the body's ability to survive and complete daily activities. Especially for athletes and the elderly, the quality of muscle fitness is particularly important. Blood Flow Restriction (BFR) Training, also known as Blood Flow Restriction Training, refers to the use of a compression device to moderately compress the proximal end of the limb, restrict blood flow, and cause relative ischemia in the distal end of the limb, while at the same time performing lower-intensity exercise. A high-attention training method (Da Silva et al., 2013). A large number of studies have shown that intervention through compression or blood flow restriction combined with exercise can produce a series of adaptive changes in skeletal muscles, thereby stimulating muscle growth and improving muscle fitness (Kraemer et al., 2002). Compression or blood flow restriction combined with exercise has the characteristics of diverse exercise forms, smaller exercise intensity, lower exercise risk, higher training efficiency, easy operation and relative safety (Marcon et al., 2011), It has good application value in the fields of sports and fitness, auxiliary training, elderly rehabilitation and other fields (Rittweger, 2010). In the above fields, foreign research is relatively mature, and China is currently in a stage of rapid development. In the context of increasingly sophisticated and effective training methods and methods in competitive sports, the need for new training methods is becoming more and more urgent. Based on this, this study conducted a quantitative analysis and evaluation of human muscle strength and muscle volume-related indicators for the intervention of compression or blood flow restriction combined with aerobic exercise and resistance exercise to clarify the effects of compression or blood flow restriction combined with aerobic exercise and resistance exercise. The impact of resistance exercise on human muscle strength and muscle volume related indicators and based on the current status of existing domestic research, targeted suggestions for follow-up related research are provided to provide theoretical reference for better application of pressurized blood flow restriction training.

RESEARCH METHODS

Literature review

Since compression training is also called blood flow restriction training, in order to maximize the search for relevant literature, the following keywords were selected during the search process. With "*Blood Flow Restriction (BFR) Training*" and "*Blood Flow Restriction Training*" Blood Flow Restriction (BFR) Training "*Training and Muscle and Blood Flow Restriction Training and Muscle*" was used as the keyword to search in the foreign databases PubMed, Web of Science, EBSCO, and Embase. Select the keywords "*Blood Flow Restriction (BFR) Training*" and "*Blood Flow Restriction (BFR) Training and muscles*" to search in the Chinese database CNKI and VIP database. Then, according to the different search requirements and characteristics of each database, different search element settings are used: the PubMed database uses all-field searches (All Fields) of search keywords; the Web of Science database uses keywords of topics and topics. The search method; EBSCO database uses full-text search (Tx All Text); Embase database uses full-text search (All Fields). Full-text searches were conducted in the CNKI and VIP databases to retrieve relevant Chinese literature. In addition, a secondary search was conducted based on the references of relevant documents in the above search results to maximize the acquisition of relevant documents.

Literature screening and inclusion criteria

Literature inclusion criteria: (1) Full text of journals that have been published in academic databases or academic journals; (2) Chinese and English literature; (3) Compression or blood flow restriction combined with aerobic exercise and resistance exercise and muscle-related indicators randomized controlled study. The specific literature inclusion criteria are shown in Table 1.

Data extraction and evaluation of included literature

After retrieval and screening, the literature included in the evaluation and analysis of this article was mainly extracted and analysed based on the PICOS principle (An et al., 2016).

P represents the basic information of the research object, I represent the research intervention plan in the study, C represents the controlled design, O represents the main results part of the study (including the main indicators measured and changes in indicators), and S represents the type of research design. For the grade evaluation of the included literature, this article used the 2011 version of the Oxford University Center for Evidence-Based Medicine's Clinical Reporting Evidence Grade Scale (OCEBM) (Edwards, 2006).

Review Manager 5.3 was used for data processing, and the original data were extracted from the literature. The difference between the pre-intervention mean and the post-intervention mean of each indicator in the pressurized blood flow restriction group and the control group was used to determine the difference before and after the intervention for this group. The mean and standard deviation of the values were estimated according to the method provided by the Cochrane Handbook (Da Silva et al., 2013). The data included in the study are all continuous data. Therefore, the difference in change values before and after intervention between the pressurized blood flow restriction group and the control group is expressed as the weighted mean difference and 95% CI. The heterogeneity between studies is judged according to the x2 test and I2 test. If $p \geq .1$ and I2 < 50%, the fixed effect model is used, otherwise the random effect model is used; if the heterogeneity is large, subgroup analysis or Sensitivity analysis.

