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James M. McKivigan

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Blood Flow Restriction Exercise: A Systematic Review of the Literature

James McKivigan*

Touro University Nevada, School of Physical Therapy, USA

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***Corresponding author:** James McKivigan, Touro University Nevada, School of Physical Therapy, 874 American Pacific Drive, NV 89122, Henderson, USA

Abstract

Blood flow restriction training is quickly gaining popularity in the United States. However, it is not without controversy. While there are many reported health benefits, there are equally as many risks. Most concerning is the lack of industry standardizations regarding cuff size and pressure. There is no required training to implement blood flow restriction training, which can be problematic when people with little knowledge practice this type of exercise. When blood flow is restricted, there is an impact on the cardiovascular system, nervous system, and muscular system. Damage can be done when blood flow is restricted with too much pressure or too long of a duration. This paper provides a systematic review, including a comprehensive overview of the literature, regarding blood flow restriction exercise.

Keywords: Resistance training; Blood flow restriction; Exercise; Occlusion training; BFR exercise

Introduction

Blood flow restriction exercise, or blood flow restriction training, is rapidly gaining popularity among bodybuilders and exercise enthusiasts. This type of exercise can be used within a wide range of exercise modalities, including walking, cycling, and resistance training. It works by placing cuffs or wraps around a limb with the goal of maintaining arterial inflow while occluding venous return during exercise. The cuffs are wrapped at a perceived tightness of seven out of ten, and when used as a part of resistance training, low loads of 20%-30% of 1 repetition maximum (RM) should be used [1]. This type of exercise stems from Kaatsu training, which was developed by Yoshiaki Sato, who in 1994 applied for a patent for his Kaatsu bands. He created these bands by experimenting on himself with bicycle tubes, ropes, and bands on various parts of his body. Kaatsu is a patented training approach developed by Dr. Sato specifically using the Kaatsu Master Device. Blood flow restriction training or exercise is the term used when apparatuses are used that are not the specific Kaatsu Master Device. Often the terms are used interchangeably. Also used interchangeably with blood flow restriction exercise is the term "occlusion training." Blood flow restriction training is believed to cause a localized hypoxic effect which is the condition of low oxygen in the body's tissues [2]. Blood flow restriction exercise is reported to increase growth hormone, muscle hypertrophy, and muscle strength. This condition is due to the inability of the blood to escape so that metabolic stress and cellular swelling are increased. This restriction exercise training allows a person to achieve strength and muscle growth without having to use higher loads and in a much shorter time frame. This situation is especially useful when it comes to rehabilitation, as rehabilitation can begin much sooner, and this prevents atrophy as well as facilitates a faster return to normal functioning compared to traditional approaches [3]. It is also suggested that blood flow restriction training positively affects circulating hormone levels. By using blood flow restriction before intense exercise, ischemic preconditioning can occur, which results in less damage and shorter recovery time after exercise. There is also the potential for this type of exercise to benefit those with chronic pain who desire to be more active [3]. The research into blood flow restriction exercise often lacks details regarding how much pressure should be used for specific outcomes. This lack of detail is an area of concern in that too much pressure can increase the associated risks. However, not enough pressure can cause no benefits to occur [2]. The aim of this review was to conduct a comprehensive review of the literature to determine the efficacy and safety of blood flow restriction exercise.

Methodology

For the purposes of this literature review, the definition of blood flow training is exercise completed by placing a cuff

proximally to the muscle being exercised through low-intensity exercise with the purpose of recreating a hypoxic environment. Data from the included studies was evaluated regarding commonalities and areas of uniqueness to develop themes related to the research aims of efficacy and safety of blood flow restriction exercise. The requirement for informed consent was waived given the retrospective nature of the review. The study design was approved by the appropriate ethics review board.

Search strategy

A comprehensive search for research-based articles published in a peer-reviewed journal within the years 2014–2019 was conducted. The following electronic databases were searched: PubMed, SPORT Discus, SBRnet, and Sports Medicine & Education Index. The keywords blood restriction exercise, blood restriction training, occlusion training, and Kaatsu training were used. Abstracts were read to determine relevancy and adherence to the inclusion criteria. Reference lists of relevant articles were also reviewed to locate additional publications not included in the online databases.

Inclusion criteria

Only research studies using the above definition of blood flow exercise were included. Additionally, only articles that contributed data regarding the efficacy and safety of blood flow restriction exercise were included. This included research specifically on the Kaatsu training method. While abstracts were used to narrow down relevant articles, only those with full text were considered. All types of research studies were evaluated for inclusion which included experimental/control group studies, pilot studies, case studies, and systematic reviews.

