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KAATSU Training

Efrain De Leon Angon
Gettysburg College

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Abstract

This paper explores the use of blood flow restriction training as a rehabilitation tool in physical therapy and as a training method for the general population such as the fact that BFR training can be an alternative option for individuals who cannot tolerate high-load resistance training due to injury or surgery. This allows BFR training to be used by a wide spectrum of ages and physical capacities. However, the safety of BFR is still being questioned as well as its effects on well-trained athletes.

Keywords

KAATSU, Blood Flow Restriction, Training, BFR

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Efrain De Leon Angon

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Introduction

According to the American College of Sports Medicine or ACSM, there are clear health benefits from physical activity and exercise (Liguori & American College of Sport Medicine 2020). Virtually anyone can benefit from becoming more physically active and most guidelines recommend a total of about 50 minutes, 5 days of the week for any moderate exercise or 30 minutes, 3 days a week of vigorous exercise or physical activity (Warburton & Bredin., 2017; Liguori & American College of Sport Medicine 2020). Such benefits include the fact that skeletal muscles will adapt positively if they are trained appropriately (Karabulut et al., 2007). Out of all of the adaptations the body goes through with physical activity, the most beneficial one is that muscular hypertrophy will occur in response to resistance exercise or training (Wackerhage et al., 2019). In terms of how to train to achieve such adaptations, there seems to be multiple, different methods of training. However, the one that has gained popularity over the years is KAATSU training, also known as Blood Flow Restriction (BFR) Training (Sato, 2005). KAATSU Training or BFR training requires a belt or a tourniquet to be wrapped around the proximal portion of an extremity to partially and temporarily restrict blood flow. This, in turn, stimulates the muscular adaptations that improve overall muscular mass and strength.(Miller et al., 2021). However, those who suffer from injuries or are in rehabilitation can not perform moderate to vigorous resistance training due to the added mechanical stress that the resistance training will add to the injury. In situations such as these, BFR training can actually be beneficial, because the physiological mechanisms of BFR training facilitate muscle hypertrophy with the use of low-load/low-level resistance training. This allows BFR training to be used both in general training settings and in therapeutic/rehabilitation settings as an effective treatment to increase muscular strength and function (Bobes et al., 2020).

Before it gained popularity in the training and therapeutic setting, the idea was actually first thought out by Dr. Yoskiaki Sato (Patterson et al., 2019). Dr. Yoskiaki Sato was actually in his last year of high school in Japan when he got the inspiration for KAATSU Training. He discovered KAATSU while attending a Buddhist memorial; in the middle of mass, he noticed that his calf had become numb due to the way he had been sitting and noted how the discomfort and swelling in the area were similar to the sensation he felt while performing strenuous calf-raise exercises (Sato, 2005). Sato (2005) stated that it took him nearly 6 months before he was able to feel a "pump" effect from his personal KAATSU technique and it would take him four years to come up with the basic manual for KAATSU training. However, it was not without sacrifice. During his first year in college, he suffered from recklessly experimenting on himself and was hospitalized causing him to doubt his work with blood flow resistance training. However he would continue to experiment and refine the training technique and ten years later in 1983, the methods for KAATSU or BFR training were generalized for public use. In 1994, Dr. Yoskiaki Sato applied for his first patent for BFR training in Japan and was later approved for it in 1997. From there on, the process became easier and by 2002 it had become even easier for the general public to participate in KAATSU or BFR training (Sato, 2005). Since then, there has been an increasing amount of studies done on BFR and its relevance to muscular hypertrophy as well as its connection to general strength training and therapeutic/rehabilitation setting.

Use of Blood Flow Restriction in Therapeutic Training

Skeleton muscle injuries are often associated with muscle atrophy, muscle weakness, increased pain, functional incapacity, and lower physical fitness, ultimately resulting in decreased muscle function (Caetano et al., 2021). The purpose of musculoskeletal rehabilitation is to achieve a level of muscle function that matches the pre-injury and/or the pre-surgical level with a low risk of re-injury (Bielitzki et al., 2021). Achieving this requires the prioritization of improving muscle function in the rehabilitation process. An effective way to preserve and increase muscle mass, as well as neuromuscular function, is with the use of resistance training (Caetano et al., 2021; Bielitzki et al., 2021). However, the use of resistance training has been shown to put a great deal of mechanical stress on damaged or reconstructed tissues. This would be contradictory to the healing process and could lead to further injuries and/or pain (Barber-Westin & Noyes 2019).