Table 1. Contemporary sports technology.

Inclusion criteria	Main content
Research design	Randomized controlled trial study.
Interventions	Human studies.
Test subject	Human studies of compression or blood flow restriction combined with aerobic and resistance exercise.
Experimental grouping	compression or blood flow restriction combined aerobic and resistance Exercise group; Compared with the control group (no compression exercise group and the same exercise intervention group without compression).
Outcome measures	Indicators related to muscle volume and muscle strength.

RESULTS

Literature search and inclusion results

Literature screening process: (1) Search each database according to the previously established literature search strategy, screen keywords, and conduct preliminary screening of titles; (2) Then, based on the inclusion criteria, remove articles that do not meet the article type; (3) Eliminate duplicate documents after screening; (4) After reading the full text of the remaining documents, eliminate those that do not meet the inclusion criteria (reason for elimination).

Including: conference-type research, no valid data, experimental research design does not match the indicators) and manually searched the references of documents that met the inclusion criteria, added 7 documents to the included documents, and determined that 18 documents were included.

Basic information and evaluation of included literature and report on literature research results

The 18 documents included in this study are all full text of journals.

There are 7 documents that study the effects of compression or blood flow restriction combined with aerobic exercise on muscle-related indicators (Watanabe et al., 2004).

There are 11 documents that study the effects of compression or blood flow restriction combined with resistance exercise on muscle-related indicators (Spennewyn, 2008). Judging from the evaluation results of this study, the selected literature materials are all randomized controlled intervention studies, and the evidence-based level belongs to the second level. The intervention methods in the included literature are compression or blood flow restriction combined with aerobic exercise and resistance exercise. The research object is the human body. The selected indicators are highly correlated with human muscle strength and muscle volume. The research method has a certain scientific nature. and objectivity, the research results have strong data theoretical basis and practical reference value and meet the literature inclusion criteria of this study.

The impact of compression or blood flow restriction combined with aerobic exercise on muscle-related indicators of the body

Three documents evaluated the changes in quadriceps muscle volume of subjects before and after intervention (Spennewyn, 2008), including 28 cases in the BFR group and 27 cases in the CON group. A random effects model was chosen for analysis. The results showed that the BFR group was better than the CON group (MD = -56.97, 95%CI: -100.89~-13.05, *p* = .01) in improving the quadriceps muscle volume of subjects, as shown in Table 2.

Table 2. Meta-analysis results of the effect of BFR combined with aerobic exercise on quadriceps muscle volume.

Study or subgroup	**BFR Group**			**CON Group**				**Mean difference**
	Mean	SD	Total	Mean	SD	Total	Weight	IV.Randon.95%CI
Abe 2006	-70	13	9	3	7	9	33.4%	-73.00[-82.65,-63.35
Abe 2010	-80	21	9	-1	10	10	32.6%	-79.00[-94.05,-63.95]
Ozaki2011	-16	1	10	4	1.35	8	33.9%	-20[-21.12,-18.88]
Total			28			27		-56.97[-100.89,-13.05]

Three literatures reported changes in thigh muscle volume of subjects before and after intervention (Bautmans et al., 2005), including 28 cases in the BFR group and 26 cases in the CON group. A random effects model was chosen for analysis. The results showed that the BFR group was better than the CON group in increasing the volume of subjects' thigh muscles (MD = -108.65, 95%CI: -178.03~-39.27, *p* < .01), as shown in Table 3.

Table 3. Meta-analysis results of the effect of BFR combined with aerobic exercise on thigh muscle volume.

Study or subgroup	**BFR Group**			**CON Group**				**Mean difference**
	Mean	SD	Total	Mean	SD	Total	Weight	Iv.Randon.95%Ci
Abe 2010	-133	37	9	7	29	10	32.0%	-140.00[-170.12,-109.88
Ozaki 2011	-49	4	10	2	1	8	34.1%	-51.00[-53.57,-48.43]
Sakamaki2011	-124	15	9	13	1	8	33.9%	-137.00[-146.82,-127.18]
Total			28			26	100.0%	-108.65[-178.03,-39.27]

Note. Heterogeneity; Tau = 3674.58; chi = 304.76, df = 2 (p < .00001). Teats for overall effect: Z = 3.07 (p = .002).