Exclusion criteria

All publications before 2014 were excluded. Publications written in languages other than English were also excluded. Given that the specific focus of this work was to explicitly investigate the safety and efficacy of blood flow exercise, all research focusing on other aspects of this exercise method were not included.

Results

[1] define blood flow restriction training as a "method partially restricting arterial inflow and fully restricting venous outflow in working musculature during exercise". One primary issue surrounding this type of training is safety. There is a lack of standards and regulations for blood flow restriction exercise. Therefore, as the name implies, blood flow is restricted, and there is no required training for practitioners, so there is the possibility of injury. The areas of concern in terms of health are the cardiovascular response, central vascular response, peripheral vascular injury, venous thromboembolism, the fibrinolytic system injury, reactive oxygen concerns, and muscle damage [4].

Research by Patterson & Bradner [5] found that with the growing popularity of blood flow restriction training, there is an increasing population of practitioners who lack the knowledge regarding using and applying the exercise in a manner that is following standards developed by research. It was found that the primary concern is a significant range of pressure that is being applied with the cuffs. Instances of too much pressure being used has resulted in large numbers of exercisers experiencing numbness following their exercise session. This concept is supported in research [6]. The researchers compared low-load training, and low-load blood flow restriction training in clinical musculoskeletal rehabilitation. It was found that blood flow restriction training is more effective and more easily tolerated, making it a potential clinical rehabilitation approach. However, the researchers clearly stated that more research should be done to create standards so that this type of training, or rehabilitation, can be individualized to minimize risk to patients and ensure the highest possible level of effectiveness. In a 2016 survey conducted [7], it was found that blood flow restriction training within facilities is used for a variety of purposes. Responses from 232 facilities employing this type of training revealed:

a) 87% use this training for health promotion.

b) 85% use it for diet.

c) 70% use it for beauty and anti-aging.

d) 71% use it for an increase in muscle strength.

e) 72% use it for muscle hypertrophy.

f) 72% use it for improvement of sports performance.

g) 38% use it for rehabilitation.

h) 38% use it for helping with orthopedic disease.

i) 17% use it for obesity.

j) 12% use it for improving diabetes.

k) 11% use it for cerebrovascular disease.

l) 8% use it for cardiovascular disease.

m) 7% use it for depression.

n) 6% use it for treating infertility.

o) 5% use it for neuromuscular diseases.

p) 3% use it for treating immune diseases.

q) 53% use it for additional/other purposes.

Additionally, the survey found that 92% of the facilities found at least .5% improvement in the areas of which they used this type of training. Also reported was the presence of minor side effects including dizziness, subcutaneous hemorrhage, drowsiness, numbness, nausea, and itchiness. The researchers considered these as minor side effects and reported no serious side effects as

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reported on the survey. The study concluded that when under the care of trained professionals, blood flow restriction training can be used safely with positive benefits with any person regardless of age, sex, or physical condition. However, the study failed to provide details as to what they considered a trained blood flow restriction professional to be, and the results were self-reported from a survey of facilities where this type of training comprised a significant proportion of their provided training. In practice, frequency, intensity, and duration are focused on postsurgical rehabilitation when it comes to planning for and implementing blood flow restriction exercise. [8] specifically investigated cuff width, cuff pressure, and intermittent pressure application in terms of effectiveness and safety. Practitioners typically use 40%-90% of a person's arterial occlusion pressure. This span is a broad range indicating that standardized safety measures are lacking. When investigating the effectiveness and safety of various cuff widths, it was found that in terms of the lower body, wider cuffs had a lower absolute occlusion pressure than narrow cuffs. Additionally, using the lowest possible pressure is considered the safest as it is the least stressful and offers the most therapeutic results. [9] also found that wider cuffs are more efficient than narrow cuffs and supports the concern of a lack of training standards for blood flow restriction training. This research also found that 28 of 30 studies reported an increase in strength for both men and women; however, these studies also clarified that the data for women and blood flow restriction exercise is lacking [9]. Also reported were positive outcomes in bone health. Heitkamp states that an occlusion pressure of 150mm Hg with an intensity of 20% for 1RM with wider cuffs should be the recommendation [9]. Additionally, this research stated that blood flow restriction exercise showed no correlation with an increase in the risk of thrombosis. Specific areas of safety concerns regarding blood restriction training were studied [10] in the form of a comprehensive literature review. One area of concern is thrombus, or blood clot, formation. Research in this area conducted on healthy individuals and older people with heart disease found no change in blood indicators for thrombin development or clot formation [10]. Considering the results of 13,000 persons using blood flow restriction exercise found that the rate of deep venous thrombosis was less than .06% and the rate of pulmonary embolism was less than .01% [10,11] conducted blood flow restriction research specifically on elderly people with a mean age of 64.7 years. Participants were assigned to a control group and experimental group who engaged in blood flow restriction training focusing on aerobic Fitness, muscle mass, and muscle strength. The exercise was completed two days a week performing leg presses with one set of 30 presses and three sets of 15 presses at 20%-30% restriction. This process was performed for 12 weeks and then compared to the health markers before beginning the program. The cuffs used were those that are commonly found in fitness centers. Muscle damage is also a safety concern with blood flow restriction exercise. The literature finds that low-load blood flow restriction training carries a low risk for serious muscle damage. Muscle damage and delayed onset muscle soreness for restriction exercise are comparable to any type of exercise in which a person is unaccustomed to [11].