BFR training provides an alternative treatment option for individuals who cannot tolerate high-load resistance training due to injury or surgery. Many studies have observed the positive effects of BFR training such as its ability to increase muscle mass very similar to heavy resistance training in both young and old individuals (Barber-Westin & Noyes 2019; Bielitzki et al., 2021). The techniques of blood flow manipulation with BFR have been associated with promoting blood pooling and local hypoxia with the goal to increase the level of metabolic stress (Bielitzki et al., 2021). This increase will result in accelerated fatigue with very little mechanical stress which allows BFR to be a safe alternative for a wide spectrum of ages and physical capacity (Lixandrao et al., 2018).

BFR has been particularly useful in elderly patients since a variety of changes occur in skeletal muscle with aging. More specifically, it's been observed that skeletal muscle mass decreases by as much as 3-8% every decade after the age of 30. Age-related reduction in both muscle mass and strength is known as sarcopenia. Sarcopenia causes functional and metabolic issues that are often associated with the increased risks of falling and mortality in the elderly population (Papa & Hassan, 2017). Along with age-related obstacles, resistance training is often not considered a feasible option for the elderly population because of other physical limitations such as heart diseases and other musculoskeletal impairments or diseases (Centner et al., 2019).

Currently, the research supports the use of BFR with elderly patients. The studies suggest that BFR aids in rehabilitation efforts by inducing muscle hypertrophy, combating muscle atrophy, increasing muscle strength, and improving muscle function (Baker et al., 2019). The limitations of using BFR with the elderly population arise from the fact that currently there is limited data or research on the implication that BFR training can cause increased risk of cardiovascular issues in elderly patients that are already diagnosed with cardiovascular diseases (CVDs). Therefore, more research is required to be able to properly assess the cardiovascular safety of BFR on elderly patients with CVDs (Cristina-Oliveira et al., 2020). Despite that lack of information, BFR usage is increasing as a clinical rehabilitation tool for both young and old (Baker et al., 2019; Cristina-Oliveira et al., 2020).

Those who do not fall within the elderly population can also benefit from the use of BFR as a clinical rehabilitation tool. BFR has been found to be a useful tool when treating a multitude of impairments for young adults and adults such as knee osteoarthritis (Ferlito et al., 2020). Osteoarthritis commonly occurs in young adults as a result of a previous knee injury. It is often characterized by the presence of pain in the leg or thigh which occurs from alterations to the injured knee. Those who suffer from osteoarthritis are also at increased risk of falls and fractures which can hinder the healing process or create more of an injury (Rose, 2005). Studies have shown, however, that BFR can be an applicable strategy in the treatment of osteoarthritis because of its ability to increase strength and muscle function without the need to place great mechanical stress on the injured knee. Since most rehabilitation treatment occurs at a hospital or clinic, the application of BFR is often done safely and is monetized by a trained professional (Ferlito et al., 2020).

The applications of BFR as a clinical rehabilitation tool have been shown to mimic the effects of heavy resistance training by increasing skeletal muscle hypertrophy, strength, and physical function after injury or surgery. Studies have shown, however, that not only can it be useful as a treatment but it can be used earlier than resistance training to promote more recovery or an easier transition to other treatments (Hughes et al., 2019). One study looked at the rehabilitation of the ACL after surgery. Anterior cruciate ligament (ACL) injuries are very common in a wide range of age groups. However, active individuals are at greater risk. ACL injuries are complex and often require a lengthy rehabilitation process (Alexanders et al., 2021). The study conducted on the rehabilitation of the ACL after surgery with the use of BFR found that not only did it improve skeletal muscle hypertrophy and strength with a greater reduction in knee joint pain when compared to resistance train but it could be done earlier to help progress the loading phase of rehabilitation following surgery in ACLR (Hughes et al., 2019).

Use of Blood Flow Restriction Training in General Training

The application of BFR training has not only increased in popularity as a rehabilitation tool but it has also gained some momentum as an effective training method for the general population. However, studies on using BFR as a training strategy for healthy, well-trained athletes is currently not widely available (Scott et al., 2016). The studies that do exist look at the connections between BFR adaptations and well-trained athletes. The BFR training adaptations were looked at within strength-trained athletes and endurance-trained athletes. BFR-resistance exercise positively influences adaptations in strength-trained populations (Pignanelli et al., 2021). A study performed on elite powerlifters found that high-frequency BFR training caused a significant increase in muscle size (Bjørnsen et al., 2018). Another study looking at strength-trained athletes looked at trained D1 football players. The study followed two groups of athletes: a controlled group and a group using BFR through a 5-week strength training program that focused on bench pressing and squatting. At the end of the 5 weeks, it was discovered that the group using BFR demonstrated greater growth in their chest in comparison to the controlled group. However, there was no difference in growth between the controlled group and the group using BFR for squatting (Yamanaka et al., 2012).