Two articles evaluated the changes in knee extension strength of subjects before and after intervention (Bautmans et al., 2005), including 22 cases in the BFR group and 20 cases in the CON group. Choose random effect The model should be analysed. The results showed that the BFR group was better than the CON group in enhancing subjects' knee extension strength (MD = -8.59, 95%CI: -14.42~-2.77, *p* < .01), as shown in Table 4.

Table 4. Meta-analysis results of the effect of BFR combined with aerobic exercise on thigh muscle volume.

Study or subgroup	BFR Group			CON Group				Mean difference
	Mean	SD	Total	Mean	SD	Total	Weight	Iv.Randon.95%Ci
Abe 2010	-15	7	9	-3	2	10	43.2%	-12.00[-16.74,-7.26
Ozaki 2011	-10	1	13	-4	3	10	56.8%	-6.00[-7.94,-4.06]
Total			22			20	100.0%	-8.59[-14.42,-2.77]

Note. Heterogeneity; Tau = 14.59; chi = 5.28,df = 1 (p < .002). Teats for overall effect: Z = 2.89 (p = .004).

Two documents evaluated the impact on subjects' knee flexion moments (30°/S) and (180°/S) before and after intervention (Lin & Sharifi, 2021), including 21 cases in the BFR group and 16 cases in the CON group. A random effects model was chosen for analysis.

The results showed that the BFR group was better than the CON group in enhancing subjects' knee flexion moment at 30°/S (MD = -9.05, 95%CI: -11.00~-7.09, *p* < .01).

The BFR group was better than CON in enhancing subjects' knee flexion moment at 180°/S (MD = -7.06, 95%CI: -9.02～-5.11, *p* < .01), as shown in Table 4. Sensitivity analysis was performed by removing documents one by one, and the results did not change. The funnel plot of the 7 documents included in this study on the effects of pressurized blood flow restriction combined with aerobic exercise on body muscle-related indicators is basically symmetrical, showing no obvious publication bias.

Effects of compression or blood flow restriction combined with resistance exercise on muscle-related indicators of the body

Two literatures reported changes in the circumference of the mid-thigh muscles of subjects before and after intervention (Zakas et al., 2006), including 19 cases in the BFR group and 20 cases in the CON group. A fixed effects model was selected for analysis. The results showed that the BFR group was better than CON in improving the circumference of the subjects' mid-thigh muscles (MD = -0.8095% CI: -0.99~-0.62, *p* < .01), as shown in Table 5.

Table 5. Meta-analysis results of the effect of BFR combined with aerobic exercise on knee flexion moment (30°/S (180°/S).

Study or subgroup	BFR Group			CON Group				Mean difference
	Mean	SD	Total	Mean	SD	Total	Weight	Iv.Randon.95%Ci
Abe 2010	-6	2	11	2	1.35	8	47.7%	-8.00[-9.51,-9.49
Ozaki 2011	-8	1.35	10	2	1.35	8	52.3%	-10.00[-11.26,-8.74]
Total			21			16	100.0%	-9.05[-11.00,-7.09]

Note. Heterogeneity; Tau = 1.50; chi = 3.99, df = 1 (p < .05). Teats for overall effect: Z = 9.05 (p = .00001).

Three documents evaluated the changes in cross-sectional area of flexor joint muscles of subjects before and after intervention, including 23 cases in the BFR group and 22 cases in the CON group. A random effects model was chosen for analysis. The results showed that the BFR group was better than the CON group in increasing the cross-sectional area of subjects' flexor joint muscles (MD = -2.74, 95%CI: -4.59~-0.89, *p* < .01), as shown in Table 6.

Table 6. Meta-analysis results of the effect of BFR combined with aerobic exercise on knee flexion moment (30°/S (180°/S).

Study or subgroup	BFR Group			CON Group				Mean difference
	Mean	SD	Total	Mean	SD	Total	Weight	Iv.Randon.95%Ci
Abe 2010	-4	1.35	11	2	2	8	46.8%	-6.00[-7.60,-4.40]
Ozaki 2011	-7	1.35	10	1	1.35	8	53.2%	-8.00[-9.26,-6.74]
Total			21			16	100.0%	-7.06[-9.02,-5.11]

Note. Heterogeneity; Tau = 1.46; chi = 3.72, df = 1 (p = .05). Teats for overall effect: Z = 7.08 (p = .00001).