There are also cardiovascular risks associated with this type of exercise. There is a concern that restricted blood flow can result in cardiovascular changes while one is exercising. This change comes from the autonomic nervous system. The decreased blood flow to the muscles could cause excessive pressure reflex resulting in excessively high blood pressure. Although the risk is present in anyone using this method, those with heart failure, hypertension, or peripheral artery disease are at especially high risk [11]. Numbness is also a safety concern and is most often caused by band pressure that is too high which results in peripheral nerve compression. However, the research has shown that this has little chance of occurring with less than 2% of those participating in studies on this issue having experienced numbness. Having the appropriate size cuff and correct placement are vital to prevent peripheral nerve irritation [12]. Jessee and colleagues also found a muscular benefit to blood flow restriction training and recommended it for clinical rehabilitation [13]. These researchers also found little evidence that this type of training is any more dangerous than other types and that concerns over safety are unfounded [13]. However, it must be noted that in their research cuffs were only used at a five to seven-centimeter overlap and higher pressure was not studied [13]. The researchers also used the concept that a wrap was too tight if no pulse can be detected. If this occurred, then the cuffs were loosened [13]. Like the other research studies, [13] suggested the need for more research and standardization. Similarly, in another study, [14] found that the swelling of cells and metabolite-induced fatigue produced through blood flow restriction exercise resulted in stimulated synthetic pathways leading to muscle growth. The researchers also determined that this type of exercise was relatively safe, but the cuff size, cuff width, and the limb circumference must all be considered [14]. However, despite the research concluding that blood flow restriction training is safe, a study [15] found that there is a lack of focus on personal, medical, social, and family history before one engages in this type of training. The researchers found that specific attention should be given to one's medical conditions and lifestyle activities to determine the safety of blood flow restriction training [15]. As a result, the researchers developed a risk assessment screening instrument that they recommend is used before engaging in blood flow restriction exercise [15]. The researchers created a list of absolute or relative categories where the presence of any absolute risk factors should exclude persons from participating in this type of training (Table 1). The absolute risk factors are:

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Table 1: Absolute or relative risk categories.

Magnitude of Risk	Medical History or Lifestyle Factor	Patient Response	Decision
Absolute	Do you have a family history of clotting disorders (SLE, hemophilia, high platelets)?	Yes	Stop
		No	Continue
	Do you have level 1 hypertension (SAP >140mmHg)?	Yes	Stop
		No	Continue
	Do you have a past history of DVT or pulmonary embolus?	Yes	Stop
		No	Continue
	Have you suffered from a hemorrhagic or thrombotic stroke?	Yes	Stop
		No	Continue
Relative	Do you have a family history of clotting disorders (SLE, hemophilia, high platelets)?	Yes	Seek medical advice
		No	Continue
	Do you smoke?	Yes	Seek medical advice
		No	Continue
	Are you on any medication, including the contraceptive pill?	Yes	Seek medical advice
		No	Continue
	Do you have a history of injury to your arteries or veins?	Yes	Seek medical advice
		No	Continue
	Do you have diabetes?	Yes	Seek medical advice
		No	Continue
	Does one of your parents or siblings have diabetes?	Yes	Seek medical advice
		No	Continue
	Do you have hypertension (SAP 120-140mmHg)?	Yes	Seek medical advice
		No	Continue
	Do you have metal work in situ?	Yes	Seek medical advice
		No	Continue
	Do you have any undiagnosed groin/calf pain?	Yes	Seek medical advice
		No	Continue
	Do you have/you suffered from compartment syndrome?	Yes	Seek medical advice
		No	Continue
	Have you had surgery in the past 4 weeks?	Yes	Seek medical advice
		No	Continue
	Have you had a journey lasting more than 4 hours or a flight in the last 7 days?	Yes	Seek medical advice
		No	Continue
	Do you have any other medical conditions, including a history of synovitis?	Yes	Seek medical advice
		No	Continue

a) History or presence of clotting disorders (includes systemic lupus erythematosus, hemophilia, and high platelet count).

b) History or presence of deep vein thrombosis, or pulmonary embolism.

c) History of thrombotic or hemorrhagic stroke.

d) Presence of level 1 hypertension or higher [15].