BFR training has also been seen to increase the physiological response to interval training in athletes. This was done by looking at endurance-trained athletes and their responses to BFR. Although BFR is often associated with resistance training, some supplementation use has shown it can increase the aerobic power of endurance-trained athletes (Pignanelli et al., 2021).

Risks of Blood Flow Restriction Training

The use of blood flow restriction training has become common pratice in rehabilitation centers around the globe (Lorenz, 2021). It is currently used for a wide variety of populations including both healthy and clinical populations worldwide. Evidence has suggested that the application of BFR has been proven efficient in creating significant hypertrophy and increasing muscular strength (Hughes et al., 2017). However, the safety of BFR training has been questioned. The current side-effects experienced by those who use BFR training include fainting, numbness, pain, and discomfort, delayed onset muscle soreness, and muscle damage. There are also lots of variables that affect the safety of BFR like selecting the appropriate BFR pressure cuff, cuff width and placing the cuff in the correct place (Brandner et al., 2018). There is also growing concern that BFR training may generate abnormal cardiovascular responses which have been linked to increased risk of cardiovascular health (Cristina-Oliveira et al., 2020). Some health officials are even concerned about the risk of deep venous thrombosis from the use of BFR training (Lorenz, 2021). Future research is needed in order to fully grasp the connection between BFR and its association with increased risk of deep venous thrombosis and cardiovascular health (Cristina-Oliveira et al., 2020).

Other concerns do arise from the fact that currently there is no requirement for certification and no standardized recommendations for the use of BFR training but, despite that, evidence shows that BFR training is safe when used appropriately & under proper safety guidelines (Lorenz, 2021). Therefore, in order to reduce the possibility of risk from BFR training, screening and monitoring patients should be taken into consideration by health officials. Screening an individual will help identify any potential risk factors and monitoring the individual's physiological responses can help prevent any unwanted risk (Bielitzki et al., 2021).

Physiology of Blood Flow Restriction Training

It has been observed that the physiological mechanisms of BFR training will facilitate muscle hypertrophy similar to that of heavy resistance training (Bobes et al., 2020). However, in order to understand the physiological mechanisms, it's important to first understand what muscle hypertrophy is and how it correlates with resistance training.

Muscular hypertrophy is a response to stimuli, often resistance training, that increases muscle mass and the cross-sectional area of the muscle (Russell. et al., 2000). Russell. et al (2000) have suggested that there is a direct correlation when looking at the potential force a muscle can produce with its mass and cross-sectional area; an increase in both mass and cross-sectional area of the muscle leads to an increase of the potential force production. With resistance training, the two most common long-term goals are muscular hypertrophy and strength which can be mediated by a variety of different things such as load, volume, and even speed or tempo of the exercise being performed (Wilk. et al., 2021). During resistance training, motor units and muscle fibers are recruited according to the Henneman size principle (Pearson & Hussain 2015).

According to the Henneman size principle, smaller motor units associated with type I muscle fibers are activated initially at low intensities, while larger motor units typically associated with type II muscle fibers are recruited at higher exercise intensities with increasing levels of contractile force (Pearson & Hussain 2015). Pearson and Hussain (2015) both believe that activation of type II muscle fibers during training is very important because the muscle fibers associated with type II fibers are more responsive to hypertrophy than type I fibers. Type II fibers are generally larger as well and typically anaerobic, meaning that they don't use oxygen in the formation of their energy, while type I muscle fibers are often associated with oxidative properties, such as using oxygen, and are typically smaller than type II. Hagstrom et al. (2016) looked at the effect of resistance training in women on dynamic strength and muscular hypertrophy.

Hagstrom et al. (2016) results stated that resistance training will result in significant increases in upper and lower body strength and muscular hypertrophy. This occurs because resistance training leads to increased amounts of damage on the muscle, normally microtears, which will be repaired by satellite cells and will promote muscular growth. In a study looking at the role of muscle damage in the development of skeletal muscle hypertrophy through resistance training, it was found that one of the main stimuli to activate satellite cells is actually muscle damage and muscle damage promotes/increases satellite cell proliferation (Damas et al., 2018). The role of satellite cells in muscle damage is critical since they donate their nuclei to muscle fibers in order to promote tissue regeneration after exercise-induced injuries (Damas et al., 2018).

