Occlusion Training Increases Strength and Hypertrophy in Collegiate Male Collision Sport Athletes

Alimenti AN[1], Fisher ET[1], Cacolice PA[2]
[1]Undergraduate student, [2]Instructor, Department of Athletic Training, Duquesne University, Pittsburgh, PA

Duquesne University Athletic Training
Rangos School of Health Sciences

CLINICAL SCENARIO

In collision sports such as football and rugby, muscle strength and hypertrophy are essential for player safety. Historically, strength and hypertrophic gains have been achieved with resistance training. Vascular occlusion or blood flow restriction (BFR) with resistance training has been hypothesized to augment increases in strength and hypertrophy.[1,2,3,4,5] It has even been suggested that the use of BFR and resistance training will allow for strength and hypertrophy gains with greatly reduced initial resistances.[1,2,3,4,5] If this is accurate, BFR and resistance training could allow for rapid strength and hypertrophic gains in a weakened state, such as during rehabilitation from an injury.

PURPOSE

To determine the effect of BFR exercises to increase strength and hypertrophy in collegiate male collision sport athletes compared to unrestricted exercises.

METHODS

Search Strategy
Terms Used to Guide Research
Patient/Client Group: College AND Athlete
Intervention: Vascular Occlusion OR Blood Flow Restricted Training
Comparison: No Intervention AND Control
Outcomes: Increased Muscle Strength AND Hypertrophy
(College AND Athlete) AND (Vascular Occlusion OR Blood Flow Restricted Training) AND (No Intervention AND Control) AND (Increased Muscle Strength OR Hypertrophy)

Sources of Evidence searched
- PubMed
- PEDro Database
- CINAHL
- Sport Discus
- Additional resources obtained via review of references lists and hand search

Inclusion and Exclusion Criteria
Inclusion
- Male only
- Collision Sport
- Level 3 evidence or higher
- Limited to the last 12 years (2002-2014)
- Limited to the English language
- Limited to humans

Exclusion
- Non-contact sports
- Female sample

RESULTS

Five relevant studies were located with our PICO search. Four studies met our inclusion and categorized as shown in Table 1. One additional study investigating occlusion training and serum chemistry was located but not included in this Critically Appraised Topic (CAT) because it did not measure muscle strength or hypertrophic changes.

DISCUSSION AND CONCLUSIONS

Four studies met our inclusion criteria and were reviewed for this CAT. All four investigations demonstrated that a significant increase in muscle strength or hypertrophy occurred with BFR and training. These findings indicate in general, BFR is an effective augmentation to traditional resistance training regimens once risk of thrombosis has been fully explored and minimized.[1,3,4,5]

These results were achieved with the implementation of cuffs or wraps that prevented venous return in the limb. It is suggested that only 50-100 mmHg of pressure is needed to prevent venous return.[5] In a clinical setting, sphygmomanometer cuffs may be utilized to assure proper pressure is applied. Common lifting wraps or commercial BFR straps can be used for a more practical application in the weight room.[3]

Based upon these findings, clinicians could select BFR as an adjunct to a healthy athlete's resistance training plan. In addition, BFR augmentation was shown to be beneficial even when using only a limited amount of resistance.[2,3,4] Benefits were seen with as little as 20-50% of the athlete's single repetition maximal limit (1RM) for a specific activity.[3,4,5] These findings may indicate that an individual can utilize BFR even when they are unable to train at their normal intensity due to injury or fatigue.

Three studies showed an increase in bench press and squat 1RM.[1,3,5] In one of these studies only the lower limbs were occluded during training and bench press still showed a significant increase after the training.[1] This suggests that there may be a systemic effect of BFR as well.[1] In fact, Fujita et al noted an increase in blood lactate, cortisol, and growth hormone following BFR training.[2] This activation appears to be responsible for an eventual increase in muscle protein synthesis.[2]

Future research should investigate effects occlusion / BFR may have on the healing rate of specific tissue injuries such as sprains, strains and fractures. Occlusion training may impact how the metabolites collect in ligamentous, muscular or skeletal tissues. The BFR could lead to greater nourishment being released to the area following occlusion.

In addition, the optimal pressure range of the occlusion during training remains unclear from the literature. The clinician would benefit from research to determine this range. Finally, this CAT should be reviewed in two years to determine whether additional best evidence has been published that may change the analysis for this specific clinical question.

REFERENCES

1. Cook CJ, Kilduff LP, Beaven CM. Improving Strength and Power in Trained Athletes With 3 Weeks of Occlusion Training. *Int J Sports Physiol Perform* 2014;9(1):166-172.
2. Fujita S, Abe T, Drummond MJ, et al. Blood flow restriction during low-intensity resistance exercise increases S6K1 phosphorylation and muscle protein synthesis. *J Appl Physiol* 2007;103(3):903-910.
3. Luebbers PE, Fry AC, Kriley LM, Butler MS. The Effects of a Seven-week Practical Blood Flow Restriction Program on Well-trained Collegiate Athletes. *J Strength Cond Res* 2014;28(8):2270-2280.
4. Takarada Y, Sato Y, Ishii N. Effects of resistance exercise combined with vascular occlusion on muscle function in athletes. *Eur J Appl Physiol* 2002;86(4):308-314.
5. Yamanaka T, Farley RS, Caputo JL. Occlusion training increases muscular strength in division IA football players. *J Strength Cond Res* 2012;26(9):2523–2529.

