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Blood Flow Restriction Training: A Fact Check on Scientific Rationale, Current Evidence and Trends in Clinical Musculoskeletal Rehabilitation

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ABSTRACT

Muscle weakness is exceedingly prevalent among the most musculoskeletal (MSK) conditions worldwide. The ramification of injury related and progressive loss of muscle strength can be life changing. Factually, heavy exercise loads of approximately 70% of an individual's one repetition maximum (1RM) have been adjudged necessary to elicit muscle hypertrophy and strength gains. Blood flow restriction (BFR) is a training method partially restricting arterial inflow and fully restricting venous outflow of blood in working musculature during low intensity exercise, so as to bring a desired effect of high intensity training. Low intensity BFR training is a novel technique aims to reproduce the effects of a high intensity training and is desirably applicable to the individuals who cannot perform high intensity training during the phase of rehabilitation. This would be really beneficial to the group of people who cannot perform high intensity strengthening as a result of joint and muscular issues which limits them from high joint forces and mechanical stress associated with heavy load exercise. There is a need for the evolution of an individualized approach to training recommendation to minimize patient risk and increase effectiveness. Effective implementation of BFR training depends on various factors such as age, gender, physical inactivity, occlusion pressure, and limb circumference. Research has demonstrated effective attenuation of muscle atrophy and muscle strength using an occlusion protocol even at a low pressure of 50 mmHg, suggesting that BFR intrinsically is effective at minimizing atrophy. Future research should embrace an individualized and evidence based progressive approach to facilitate the effectiveness and safety of BFR training

Keyword: Blood flow restriction; Musculoskeletal; Rehabilitation

Muscle weakness is exceedingly prevalent among the most musculoskeletal (MSK) conditions worldwide. The degenerative effects of muscle atrophy can be seen with both acute and chronic injuries that result in prolonged muscle immobilization, such as fractures and ligament injuries. Loss of strength is a major risk factor for degenerative diseases responsible for reduced function and quality of life. Muscle weakness is increasingly evident in unscathed healthy populations such as older adults due to sarcopenia. The ramification of injury related and progressive loss of muscle strength can be life changing. Strength training is indispensable in clinical musculoskeletal rehabilitation, heavy load resistance training has been recommended to offset age related loss in muscle strength and mass, and strength training post immobilization is necessary to reclaim the strength lost as a consequence of muscle disuse atrophy.[1, 2, 3]

Factually, heavy exercise loads of approximately 70% of an individual's one repetition maximum (1RM) have been adjudged necessary to elicit muscle hypertrophy and strength gains. Cross sectional comparisons suggest that hypertrophy and strength gains distinguished with low load training are not as sizeable as those achieved with heavy load training. Training with low loads is considered to be effective, as the early inclusion of muscle mass and function in rehabilitation may be favorable for individuals who have suffered from atrophy. In recent years, research has exemplified that augmentation of low load resistance training with blood flow restriction to the active musculature can produce significant hypertrophy and strength gains, using loads as low as 30% 1RM. BFR training has been found to capitulate hypertrophy responses comparable to that observed with heavy load resistance training.[3,4]

Blood flow restriction (BFR) is a training method partially restricting arterial inflow and fully restricting venous outflow of blood in working musculature during low intensity exercise, so as to bring a desired effect of high intensity training. Performing exercise with reduced blood flow accomplished by restriction of the vasculature proximal to the muscle dates back to Dr. Yoshiaki Sato in Japan, where it was known as "kaatsu training," meaning "training with added pressure" which is now performed all over the world and is more commonly referred to as "BFR training" and achieved using a pneumatic tourniquet system. Low intensity BFR training is a novel technique aims to reproduce the effects of a high intensity training and is desirably applicable to the individuals who cannot perform high intensity training during the phase of rehabilitation. In recent years, research has illustrated that augmentation of low load resistance training with blood flow restriction to the active musculature can produce significant hypertrophy and strength gains, using loads as low as 30% 1RM. This training has been found to yield hypertrophy responses comparable to that observed with heavy load resistance training. Low intensity BFR strength training may be a clinically relevant musculoskeletal rehabilitation tool as it does not require the high joint forces associated with heavy load exercise.[6, 7]

When a muscle is placed under mechanical stress, the concentration of anabolic hormone levels increase. The activation of myogenic stem cells and the elevated anabolic hormones result in protein metabolism and muscle hypertrophy occurs. Release of hormones, hypoxia and cell swelling occur when a muscle is under metabolic stress. These are the primary hypertrophy factors which result in mechanical tension there by activates myogenic stem cells, causes anabolic reaction leading to hypertrophy. In BFR training this hypoxic environment of high intensity exercise is recreated by a tourniquet cuff. Cuff is placed proximally to the muscle being exercised and low intensity exercises performed, results in anaerobic tissue response, increase in protons and lactic acid production, mechanical tension and metabolic stress. However, at present these are mainly hypothetical and theoretical based consortium. Expedient and specific identification of these proposed mechanisms, including their magnitude of involvement and actual source of activation in induced hypertrophy is currently lacking and requires further exploration. However, these findings have important implications for individuals who cannot tolerate the mechanical stress of heavy load exercise.[8, 10]