[16] investigated participant muscular pain when participating in blood flow restriction exercise using low-loads. In this study, researchers participated in blood flow restriction exercise two times a day [16]. Data were collected every five training sessions for three weeks. Overall, participants reported mild muscular discomfort while exercising [16]. However, within five minutes after exercise was completed, pain was reported to be back to pre-exercise pain levels [16]. Pain during exercise ranged from 44-66 mm Hg which was significantly greater than the baseline established both before and after exercise [16]. After the completion of three weeks of blood flow restriction exercise, there was a reduction in muscular pain levels [16]. This data is represented in Figure 1 [16]. Research has also been

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conducted regarding pain, particularly the influence of the type of cuff material used, including elastic or nylon. In other research, the cuff material was not explicitly discussed. However, [17] studied how the cuff material affected both discomfort levels and exertion levels from the patient perspective. The results are shown in Figure 2 [17].

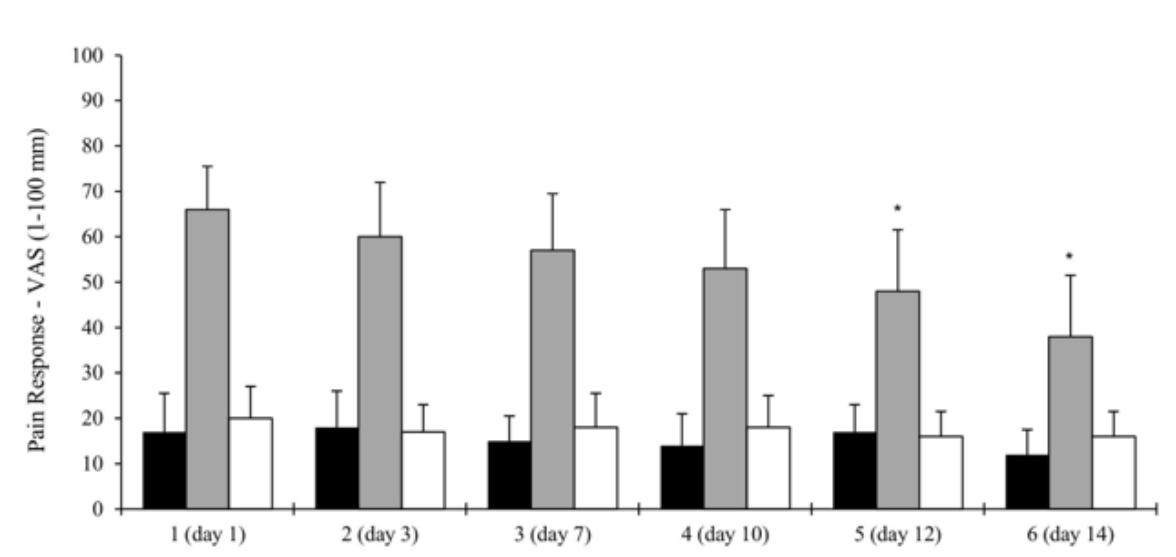

Figure 1: Visual Analog Scale (VAS). The black bar represents pre-exercise, the gray bar represents during exercise, and the white bar represents post exercise [16].