Traditionally it was believed that to induce hypertrophy, some form of high-intensity training was required (Schoenfeld et al., 2019). However, BFR studies indicate the opposite and state that the intensity of the training does not have to be difficult in order to induce skeletal muscle hypertrophy (Karabulut et al., 2007). Skeletal muscle hypertrophy is achieved by restricting blood flow out of the muscle with the application of external pressure via a tourniquet or pressurized cuff. The cuff will be placed on the proximal portion of the upper or lower extremities. The pressure applied to the extremities must be enough to limit both arterial inflow and venous outflow of blood (Pearson & Hussain, 2015). The limiting arterial and venous blood flow should then lead to a buildup of blood pooling and the creation of an ischemic/hypoxic environment that enhances the training effect (Tegtbur et al., 2020: Pearson & Hussain, 2015). According to Pearson & Hussain (2015), the desired hypertrophic effects of resistance training with BFR have been primarily attributed to increased levels of metabolic stress. The metabolic stress associated with blood flow resistance training is the build of metabolic by-products that often promote growth by acting on other factors such as swelling and hormones (Teixeira et al., 2018: Pearson & Hussain 2015).

One study conducted by Takarada et al. (2000) looked at the hormonal and inflammatory responses to low-intensity resistance training with blood flow restriction. They took measurements of the plasma concentrations of growth hormone, norepinephrine, and lactate before and after exercise and found that all plasma concentrations dramatically increased after the exercise with blood flow restriction. They found that the same plasma concentration did not change a great deal after the exercise without the use of BFR even though it was done at the same intensity and volume. The growth hormone concentration was larger in low-intensity resistance training with the use of BFR than in high-intensity training that did not use blood flow restriction; this shows that exercise with occlusion can cause strong endocrine responses even at extremely low intensity. The concentration of lipid peroxide, interleukin-6, and activity of creatine phosphokinase were also looked at. Interleukin-6 and creatine phosphokinase are the plasma markers for muscular damage and the study showed that training with BFR training and training without it did not increase considerably so it was concluded that the damage done to the muscle is the same in both training with BFR and without BFR (Takarada et al., 2000).

Future of Blood Flow Restriction

The future of BFR seems like a positive one because of its increased popularity in both as a rehabilitation tool and a training tool for athletes. However, currently, there is limited information regarding the effects of BFR and its association to increased risk of deep venous thrombosis and cardiovascular health (Cristina-Oliveira et al., 2020). Not only that, but there is limited information on the effects of BFR on well-trained athletes (Scott et al., 2016). Although the existing evidence suggests that BFR is safe and can provide benefits to both the clinical population and healthy population worldwide, there is still a need for more research to be able to confidently state the benefits of BFR (Brandner et al., 2018).

Conclusion

In conclusion, blood flow restriction training has become a very popular rehabilitation tool in physical therapy as well as a popular training method for general training (Lorenz, 2021). This is most likely due to the fact that BFR training provides an alternative option for individuals who cannot tolerate high-load resistance training due to injury or surgery. This allows BFR to be used by a wide spectrum of ages and physical capacities (Lixandrao et al., 2018). However, the safety of BFR is still being questioned and is currently limited by the number of studies done on well-trained athletes as well as other things such as its association with increasing the risk of deep venous thrombosis and cardiovascular health (Cristina-Oliveira et al., 2020; Scott et al., 2016).

Work Cited

Alexanders, J., Chesterton, P., Brooks, A., & Kaye, J. A. (2021). An exploration of UK student physiotherapists' goal setting practices within anterior cruciate ligament rehabilitation. Musculoskeletal Care, 19(2), 172-179.

Baker, B. S., Stannard, M. S., Duren, D. L., Cook, J. L., & Stannard, J. P. (2020). Does blood flow restriction therapy in patients older than age 50 result in muscle hypertrophy, increased strength, or greater physical function? A systematic review. Clinical Orthopaedics and Related Research, 478(3), 593-606. doi:10.1097/CORR.0000000000001090 [doi]

Barber-Westin, S., & Noyes, F. R. (2019). Blood Flow-Restricted Training for Lower Extremity Muscle Weakness due to Knee Pathology: A Systematic Review. Sports health, 11(1), 69–83. https://doi.org/10.1177/1941738118811337

Bielitzki, R., Behrendt, T., Behrens, M., & Schega, L. (2021). Time to save time: Beneficial effects of blood flow restriction training and the need to quantify the time potentially saved by its application during musculoskeletal rehabilitation. Physical Therapy, 101(10), pzab172. doi:10.1093/ptj/pzab172

Bjørnsen, T., Wernbom, M., Kirketeig, A., Paulsen, G., Samnøy, L. E., Bækken, L. V., ... & Raastad, T. (2018). Type 1 Muscle Fiber Hypertrophy after Blood Flow–restricted Training in Powerlifter.