A systematic review and meta-analysis of peer reviewed literature examining BFR training in clinical MSK rehabilitation reported that: compared with low load training, low load BFR training is more effective, tolerable and therefore a potential clinical rehabilitation tool. There is a need for the evolution of an individualized approach to training recommendation to minimize patient risk and increase effectiveness. Low intensity BFR training is a novel technique aims to replicate the effects of a high intensity training and is desirably applicable to the individuals who cannot perform high intensity training during the phase of rehabilitation. This would be really beneficial to the group of people who cannot perform high intensity strengthening as a result of joint and muscular issues which limits them from mechanical stress and high joint forces associated with heavy load exercise. This technique will be a better aid during the strength and endurance rehabilitation of major joint and articular structures post-surgical phase. BFR training with safe protocols and monitoring will be always having an upper hand in rehabilitation as it provides an environment of low intensity energy demand from patient to provide a high intensity muscular effects.[6, 10, 11]

The effectiveness of BFR training in clinical rehabilitation remains unclear whether emerging research is informed by evidenced based guidelines of implementing this novel training method to ensure safety and validity of findings. Estimating the safe cuff pressure protocol, response to cardio vascular system, identifying the red flags and also estimating the exercise principles will be a key entity in designing a safer ambience for this training program. Current research recommend the use of BFR combined with different forms of exercise (resisted, aerobic, passive), considering the volume and intensity, as well as the amount of cuff pressure, restriction time, size and cuff material. Majority of studies do not report inauspicious events. Injury resulting from this type of training seems infrequent. Although muscle damage is common in BFR training and is necessary for training adaptations, the possible risks of rhabdomyolosis occurring during BFR training may be intensify in cases of muscular disuse atrophy. Rhabdomyolysis is a complex medical condition involving the swift dissolution of damaged or injured skeletal muscle. It is important that practitioners rule out possible causes of rhabdomyolosis, such as infections and prolonged immobilization before planning training, and include measures of muscle damage markers (serum creatine kinase) during the training period. The need for an individualized approach to BFR training when selecting cuff pressure for both safety and effectiveness is indispensable.[11, 12]

Effective implementation of BFR training depends on various factors such as age, gender, physical inactivity, occlusion pressure, and limb circumference. Despite evidence of the effectiveness and sufficiency of BFR training in a clinical setting, above mentioned factors must be considered during implementation. A recent technique has emerged whereby calculation of total arterial limb occlusive pressure (LOP) allows for selection of a pressure at a percentage of LOP to standardize the level of occlusion. The calculation (AOP = [SBP+10]/KTP) is made using initial SBP and tissue padding coefficient (KTP) values, in accordance with limb circumferences of the patient. After calculation of AOP, (TP) tourniquet pressure was determined by adding 20 mmHg to AOP (TP = AOP + 20 mm Hg) as a safety margin. 40% LOP produced similar increases in muscle size, strength and endurance after 8 weeks of training to that of 90% LOP but without the high ratings of discomfort that were reported with the high pressure. Lower and more tolerable pressures may elicit sufficient muscle adaptations while minimizing the risk of adverse effects and pain, highlighting the need for individualized prescription of clinical BFR training.[11, 12, 13]

Low load-BFR training is effective at improving physiological aspects aside from muscle strength and may even be used without exercise to prevent muscle atrophy in early immobilization. Moreover, addition of BFR to low load training does not appear to worsen condition or exercise related. LL-BFR training is a more effective substitute to low load training alone and may act as a deputy for heavy load training. BFR training can reduce the effects of sarcopenia and may be worthwhile at improving bone health. It may also be applicable for other populations who suffer from MSK weakness and degenerative disorders. In premature situations when individuals suffering from muscle weakness are not able to begin even low load exercise (postoperative immobilization), BFR alone can be used as an early rehabilitation intervention considering the hemodynamic stability.[11]

Nao Mills et al. in an attempt to assess the knowledge and use of blood flow restriction therapy in a sample of physical therapists in United States delineate that there were apparent gaps between physiotherapist's knowledge of BFRT and inclusion in practice, though most of these clinicians would be open to consider use of BFRT. Many would like to practice it, and would engage in professional development opportunities, as many cited lack of information or certification as leading reasons for not employing the technique. Nearly all practitioners believed it was efficacious and will continue using it. Interestingly, there reported some differences in age and gender with younger and male PTs more likely to have heard of and used BFRT. Incorporating BFRT in post PT programs could improve utilization of this technique and potentially improving clinical outcomes.[16] Research has demonstrated effective attenuation of muscle atrophy and muscle strength using an occlusion protocol even at a low pressure of 50 mmHg, suggesting that BFR intrinsically is effective at minimizing atrophy.[11] Thus, LL-BFR training may be used as a progressive clinical rehabilitation tool in the process of return to heavy load exercise.

BFR may facilitate early engagement in low load strength training with limited joint stress in a broad range of clinical populations. Effective training for BFR knowledge and practice as well as an extensive research exploration in the field of metabolic changes and the standardized protocol is lacking: therefore, its use in clinical rehabilitation warrants further study. As discussed above, future research should embrace an individualized and progressive approach to facilitate the effectiveness and safety of BFR training. Knowledge and pedagogy of this technique should be standardized with effective protocol and guidelines in an evidence based environment.

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