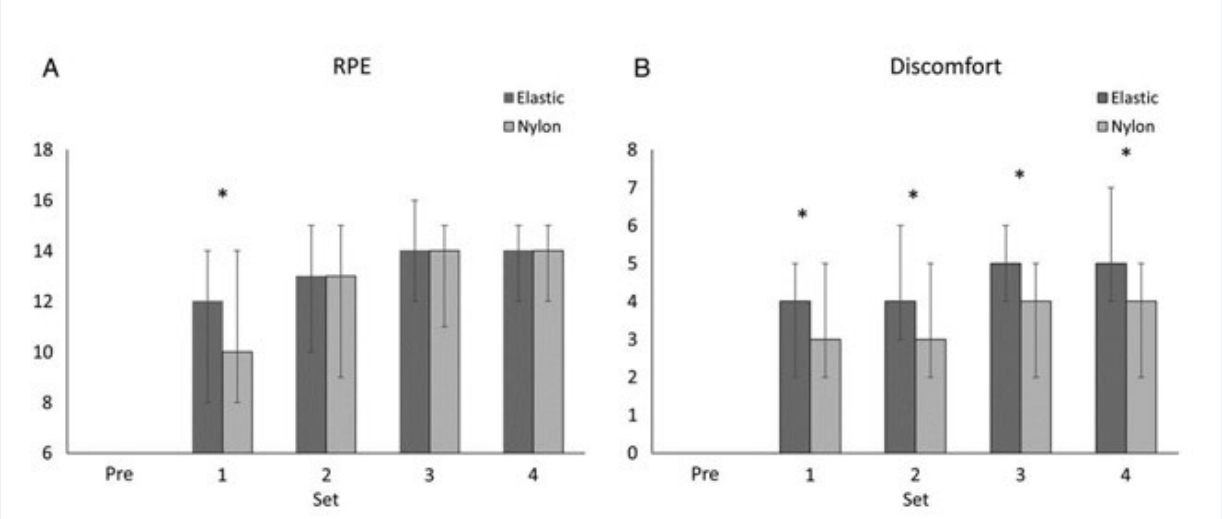

Figure 2: Rate of perceived exertion (RPE). The black bar represents elastic cuffs; the gray bar represents nylon cuffs. *Statistically different between protocols. A) Signifies responses to each exercise protocol while B) characterizes discomfort for both protocols [17].

Discussion

This review of the literature determined that there is a need for standardization regarding blood flow restriction exercise. There is a lack of guidelines in terms of cuff size, duration, and pressure. Also lacking are standards to guide practitioners when it comes to accomplishing specific outcomes. For example, for building muscle mass, a user needs to use x amount of pressure for x duration. This situation is also true for those using blood flow restriction training for rehabilitation purposes. Guidelines are needed that list the appropriate duration and cuff pressure for accomplishing specific rehabilitation goals. Standards for age, sex, and a variety of physical conditions and specific illnesses/ailments are also needed for example, standards for how a person with heart disease should use this type of training. Having these guidelines will help to achieve individualized goals and decrease safety risks. Currently, a set of standards would require more specialized research and a compilation of already

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conducted research. Those already focused on researching blood flow restriction exercise have called for standardization within the field, yet none have taken on the task.

The literature also alludes to the training of blood flow restriction training experts. The literature that mentions professional training states that there is a need for training standards and standardized requirements. However, the available research does not include any standardization suggestions for this training. Like standards for use, training requirements need to be based on relevant research, so more research on this topic should be undertaken. By having set requirements in terms of knowledge and skill, blood flow restriction trainers can further ensure that safety standards are implemented, thus lessening the risk for those engaging in this type of exercise. Available r

esearch has shown consistency in terms of how blood flow restriction functions and the benefits it brings in terms of muscle enhancement and strength. No research studies included in this review disputed the usefulness of this type of training. Most research investigating blood flow restriction exercise benefits also reported that this type of training would be, or is, even beneficial for rehabilitation. While using blood flow restriction for rehabilitation is not specified in the scope of this paper, it is acknowledged that the literature does include studies focused specifically on the use of blood flow restriction for specific rehabilitation needs such as muscle weakness, joint replacement, ligament/muscle injuries, etc. Even though the research recognized its value in terms of rehabilitation, doctors are seldom prescribing this type of therapy, and it is typically not offered at physical therapy clinics [18]. The included studies also acknowledge that there are risks to this type of exercise. Only one study stated that the risk is the same as other forms of exercise. Research has found that primarily there is an increased risk of blood clots, muscle damage, and nerve compression, but that other physical damage can also occur. These risks, however, are reported within the research to be minimal. Research also is clear in that this type of training should not be undertaken without the supervision of a knowledgeable professional. This situation leads back to the concern that there is not a set of standards or any documentation of professional training required for those helping others implement blood flow restriction exercise.

Conclusion

It is expected that the trend of blood flow restriction training will continue to grow and become a respected method for muscle enhancement, rehabilitation, and sports endurance. The available research indicates that there are many more areas that need further investigation, along with a clear need for standardization for being a trainer and for using blood flow restriction exercise safely. Overall, it can be concluded that blood flow restriction exercise is a safe form of training, leading to increased muscle development, but it should be undertaken with the guidance of a knowledgeable and experienced trainer.

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