Three articles evaluated subjects' knee extension for 1 maximum repetition before and after intervention. Changes in strength (Kanis et al., 1997), including 22 cases in the BFR group and 21 cases in the CON group. A fixed effects model was selected for analysis. The results showed that the BFR group was better than the CON group in improving the subject's 1-repetition maximum knee extension strength (MD = -9.8995%CI: -11.73~-8.05, *p* < .01), as shown in Table 7.

Table 7. Meta-analysis results of the effect of BFR combined with aerobic exercise on knee flexion moment (30°/S (180°/S).

Study or subgroup	BFR Group			CON Group				Mean difference
	Mean	SD	Total	Mean	SD	Total	Weight	Iv.Randon.95%Ci
Yasuda 2014	-0.7	2.2	9	0.2	0.2	10	1.6%	-0.90[-2.34,-0.54]
Yasuda 2016	-0.3	0.01	10	0.5	0.3	10	98.4%	-0.80[-0.99,-0.61]
Total			19			20	100.0%	-0.80[-0.99,-0.62]

Note. Heterogeneity; Tau = 0.00; chi = 0.02, df = 1 (p = .89). Teats for overall effect: Z = 8.52 (p = .00001).

Two documents evaluated the impact on subjects before and after intervention, including 17 cases in the BFR group and 17 cases in the CON group. A random effects model was chosen for analysis. The results showed that the BFR group strengthened the subjects' right knee flexion isokinetic muscles. Strength was better than that of the CON group (MD = -7.12, 95%CI: -8.94~-5.30, *p* < .01).

The BFR group was better than CON in enhancing the subjects' left knee extension isokinetic muscle strength (MD = -22.10, 95%CI: -29.20~-15.00, *p* < .01), As shown in Table 8. Sensitivity analysis was performed by removing documents one by one, and the results did not change. The 11 documents included in this study on the effects of pressurized blood flow restriction combined with aerobic exercise on muscle-related indicators of the body have basically symmetrical funnel plots, showing no obvious publication bias.

Table 8 Meta-analysis results of the effect of BFR combined with resistance exercise on mid-thigh muscle circumference.

Study or subgroup	BFR Group			CON Group				Mean difference
	Mean	SD	Total	Mean	SD	Total	Weight	Iv.Randon.95%Ci
Madarme 2008	-2	1	8	-0.1	0.2	7	32.4%	-1.90[-2.61,-1.19]
Yasuda 2014	-3.3	0.4	8	1.1	0.2	8	33.7%	-4.40[-4.71,-4.09]
Yasuda 2015	-1.8	0.1	7	0.1	0.2	7	33.9%	-1.90[-2.07,-1.73]
Total			23			22	100.0%	-2.74[-4.59,-0.89]

Note. Heterogeneity; Tau = 2.62; chi = 196.71, df =2 (p < .00001). Teats for overall effect: Z = 2.91 (p = .004).

Table 9. Meta-analysis results of the effect of BFR combined with resistance exercise on the cross-sectional area of flexor joint muscles.

Study or subgroup	BFR Group			CON Group				Mean difference
	Mean	SD	Total	Mean	SD	Total	Weight	Iv.Randon.95%Ci
Cook 2018	-15	3	6	-2	8	6	7.3%	-13.00[-19.84,-6.16]
Madarame2008	-18.5	2.6	8	-9.1	1.4	7	78.6%	-9.40[-11.48,-7.32]
Yasuda 2014	-13	7	8	-2	1	8	14.1%	-11.00[-15.90,-6.10]
Total			22			21	100.0%	-9.89[-15.90,-6.10]

Note. Heterogeneity; Tau = 0.00; chi = 1.21, df = 2 (p = .55). Teats for overall effect: Z = 10.52 (p = .00001).

Table 10. Meta-analysis results of the effect of BFR combined with resistance exercise on 1-repetition maximum knee extension strength.

Study or subgroup	BFR Group			CON Group				Mean difference
	Mean	SD	Total	Mean	SD	Total	Weight	Iv.Randon.95%Ci
Li Zhiyuan 2019	-17.5	1.7	8	-11.6	2.5	8	36.8%	-5.90[-7.99,-3.81]
Wang Mingbo2019	-17.55	0.15	9	-9.72	1.18	9	63.2%	-7.83[-8.61,-7.05]
Total			17			17	100.0%	-7.83[-8.61,-7.05]

Note. Heterogeneity; Tau = 1.21; chi = 2.87, df = 1 (p = .09). Teats for overall effect: Z = 7.65 (p = .00001).