Bobes Álvarez, C., Issa-Khozouz Santamaría, P., Fernández-Matías, R., Pecos-Martín, D., Achalandabaso-Ochoa, A., Fernández-Carnero, S., Martínez-Amat, A., & Gallego-Izquierdo, T. (2020). Comparison of Blood Flow Restriction Training versus Non-Occlusive Training in Patients with Anterior Cruciate Ligament Reconstruction or

Knee Osteoarthritis: A Systematic Review. Journal of clinical medicine, 10(1), 68.

Brandner, C. R., May, A. K., Clarkson, M. J., & Warmington, S. A. (2018). Reported side-effects and safety considerations for the use of blood flow restriction during exercise in practice and research. Techniques in Orthopaedics, 33(2), 114-121.

Caetano, D., Oliveira, C., Correia, C., Barbosa, P., Montes, A., & Carvalho, P. (2021). Rehabilitation outcomes and parameters of blood flow restriction training in ACL injury: A scoping review. Edinburgh : New York. doi:10.1016/j.ptsp.2021.01.015

Centner, C., Wiegel, P., Gollhofer, A., & König, D. (2019). Effects of blood flow restriction training on muscular strength and hypertrophy in older individuals: A systematic review and meta-analysis. Sports Medicine (Auckland, N.Z.), 49(1), 95-108. doi:10.1007/s40279-018-0994-1 [doi]

Cristina-Oliveira, M., Meireles, K., Spranger, M. D., O'Leary, D. S., Roschel, H., & Peçanha, T. (2020). Clinical safety of blood flow-restricted training? A comprehensive review of altered muscle metaboreflex in cardiovascular disease during ischemic exercise. American Journal of Physiology-Heart and Circulatory Physiology, 318(1), H90-H109.

Damas, F., Libardi, C. A., & Ugrinowitsch, C. (2018). The development of skeletal muscle hypertrophy through resistance training: The role of muscle damage and muscle protein synthesis. European Journal of Applied Physiology, 118(3), 485-500

Ferlito, J. V., Pecce, S. A. P., Oselame, L., & De Marchi, T. (2020). The blood flow restriction training effect in knee osteoarthritis people: A systematic review and meta-analysis. Clinical Rehabilitation, 34(11), 1378-1390. doi:10.1177/0269215520943650 [doi]

Hagstrom, A. D., Marshall, P. W., Halaki, M., & Hackett, D. A. (2020). The effect of resistance training in women on dynamic strength and muscular hypertrophy: A systematic review with Meta analysis.

Hughes, L., Paton, B., Rosenblatt, B., Gissane, C., & Patterson, S. D. (2017). Blood flow restriction training in clinical musculoskeletal rehabilitation: A systematic review and meta-analysis. British Journal of Sports Medicine, 51(13), 1003. doi:http://dx.doi.org/10.1136/bjsports-2016-097071

Hughes, L., Rosenblatt, B., Haddad, F., Gissane, C., McCarthy, D., Clarke, T., . . . Patterson, S. D. (2019). Comparing the effectiveness of blood flow restriction and traditional heavy load resistance training in the Post Surgery rehabilitation of anterior cruciate ligament reconstruction patients: A UK national health service randomised controlled trial. Sports Medicine, 49(11), 1787-1805. doi:http://dx.doi.org/10.1007/s40279-019-01137-2

Karabulut, M., Abe, T., Sato, Y., & Bemben, M.G. (2007). Overview of neuromuscular adaptations of skeletal muscle to KAATSU Training. International Journal of Kaatsu Training Research, 3, 1-9.

Liguori, G., & American College of Sports Medicine. (2020). ACSM's guidelines for exercise testing and prescription. Lippincott Williams & Wilkins.

Lixandrao, M. E., Ugrinowitsch, C., Berton, R., Vechin, F. C., Conceição, M. S., Damas, F., ... & Roschel, H. (2018). Magnitude of muscle strength and mass adaptations between high-load resistance training versus low-load resistance training associated with blood-flow restriction: a systematic review and meta-analysis. Sports medicine, 48(2), 361-378.