Table 1 - Characteristics of Included Studies

	Cook et al (2014) **Case Control**	**Luebbers et al (2014)** **Cohort**	**Takarada et al (2002)** **Cohort**	**Yamanaka et al (2012)** **Cohort**
Participants	Twenty, male semiprofessional rugby union athletes (Age: 21.5±1.4 years, Height: 1.84±0.05 m, Mass: 95.6±10.4 kg) participated.	Sixty-two, male collegiate American football players (Age: 20.3±1.1 years, Mass: 99.1± 19.7kg, and 7.1±2.2 years of weight training experience) participated.	A group of 17 young male rugby players participated (Trained group: Age: 25.9± 0.6 years, n=12. Untrained control: Age: 25.4 ±0.8 years, n=5).	The subjects were 32 NCAA Division IA football athletes (Age: 19.2±1.8 years).
Intervention	Performed 3 exercises (leg squat, bench press, and weighted pull up) at 70% of their 1-RM. 5 sets of 5 repetitions. Lower limb blood flow was restricted with an occlusion cuff inflated to 180 mmHg worn bilaterally at most proximal portion of the thigh during all exercises. It was only inflated during the exercise and deflated during the rest periods.	Four groups completed a 4 time per week, 7-week traditional upper- and lower-body split strength program. Group 1: high-intensity training and supplemental training both with BFR. Group 2: high-intensity training and supplemental training without BFR for either. Group 3: High-intensity training only with no BFR. Group 4: Modified training, supplemental training, both with BFR. The supplemental training consisted of bench press and squat activities using only 20% 1RM.	50% of 1RM exercise combined with an occlusion pressure of about 200 mmHg, low intensity exercise without the occlusion, and no exercise training (untrained control) were included. Bilateral knee extension was performed in a seated position using an isotonic leg extension machine.	The athletes performed 4 sets of bench press and squat in the following manner with or without occlusion: 30 repetitions of 20% predetermined 1RM, followed by 3 sets of 20 repetitions at 20% 1RM of the same exercises. Each set was separated by 45 second rest periods. The training duration was 3 times per week for 4 weeks, after the completion of regular off-season strength training.
Outcome Measures	Primary outcomes: Pre and post test for 1RM bench press, 1RM leg squat, maximal sprint time, countermovement jump power, salivary hormone concentrations Secondary outcomes: Subject compliance	Primary outcomes: Pre and post test for 1RM bench press, 1RM leg squat, and girth measurements Secondary outcomes: Subject compliance	Primary outcomes: Pre and post test measurements of muscle strength and endurance of knee extensor muscles Secondary outcomes: Subject compliance	Primary outcomes: Pre and post test for 1RM bench press, 1RM leg squat, and upper/lower body girth measurements and body mass Secondary outcomes: Subject compliance
Main Findings	Over the 8-week preseason period, mean improvements were observed in bench press (8.6±5.8 kg) and leg squat (12.0±6.7 kg). When the two training interventions were compared, occlusion resulted in significantly greater improvements in bench press (P= .004; 1.4%±0.8%), squat (P< .001: 2.0%±0.6%), maximal-sprint time (P= .016; 0.4%±0.3%), and countermovement-jump power (P< .001; 1.8%±0.7%).	Follow up univariate ANOVA indicated a significant difference for 1RM squat in the group that completed high-intensity training and supplemental training with BFR. 1RM Bench press, arm and thigh circumference also increased but were not significant when detected by the ANOVA.	The occluded group showed a significantly larger increase in isokinetic knee extension torque than that in the other two groups (P< 0.05) at all the velocities studied. The cross-sectional area of knee extensors increased significantly as well, suggesting that the increase in knee extension strength was mainly caused by muscle hypertrophy. The dynamic endurance of knee extensors estimated from the decreases in mechanical work production and peak force was also improved.	The increases in bench press and squat 1RM (7.0 and 8.0%, respectively), upper and lower chest girths (3% and 3%, respectively), and left upper arm girth were significantly greater in the experimental group.
Level of Evidence / Validity	Level 3b. Validity: N/A	Level 2b. Validity: N/A	Level 2b. Validity: N/A	Level 2b. Validity: N/A
Conclusion	Bilateral lower-limb BFR training with a moderate load produced significant benefits compared with non-occluded training and thus can be considered an effective training stimulus capable of eliciting functional improvements in well-trained athletes.	This study demonstrated that the use of a practical BFR program in conjunction with a traditional high-intensity off-season training program was effective in increasing 1RM squat performance in well-trained collegiate athletes.	Low-intensity resistance exercise combined with vascular occlusion caused, in almost fully trained athletes, increases in muscle size, strength and endurance. Neural, hormonal and metabolic factors would have been involved in the combined effects.	Occlusion training could provide additional benefits to traditional strength training to improve muscular hypertrophy and muscular strength in collegiate athletes.