Table 11. Meta-analysis results of the effect of BFR combined with resistance exercise on right knee flexion and left knee extension muscle strength.

Study or subgroup	BFR Group			CON Group				Mean difference
	Mean	SD	Total	Mean	SD	Total	Weight	Iv.Randon.95%Ci
Li Zhiyuan 2019	-23.9	6.5	8	1.4	8.6	8	56.2%	-25.30[-32.77,-17.83]
Wang Mingbo 2019	-2.95	2.3	9	15.05	13.6	9	43.8%	-18.00[-27.01,-8.99]
Total			17			17	100.0%	-22.10[-29.20,-15.00]

Note. Heterogeneity; Tau = 8.81; chi = 1.49, df = 1 (p = .22). Teats for overall effect: Z = 6.10 (p < .00001).

DISCUSSION

The study included a total of 7 studies on compression or blood flow restriction combined with aerobic exercise, 6 of which used treadmill walking and 1 used power cycling, all of which involved measuring lower limbs. Muscle related indicators. Meta-analysis results show that through for 3 to 10 weeks, 10 to 20 minutes of compression or blood flow restriction (pressure range: 120 to 230 mmHg) combined with aerobic walking exercises can effectively increase the quadriceps muscle volume of subjects compared with the control group. and thigh muscle volume. Through 6 to 10 weeks of compression or blood flow restriction for 15 to 20 minutes each time (pressure range is 140 to 210mmHg), combined with aerobic walking exercise and cycling exercise, compared with the control group, the subjects can effectively strengthen the Knee extension strength and knee flexion moment at 30° and 180°.This study included a total of 11 studies on compression or blood flow restriction combined with resistance exercise, 4 of which used a combination of resistance exercise for the upper and lower limbs, 5 used resistance exercise for the lower limbs, and 2 The upper limb resistance exercise method is used, which involves measuring relevant indicators of the muscles. Meta-analysis results show that through 12 weeks of compression or blood flow restriction twice a week (pressure range: 120~270mmHg), combined with resistance exercise of the lower limbs, compared with the control group, the subjects' mid-thighs were effectively strengthened Muscle circumference. After 10 to 12 weeks of compression or blood flow restriction twice a week (pressure range: 120 to 270 mmHg), the results are Resistance exercise of the upper and lower limbs can effectively increase the cross-sectional area of the subjects' flexor joint muscles. Through 6 to 12 weeks of compression or blood flow restriction twice a week (pressure range is 120 to 270 mmHg), combined with resistance exercise of the lower limbs, the subject's maximum repetition strength of knee extension can be effectively enhanced.

Through compression or blood flow restriction (pressure range: 200mmHg) three times a week for 4 to 8 weeks, combined with resistance exercise of the lower limbs, the subject's right knee flexion and left knee extension isokinetic strength can be effectively enhanced.

Research suggests that changes in skeletal muscle volume are due to muscle hypertrophy It is not a change in the fluid content of extracellular tissue (Pantović et al., 2015).

The reason why compression or blood flow restriction combined with exercise results in hypertrophy of muscle size and increase in muscle strength.

Reasons may include the following points

Pulse pool effect

Compression limits venous blood flow, causing a venous pooling effect in the distal limb, which in turn induces acute cellular swelling, inhibits protein catabolism, increases anabolism, promotes a net increase in protein balance, and subsequently increases muscle anabolism reaction, promoting the increase in muscle volume (Edwards, 2006).

Influence of synthetic pathways

Pressurized blood flow restriction combined with exercise-activated signalling pathways such as target of rapamycin (mTOR) and adenylate-activated protein kinase (AMPK) enhances muscle synthesis signals and promotes bone development by upregulating a variety of muscle growth factors and proteins. Studies believe that changes in skeletal muscle volume are due to muscle hypertrophy rather than changes in extracellular tissue fluid content (Ryall et al., 2008).

Reasons why compression or blood flow restriction combined with exercise can cause hypertrophy and increased muscle strength may include the following. Pulse pool effect. Pressure limits venous blood flow, causing a venous pool effect in the distal limbs, which in turn induces acute cell swelling, inhibits protein catabolism, and inhibits protein synthesis.