Lorenz D. (2021). Blood Flow Restriction: Cause for Optimism, But Let's Not Abandon The Fundamentals. International journal of sports physical therapy, 16(3), 962–967. https://doi.org/10.26603/001c.23725

Miller, B. C., Tirko, A. W., Shipe, J. M., Sumeriski, O. R., & Moran, K. (2021). The Systemic Effects of Blood Flow Restriction Training: A Systematic Review. International journal of sports physical therapy, 16(4), 978–990. https://doi.org/10.26603/001c.25791

Papa, E. V., Dong, X., & Hassan, M. (2017). Skeletal Muscle Function Deficits in the Elderly: Current Perspectives on Resistance Training. Journal of nature and science, 3(1), e272.

Patterson, S. D., Hughes, L., Warmington, S., Burr, J., Scott, B. R., Owens, J., ... & Loenneke, J. (2019). Blood flow restriction exercise: considerations of methodology, application, and safety. Frontiers in physiology, 10, 533.

Pearson, S. J., & Hussain, S. R. (2015). A review on the mechanisms of blood-flow restriction resistance training-induced muscle hypertrophy. Sports Medicine, 45(2), 187-200. Retrieved from http://ezpro.cc.gettysburg.edu:2048/login?url=https://www.proquest.com/scholarly-journals/review-on-mechanisms-blood-flow-restriction/docview/1666285413/se-2?accountid=2694

Pignanelli, C., Christiansen, D., & Burr, J. F. (2021). Blood flow restriction training and the high-performance athlete: science to application. Journal of Applied Physiology, 130(4), 1163-1170.

Roos E. M. (2005). Joint injury causes knee osteoarthritis in young adults. Current opinion in rheumatology, 17(2), 195–200. https://doi.org/10.1097/01.bor.0000151406.64393.00

Russell, B., Motlagh, D., & Ashley, W. W. (2000). Form follows function: how muscle shape is regulated by work. Journal of applied physiology (Bethesda, Md. : 1985), 88(3), 1127–1132.

Sato, Y. (2005). The history and future of KAATSU training. International Journal of KAATSU

Training Research, 1(1), 1-5.

Schoenfeld, B. J., Ogborn, D., & Krieger, J. W. (2016). Effects of resistance training frequency on measures of muscle hypertrophy: A systematic review and meta-analysis. Sports Medicine, 46(11), 1689-1697.

Scott, B. R., Loenneke, J. P., Slattery, K. M., & Dascombe, B. J. (2016). Blood flow restricted exercise for athletes: A review of available evidence. Journal of Science and Medicine in Sport, 19(5), 360-367. doi:http://dx.doi.org/10.1016/j.jsams.2015.04.014

Takarada, Y., Nakamura, Y., Aruga, S., Onda, T., Miyazaki, S., & Ishii, N. (2000). Rapid increase in plasma growth hormone after low-intensity resistance exercise with vascular occlusion. Journal of applied physiology, 88(1), 61-65.

Tegtbur, U., Haufe, S., & Busse, M. W. (2020). Anwendung und Effekte des „blood flow restriction training “. Der Unfallchirurg, 123(3), 170-175.

Teixeira, E. L., Barroso, R., Silva Batista, C., Laurentino, G. C., Loenneke, J. P., Roschel, H., ... & Tricoli, V. (2018). Blood flow restriction increases metabolic stress but decreases muscle activation during high load resistance exercise. Muscle & Nerve, 57(1), 107-111.

Wackerhage, H., Schoenfeld, B. J., Hamilton, D. L., Lehti, M., & Hulmi, J. J. (2019). Stimuli and sensors that initiate skeletal muscle hypertrophy following resistance exercise. Journal of applied physiology (Bethesda, Md. : 1985), 126(1), 30–43.

Warburton, D., & Bredin, S. (2017). Health benefits of physical activity: a systematic review of current systematic reviews. Current opinion in cardiology, 32(5), 541–556. https://doi.org/10.1097/HCO.0000000000000437

Wilk, M., Zajac, A., & Tufano, J. J. (2021). The Influence of Movement Tempo During Resistance Training on Muscular Strength and Hypertrophy Responses: A Review. Sports

Medicine (Auckland, N.Z.), 51(8), 1629–1650.

Yamanaka, T., Farley, R. S., & Caputo, J. L. (2012). Occlusion training increases muscular strength in division IA football players. The Journal of Strength & Conditioning Research, 26(9), 2523-2529.