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Blood flow restricted resistance training in older adults at risk of mobility limitations☆

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ABSTRACT

High-load resistance training (HL) may be contraindicated in older adults due to pre-existing health conditions (e.g. osteoarthritis). Low-load blood flow restricted (BFR) resistance training offers an alternative to HL with potentially similar strength improvement.

Purpose: To compare muscle strength, cross-sectional area (CSA), physical function, and quality of life (QOL) following 12-weeks of HL or BFR training in older adults at risk of mobility limitations.

Methods: Thirty-six males and females (mean: 75.6 years 95% confidence interval: [73.4–78.5], 1.67 m [1.64–1.70], 74.3 kg [69.8–78.8]) were randomly assigned to HL (70% of one repetition maximum [1-RM]) or low-load BFR (30% 1-RM coupled with a vascular restriction) exercise for the knee extensors and flexors twice per week for 12 weeks. A control (CON) group performed light upper body resistance and flexibility training. Muscle strength, CSA of the quadriceps, 400-m walking speed, Short Physical Performance Battery (SPPB), and QOL were assessed before, midway and after training.

Results: Within 6-weeks of HL training, increases in all strength measures and CSA were evident and the gains were significantly greater than the CON group ($P < 0.05$). The BFR group had strength increases in leg extension and leg press 1-RM tests, but were significantly lower in leg extension isometric maximum voluntary contraction (MVC) and leg extension 1-RM than the HL group ($P < 0.01$). At 12-weeks HL and BFR training did not differ in MVC ($P = 0.14$). Walking speed increased 4% among all training groups ($P < 0.01$) and no changes were observed for overall SPPB score and QOL ($P > 0.05$).

Conclusion: Both training programs resulted in muscle CSA improvements and HL training had more pronounced strength gains than BFR training after 6-weeks and were more similar to BFR after 12-weeks of training. These changes in both groups did not transfer to improvements in QOL, SPPB, and walking speed. Since both programs result in strength and CSA gains, albeit at different rates, future research should consider using a combination of HL and BFR training in older adults with profound muscle weakness and mobility limitations.

1. Introduction

Sarcopenia is the age-related loss of muscle mass and strength that places older adults at increased risk of many adverse outcomes (Studenski et al., 2014). For example, low knee extensor muscle strength is a predictor of poor physical function, disability, hospitalization and mortality (Kim et al., 2012; Legrand et al., 2014; Liu and Latham, 2011; Manini et al., 2007b), which in turn are closely related to lower quality of life (QOL) (Fusco et al., 2012). The premise of many physical activity programs for older adults is to improve muscle strength and size using resistance exercise with the goal of transferring these gains to physical function and enhanced QOL. While the relationship between strength and physical function tends to be linear and most robust for weak older adults, greater muscle strength is not always associated with better function for those on the high end of the strength spectrum (Cress and Meyer, 2003; Manini et al., 2007b). Resistance exercise may therefore be most efficacious for older adults with muscle weakness who are at risk of mobility limitation and disability.

It is recommended that older adults perform high-load (HL) resistance training at 60–80% of their maximum strength at least two days per week (Garber et al., 2011) and it is well documented that

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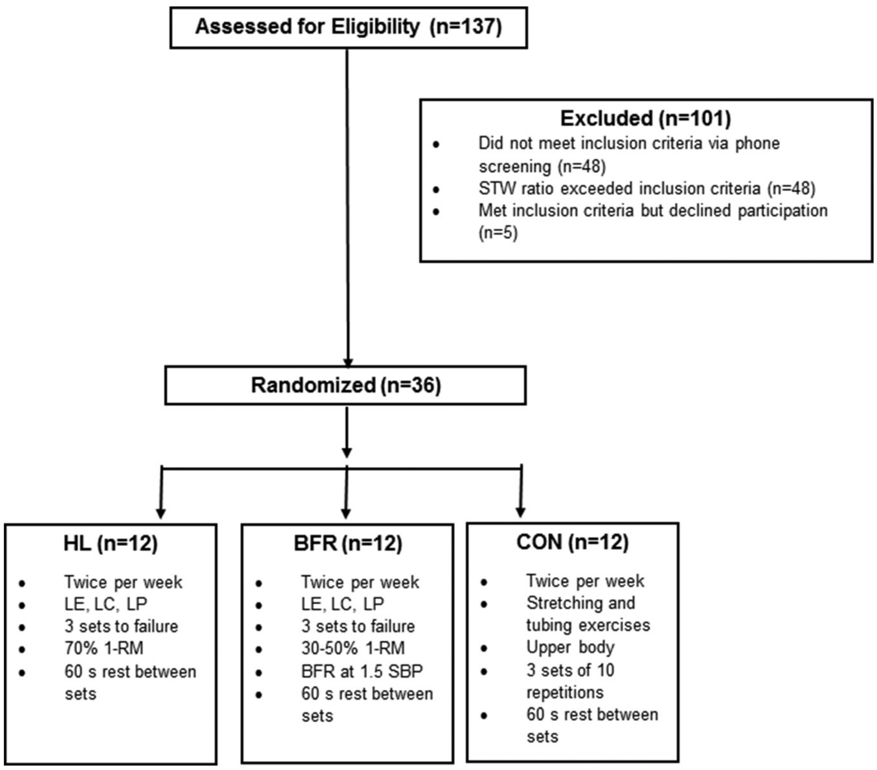