Increased metabolism promotes a net increase in protein balance and subsequent muscle gain

The anabolic reaction of meat promotes the increase in muscle volume (Saini et al., 2009).

Influence of synthetic pathways

Pressurized blood flow restriction combined with exercise-activated signalling pathways such as target of rapamycin (mTOR) and adenylate-activated protein kinase (AMPK) enhances muscle synthesis signals and promotes bone development by upregulating a variety of muscle growth factors and proteins. The increase and rapid growth of muscle cells in the muscle promotes protein synthesis and increases muscle fibre volume (Edwards, 2006).

Metabolic hormone secretion

Pressurized blood flow restriction combined with exercise promotes an increase in circulating anabolic hormones such as testosterone, growth hormone, and insulin-like growth factor-1 and a decrease in myostatin, which may cause muscle hypertrophy (Hazim et al., 2024).

Fiber recruitment

Pressurized blood flow restriction combined with exercise appropriately increases the metabolic level of muscles, causing ischemia, hypoxia, and metabolic changes within the muscles. The accumulation of lactic acid inhibits slow-twitch muscle fibres and mobilizes a large number of additional fast-twitch muscle fibres. The muscle fibre recruitment ability is enhanced, and more muscle fibres can be mobilized and recruited to participate in work, increasing muscle volume and muscle strength (Orsega-Smith et al., 2007). Different aerobic and resistance exercise methods, differences in exercise intensity, exercise time, and exercise parts may lead to changes in effects, and they need to be treated differently and finely controlled. Further research is needed from the perspectives of molecular mechanisms of cellular and skeletal muscle adaptation, changes in mitochondria, changes in capillary density, and activation of muscle enzymes to elucidate the effects of compression or blood flow restriction combined with aerobic exercise and resistance exercise. Possible mechanisms responsible for the different effects of muscle-related indicators (Clayton et al., 2015).

At present, domestic research on compression or blood flow restriction combined with exercise is in a stage of rapid development. Based on the current research status, future research may consider conducting more detailed and in-depth discussions in the following aspects.

Pressurized pressure

The included studies show that the pressure during compression combined with aerobic exercise can be 120~230mmHg, and the pressure during combined resistance exercise can be 120~270mmHg. However, since the choice of compression pressure is affected by the age of the user, the site of blood flow restriction, and muscle size, The influence of factors such as exercise level and sport specialization is needed. More research is needed to provide a comprehensive overview of the use and characteristics of compression pressure.

Mode of exercise

Existing studies basically combine a single exercise method with compression or blood flow restriction. Few studies combine aerobic exercise with resistance exercise at the same time, or use a variety of Combining exercise methods, it is recommended to consider designing multiple exercise methods combined with compression or blood flow restriction to understand their possible effects and effects on the muscles of the upper and lower limbs of the body.

Exercise load

The load of compression combined with aerobic exercise can generally be above 40% VO_{2max} or heart rate reserve. The load weight of compression combined with resistance exercise is usually set at 20%~40%1RM/MVC (maximum weight lifted only once/maximum voluntary exercise) contraction force). However, the specific compression exercise load for different groups of people and different sports needs to be adjusted according to the purpose and stage of exercise.

Exercise cycle

Existing studies are basically fixed exercise program cycles (mainly medium and long-term chronic exercise), and the intervention period is relatively long. For combinations of one acute exercise, or intermittent acute exercise and intermittent chronic exercise, There are not many experimental studies on blood pressure or blood flow restriction. It is recommended to consider combining exercise patterns of different periods to better observe the different effects of different exercise periods, especially to understand the possible effects of acute stress training before competition.

Evaluation indicators

Current research mostly uses indicators such as muscle circumference, volume, strength, etc. to explain the problem. There are not many studies on related special sports ability indicators, molecular pathway indicators and morphological structure indicators. It is recommended that it be considered if conditions permit and can be achieved. It can measure indicators related to special sports ability, conduct muscle biopsy, and conduct animal experiments to measure its related molecular pathway indicators, so as to gain a more comprehensive and systematic understanding of its mechanism of action (Ajmiri & Bahir, 2023).

