CESPU
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Comparative Effects of Blood Flow Restriction and Traditional Strength Training on Proximal Shoulder Musculature: A Randomized Clinical Trial

Approved by the ethics committee of Instituto Politécnico de Saúde do Norte (31/CE-IPSN/2024).

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STUDY OBJECTIVES

This study compared a 4-week blood-flow–restriction (BFR) resistance-training program performed at 30% of one-repetition maximum (1RM) with traditional high-load strength training at 70% of 1RM on shoulder muscle strength, power, endurance, and hypertrophy in healthy adults.

STUDY DESIGN

Parallel-group randomized controlled trial with two intervention arms: an experimental BFR group (n = 12; 3 men, 9 women) and an active comparator high-load group (n = 11; 3 men, 8 women; one dropout). All participants provided written informed consent in accordance with the Declaration of Helsinki.

PARTICIPANTS AND RECRUITMENT

Healthy volunteers were recruited via social media, discussion groups, and physical postings at CESPU facilities. Individuals of both sexes were eligible because prior work indicates comparable metabolic responses to BFR across genders. Eligibility was screened using an online questionnaire covering demographics, sport participation, and medical history. Eligible respondents were contacted by email to schedule baseline testing.

Eligibility Criteria

Inclusion criteria

- Age 18–40 years
- Body mass index (BMI) 18.5–30 kg/m² (individuals with obesity are commonly excluded due to higher cardiovascular, respiratory, and rheumatologic risk)

Exclusion criteria

- Participation in sports that heavily use the dominant arm (e.g., tennis, volleyball, handball)
- Current upper-limb strength training
- History of trauma or surgery involving the dominant upper limb

- Acute or chronic shoulder pain or radiating pain
- Cervical disc herniation or prior cervical surgery
- Upper-limb edema
- History of deep-vein thrombosis or oncologic/metabolic disease
- Pregnancy
- Persistent symptoms during training: numbness, tingling, or pain >7/10 on a numeric rating scale (BFR group criterion)
- Missing more than one training session

Randomization was performed with Sealed Envelope™.

METHODS

Before data collection, the research team completed a familiarization phase to standardize equipment use, test administration, training procedures, and safety protocols. Responsibilities were assigned to specific team members, and minor adjustments were implemented as needed to ensure consistency and measurement accuracy.

Outcome assessments were performed after a standardized warm-up and always in the same sequence: Arm Circumference, Single-Arm Seated Shot-Put Test, Vertical Lift Strength, and Shoulder Endurance Test. Measurements were obtained at baseline (M0) and at least 24 h after the final training session (M1). Participants were instructed to avoid strenuous upper-limb activity for 24 h before testing.

Data-Collection Procedures

Arm Circumference: Circumference at the axillary level of the dominant arm was used as a proxy for deltoid muscle mass. With the participant at rest, three measurements were taken using a standard tape; the mean value was analyzed.

Single-Arm Seated Shot-Put Test (SASSPT): To assess shoulder power and upper-limb function, participants sat with trunk and shoulders against a wall, lower limbs extended, and the non-tested arm resting on the ipsilateral thigh to minimize compensation. Using a 4-kg medicine ball, participants performed maximal throws. Distances were recorded using floor tape; throws were video recorded to confirm first contact points. Three trials were performed; the mean distance was analyzed.

Vertical Lift Strength. Isometric strength for a vertical-lift task was measured with the Smart Groin Trainer (NeuroExcellence, Braga, Portugal). Participants were seated with the shoulder at 60° abduction and the elbow flexed; force was applied in the direction of vertical arm elevation. Three trials were performed; the best value was analyzed.

Shoulder Endurance. The Shoulder Endurance Test (SET) was used for its controlled cadence. Participants stood with their back against a wall, the contralateral heel touching the wall, and the ipsilateral leg positioned forward. The movement consisted of shoulder abduction to 90° with external rotation to 90° while touching the wall. Resistance was provided by a red elastic band; the hand-to-anchor distance was fixed at 1 m. A metronome guided cadence, starting at 60 bpm and increasing by 30 bpm every 20 s up to 150 bpm. The test ended when cadence or movement quality could not be maintained. Time to termination (seconds) was recorded.

Training Protocol

The intervention lasted 4 weeks with two sessions per week. Each session began with a warm-up including shoulder and upper-limb mobility and stretching. During the first session, 1RM for each exercise was estimated using a repetition-to-failure approach with appropriate coefficients.

Three shoulder-focused exercises were prescribed:

- Standing shoulder abduction to 90°, then return to start.

- Seated dumbbell overhead press with back support (from shoulder level to full overhead and return).

- External rotation performed lying on a bench with the upper arm against the torso and the elbow flexed at 90°.

High-load strength training group: Training followed ACSM hypertrophy guidelines at 70% 1RM. For each exercise, participants completed four sets of 8–10 repetitions with 2-min rests between sets and exercises. Tempo was moderate (1 s concentric, 2 s eccentric).

Low-load strength training with BFR group: Exercises were performed at 30% 1RM. Each exercise totaled 75 repetitions across four sets (30/15/15/15) with 30-s inter set rests. Tempo was 2 s concentric and 2 s eccentric.

BFR Application

BFR was delivered using SmartCuffs® 3.0 PRO (Smart Tools Plus). At each session start, the device determined arterial occlusion pressure, and cuffs were set to 50% limb occlusion pressure. With participants seated, a 7-cm cuff was placed directly on the skin (or over a thin T-shirt) at the most proximal portion of the dominant arm (just distal to the deltoid insertion). Pressure was maintained during each exercise, released for 60 s between exercises, and reapplied for the next exercise. Participants rated pain, tingling, and numbness on a 0–10 numeric rating scale; symptoms >7/10 prompted protocol adjustment or session cancellation.

Each training session lasted approximately 45 minutes in both groups. Participants were asked to maintain their usual physical-activity levels throughout the study.

STATISTICAL ANALYSIS

Analyses were performed in SPSS version 29.0 (SPSS Inc., Chicago, IL, USA). Quantitative variables are presented as mean ± SD or median (interquartile range), as appropriate. Between-group comparisons used Fisher's exact test, the Mann–Whitney U test, or independent-samples t tests. Within-group pre- to post-changes were evaluated with paired-samples t tests. For significant outcomes, Cohen's d was calculated and interpreted as: very small, $0.01 < d \leq 0.20$; small, $0.20 < d \leq 0.50$; moderate, $0.50 < d \leq 0.80$; large, $0.80 < d \leq 1.20$; very large, $1.20 < d \leq 2.00$; and huge, $d > 2.00$. Statistical significance was set at $p < 0.05$.