Fig. 1. Schematic of study recruitment and intervention allocation. HL: high-load; BFR: blood flow restricted; CON: control; STW: Strength-to-weight; LE: leg extension, LC: leg curl; LP: leg press; SBP: systolic blood pressure.

this regimen increases muscle strength and hypertrophy (Peterson et al., 2010). However, resistance loads of 60–80% of one repetition maximum (1-RM) may be challenging for older people with profound muscle weakness, joint pathologies, neuromuscular disorders, or those undergoing medical treatments that limit physical capacity. Within the last two decades, resistance training at low-loads (~20–30% 1-RM) with blood flow restriction (BFR) to the exercising muscle has been shown to improve muscle strength and size to a similar magnitude as HL training (Karabulut et al., 2010; Kubo et al., 2006; Laurentino et al., 2012). Since BFR resistance training puts less mechanical stress on joints than HL training and increases strength and hypertrophy similarly, it could be an adjunct therapy for older individuals with muscle weakness, arthritis, and other orthopedic comorbidities. If older adults gain muscle strength and mass as a result of BFR exercise, these adaptations may improve physical function and QOL in a segment of the population who are otherwise unable to benefit from resistance exercise.

Currently, there are only a few studies directly comparing muscle adaptations of BFR to HL resistance training in older adults (Karabulut et al., 2010; Vechin et al., 2015), and neither of these studies included individuals with existing muscle weakness. Additionally, the transfer of muscular adaptations to physical function in older adults is inconsistent as some studies demonstrate enhanced physical function following resistance training (Capodaglio et al., 2007; Correa et al., 2016; Cress et al., 1999; Fiatarone et al., 1994) and others do not (Manini et al., 2007a; Vasconcelos et al., 2016). Therefore, the purpose of this study was to compare the effects of 12-weeks of HL and BFR training on lower extremity strength, hypertrophy, physical function, and QOL in older adults who were at risk of mobility limitations due to muscle weakness. It was hypothesized that HL and BFR training programs would improve muscle strength, cross-sectional area (CSA) of the quadriceps, walking speed, Short Physical Performance Battery (SPPB) and QOL equally and to a greater extent than a control program.

2. Methods

2.1. Experimental design

A between groups repeated measures design was used to assess muscle strength, CSA and physical function of older adults classified as being weak and at risk of mobility limitations before, midway, and after 12-weeks of an exercise intervention. A stratified randomization approach was used to place participants by age (65–75 years and 75 + years) and sex into one of three exercise intervention groups: HL resistance training for the legs, BFR resistance training for the legs, or upper body stretching and light resistance training that served as an attention control group (CON).

2.2. Subject recruitment and participant descriptions

Community dwelling males and females ≥ 65 years old were recruited via newspaper advertisements, mailings and local presentations. Potential participants (137 individuals; Fig. 1) underwent a telephone screening to determine their eligibility for the study. Individuals were eligible to participate in a strength screening following the telephone interview if they had a self-reported body mass index < 30 $kg \cdot m^{-2}$, did not engage in resistance training within the last six months, and did not self-report uncontrolled hypertension (> 150/90 mmHg), the presence of neuromuscular disease, a terminal disease, myocardial infarction in the past 6 months, unstable cardiovascular disease or a fracture within the last 6 months. Older adults that met these criteria (89 individuals) were then invited to participate in a muscle strength screening session at the laboratory. In this screening, individuals signed an informed consent, had their height and body mass measured and the Mini-Mental State Exam (MMSE) was administered. If the individuals obtained a MMSE score ≥ 24 and their body mass index was < 30 $kg \cdot m^{-2}$, their muscle strength was tested using an isokinetic dynamometer (HUMAC NORM, CSMI, Stoughton, MA) integrated with a data aquisition system (MP100, Biopac Systems, Inc., Goleta, CA). Six