Measurement time

When evaluating the effect of compression or blood flow restriction combined with exercise, the time points for index measurement are basically before and after the intervention. There are not many studies on the temporal change characteristics of the index within a period of time after the intervention. In order to better understand the long-term and sustained effects of compression or blood flow restriction combined with exercise, it is recommended that subsequent experimental studies be consistent in the selection of time points for measurement indicators, which will facilitate subsequent evidence-based medical research and may be considered. Increase the measurement time points of post-intervention indicators (such as time points 1 to 96 hours after exercise) to better follow up and understand the corresponding training effects and changes.

Safety evaluation

Exercise combined with pressurized blood flow restriction is not suitable for everyone. Blind participation will bring corresponding risks and requires careful safety assessment and risk screening before participation. In addition, improper compression training programs and compression pressure selection will increase the risk of participation. It is recommended that subsequent studies consider a more detailed description of the safe application process of compression or blood flow restriction combined with exercise, so as to effectively prevent Related risks (Hazim et al., 2024).

CONCLUSION

Based on the existing literature research, this study can draw the following conclusions:

The combination of systematic compression or blood flow restriction, aerobic exercise and resistance exercise can effectively enhance muscle volume and circumference, and optimize muscle strength;

Subsequent studies related to compression or blood flow restriction combined with exercise can conduct more detailed discussions in terms of pressure, method, load, cycle, index, time, and safety evaluation.

Due to differences in individual conditions, sports specialties, and variables in compression methods, the effects of compression or blood flow restriction combined with exercise vary. Therefore, subsequent research in this field can consider applying compression or blood flow restriction to people of different ages, different physical conditions and different sports specialties, combining different experimental intervention studies with exercise, and at the same time targeting the appropriate compression pressure for individuals during its application. Discuss variables such as pressurized length, width, and selection accordingly. On this basis, more high-quality, large-sample, multi-index, and rigorously designed randomized controlled experimental studies are needed to provide a more accurate cycle for the effects of compression or blood flow restriction combined with exercise intervention on the body. Medical reference and basis.

AUTHOR CONTRIBUTIONS

The first author conducted a comprehensive literature review, developed the research methodology, analysed the data, and drafted the findings of the study. The second author was responsible for identifying the relevant sources, organizing the primary and secondary headings, and performing revisions and refinements throughout the manuscript.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

REFERENCES

Ajmiri, M. Y., & Bahir, H. (2023). Impact of Physical Exercise on the Mental Health of the Elderly. Sustainability and Sports Science Journal, 1(2), 46-52. https://doi.org/10.61486/ETCK4342

An, F. P., Balantekin, A. B., Band, H. R., Bishai, M., Blyth, S., Butorov, I., Cao, D., Cao, G. F., Cao, J., Cen, W. R., Chan, Y. L., Chang, J. F., Chang, L. C., Chang, Y., Chen, H. S., Chen, Q. Y., Chen, S. M., Chen, Y. X., Chen, Y., … Zou, J. H. (2016). Measurement of the reactor antineutrino flux and spectrum at Daya Bay. Physical Review Letters, 116(6). https://doi.org/10.1103/PhysRevLett.116.061801

Bautmans, I., Van Hees, E., Lemper, J. C., & Mets, T. (2005). The feasibility of whole body vibration in institutionalised elderly persons and its influence on muscle performance, balance and mobility: A randomised controlled trial [ISRCTN62535013]. BMC Geriatrics, 5, 1-8. https://doi.org/10.1186/1471-2318-5-17

Clayton, D. J., Barutcu, A., Machin, C., Stensel, D. J., & James, L. J. (2015). Effect of Breakfast Omission on Energy Intake and Evening Exercise Performance. Medicine and Science in Sports and Exercise, 47(12), 2645-2652. https://doi.org/10.1249/MSS.0000000000000702

Da Silva, R. P., Martinez, D., Faria, C. C., De Carli, L. A., De Souza, W. I. B. P., Meinhardt, N. G., Souto, K. E. P., Trindade, M. R. M., & Ribeiro, J. P. (2013). Improvement of exercise capacity and peripheral metaboreflex after bariatric surgery. Obesity Surgery, 23(11), 1835-1841. https://doi.org/10.1007/s11695-013-0988-x

Edwards, N. C. (2006). School Facılıtıes And Student Achıevement: Student Perspectıves On The Connectıon Between The Urban Learnıng Envıronment And Student Motıvatıon And Performance. In Global Shadows: Africa in the Neoliberal World Order (Vol. 44, Issue 1959).

Genelhu, V. A., Celoria, B. M. J., Duarte, S. F. P., Cabello, P. H., & Francischetti, E. A. (2009). Not all obese subjects of multiethnic origin are at similar risk for developing hypertension and type 2 diabetes. European Journal of Internal Medicine, 20(3), 289-295. https://doi.org/10.1016/j.ejim.2008.09.009

Hazim, H., Zalmai, M. R., & Bahir, H. (2024). Exploring the Impact of Nutrition and Physical Activity on Human Metabolism. Sprin Journal of Arts, Humanities and Social Sciences, 3(4), 39-42. https://doi.org/10.55559/sjahss.v3i4.284

Kanis, J. A., Delmas, P., Burckhardt, P., Cooper, C., & Torgerson, D. (1997). Guidelines for diagnosis and management of osteoporosis. Osteoporosis International, 7(4), 390-406. https://doi.org/10.1007/BF01623782

Kraemer, W. J., Ratamess, N. A., & French, D. N. (2002). Resistance training for health and performance. In Current sports medicine reports (Vol. 1, Issue 3, pp. 165-171). https://doi.org/10.1249/00149619-200206000-00007

Lin, X., & Sharifi, K. D. (2021). The Entire Body Quiver Effect on Lower Extremity Flexibility in Healthy Young Female. OALib, 08(10), 1-11. https://doi.org/10.4236/oalib.1107953

Marcon, E. R., Gus, I., & Neumann, C. R. (2011). Impacto de um programa mínimo de exercícios físicos supervisionados no risco cardiometabólico de pacientes com obesidade mórbida. Arquivos Brasileiros de Endocrinologia & Metabologia, 55(5), 331-338. https://doi.org/10.1590/S0004-27302011000500006

Orsega-Smith, E. M., Payne, L. L., Mowen, A. J., Ho, C. H., & Godbey, G. C. (2007). The role of social support and self-efficacy in shaping the leisure time physical activity of older adults. Journal of Leisure Research, 39(4), 705-727. https://doi.org/10.1080/00222216.2007.11950129

Pantović, M., Madić, D., Popović, B., Batez, M., & Obradović, J. (2015). Efekti primene vibracionog treninga i treninga sa dodatnim spoljašnjim opterećenjem na razvoj snage kod 13-godišnjeg dečaka nakon lezije m. biceps femoris i posttraumatske kalcifikacije. Vojnosanitetski Pregled, 72(7), 646-650. https://doi.org/10.2298/VSP140228040P

Rittweger, J. (2010). Vibration as an exercise modality: How it may work, and what its potential might be. European Journal of Applied Physiology, 108(5), 877-904. https://doi.org/10.1007/s00421-009-1303-3

Ryall, J. G., Schertzer, J. D., & Lynch, G. S. (2008). Cellular and molecular mechanisms underlying age-related skeletal muscle wasting and weakness. Biogerontology, 9(4), 213-228. https://doi.org/10.1007/s10522-008-9131-0

Saini, A., Faulkner, S., Al-Shanti, N., & Stewart, C. (2009). Powerful signals for weak muscles. Ageing Research Reviews, 8(4), 251-267. https://doi.org/10.1016/j.arr.2009.02.001

Spennewyn, K. C. (2008). Strength outcomes in fixed versus free-form resistance equipment. Journal of Strength and Conditioning Research, 22(1), 75-81. https://doi.org/10.1519/JSC.0b013e31815ef5e7

Watanabe, Y., Ohshima, H., Mizuno, K., Sekiguchi, C., Fukunaga, M., Kohri, K., Rittweger, J., Felsenberg, D., Matsumoto, T., & Nakamura, T. (2004). Intravenous pamidronate prevents femoral bone loss and renal stone formation during 90-day bed rest. In Journal of Bone and Mineral Research (Vol. 19, Issue 11, pp. 1771-1778). https://doi.org/10.1359/JBMR.040811

Zakas, A., Galazoulas, C., Doganis, G., & Zakas, N. (2006). Effect of two acute static stretching durations of the rectus femoris muscle on quadriceps isokinetic peak torque in professional soccer players. Isokinetics and Exercise Science, 14(4), 357-362. https://doi.org/10.3233/IES-2006-0249