COMPARISON OF CENTRAL HEMODYNAMICS AND ARTERIAL STIFFNESS RESPONSES TO ACUTE RESISTANCE EXERCISE WITH AND WITHOUT BLOOD FLOW RESTRICTION IN YOUNG AND OLDER ADULTS: A PARALLEL GROUP CROSSOVER RANDOMIZED TRIAL

Ivan Tadeu[1], Carlos Oliveira[1], Guilherme Ornelas[1], Miguel Gonçalves[1], Nuno Fernandes[1], Guilherme Sampaio[1], Sérgio Laranjo[2], Bo Fernhall[3], João Marôco[3], Xavier Melo[1]

[1] CiiEM Egas Moniz School of Health and Science, Almada, PT; [2]Department of Physiology, NOVA Medical School | Faculdade de Ciências Médicas da Universidade Nova de Lisboa, Lisboa, PT; [3]Integrative Human Physiology Laboratory, Manning College of Nursing & Health Sciences, University of Massachusetts Boston, Boston, USA

INTRODUCTION

Aging is characterized by progressive arterial stiffening—reflected in elevated aortic pulse wave velocity (aPWV)—and increased wave reflection, measured by augmentation index (Aix). These hemodynamic changes elevate central blood pressure in arteries such as the aorta and carotid, increasing mechanical load on vital organs like the heart and brain. As arterial compliance declines with age—due to reduced wall distensibility and endothelial dysfunction—vascular function becomes compromised. This deterioration is associated not only with cardiovascular disease but also with neurodegeneration, reduced muscle strength, and increased fatigue.

After age 50, the loss of type II muscle fibers contributes to irreversible muscle atrophy and strength decline, which may be partly vascularly mediated. While high-intensity resistance training (HIRT, 60–80%1RM) benefits musculoskeletal health, its vascular effects in older adults remain debated. Low-intensity resistance training (LIRT, 40–50%1RM), often preferred due to comorbidities, can be enhanced with blood flow restriction (BFR), although BFR may acutely impair vascular responses.

AIM

This study compared the acute effects of HIRT and LIRT+BFR on arterial stiffness and central and peripheral hemodynamic in young versus older adults.

STUDY DESIGN

This is parallel-group crossover randomized trial enrolling 21 young (18-25 y) and 20 older adults (>60 y). Exclusion criteria included a history of major cardiovascular, metabolic, or chronic diseases, active smoking, or physical impairments affecting exercise tolerance. Highly active individuals (>1,000 MET-min/week) were also excluded.

Participants attended 3 sessions (≥1 week apart, Figure 1):

- Visit 1 (Familiarization): Anthropometrics, vascular baseline assessments (Vicorder®), and 1RM determination for leg press/knee extension.
- Visits 2–3 (Interventions): Randomized LIRT+BFR or HIRT (30 min) preceded by 15-min supine rest and followed by 60-min recovery.

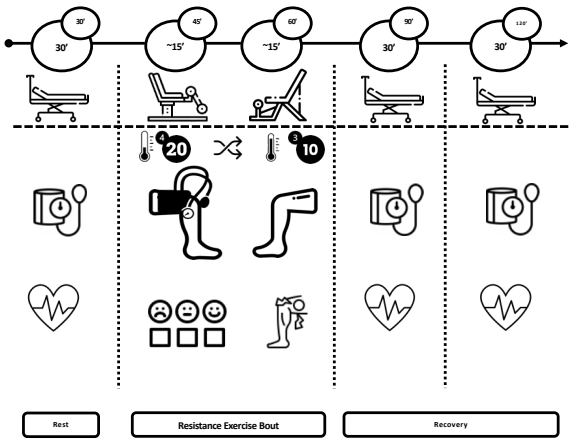

Figure 1: Study design

EXPERIMENTAL CONDITIONS

Participants completed two exercise conditions: HIRT (75% 1-RM, 3×10 reps, 2-min rests) and LIRT+BFR (30% 1-RM, 4×20 reps, 30-sec rests, continuous BFR at 1.3× ankle systolic pressure). Both protocols targeted bilateral leg press and knee extension, with session duration standardized to ~30 minutes. BFR was applied using 5×75 cm cuffs (Occlusion Cuff Pro®, Occlusion Cuff LLC, 2024), positioned proximally on each thigh and monitored via perceived exertion (RPE) and discomfort (RPD; session terminated if RPD ≥7). Adverse events were tracked throughout. Protocols were adapted from prior studies (Fahs et al., 2014; Ozaki et al., 2013; Horiuchi et al., 2023).

DATA COLECTION

aPWV was measured via Vicorder® (Figure 2), and Aix and aortic systolic blood pressure (aSBP) were derived from its Pulse Wave Analysis function at baseline, 5-min, and 30-min post-exercise.

Trial registration: NCT06596304; Ethics approval: CEIEM 1428/2024.

RESULTS

Two withdrawals occurred (1 older adult - personal reasons; 1 young adult - GERD symptoms during HIRT). Two young adults experienced transient vasovagal episodes during LIRT+BFR (possibly fasting-related), prompting session termination. Both recovered immediately and completed the study subsequently.

Physical activity patterns nor BMI classifications differed between groups. Still, older adults showed significantly higher baseline values in aSBP (+27.7 mmHg), and braquial SBP (bSBP; +21.3 mmHg), aPP (+16.9 mmHg), Aix (+9.4%), and aPWV (+1.4 m/s) compared to young adults (all p<0.001), confirming age-related vascular dysfunction.

Table 1: Participant's characteristics

Variable	Unit	YOUNG	OLD	p-value
SEX	(M/F)	11/9	11/10	>0.999
AGE	Years	21.76 (2.74)	70.15 (9.14)	<0.001
BMI	Kg/m2	22.16 (3.45)	25.85 (3.04)	<0.001
Physical Activity	MET-Min-Wk	602.10 (364.79)	1,372.45 (1,764.19)	0.070

Older adults showed significantly lower 1RM strength and higher ankle systolic BP (reflecting age-related vascular changes). BFR cuff pressures were marginally lower in older adults (p=0.052), though both groups reported similar exertion/discomfort levels during testing.

Table 2: Muscle strength, blood pressure pressure, and perceptions between age groups

Variable	Unit	YOUNG	OLD	p-value
LEG CURL 1RM	kg	51.78 (13.86)	38.65 (13.85)	0.008
LEG EXTENSION 1RM	kg	96.24 (25.11)	66.04 (33.16)	0.004
ANKLE SBP	mmHg	150.50 (16.47)	166.06 (15.50)	0.006
CUFF PRESSURE	mmHg	195.65 (21.41)	182.66 (17.05)	0.052
PSE	1-10	6.96 (1.52)	6.52 (1.40)	0.431
DISCOMFORT	1-10	6.55 (1.89)	6.37 (1.59)	0.781

Significant GROUP×TIME×CONDITION interactions were found for aSBP ($F(4,309)=5.09$, $p<0.001$, $\omega^2=0.05$; Figure 3), bSBP ($F(4,309)=2.45$, $p=0.046$, $\omega^2=0.02$), and aPP ($F(4,309)=6.35$, $p<0.001$, $\omega^2=0.06$). In older adults, HIRT acutely reduced aSBP (−9.8 mmHg) but led to a rebound above baseline at 30 minutes (+13.5 mmHg, both $p<0.001$). Similar biphasic responses were observed for bSBP (+8.5 mmHg) and aPP (+11 mmHg). LIRT+BFR elicited minimal changes in aSBP, bSBP, and aPP (Δ<5.4 mmHg, all $p>0.05$), with only a delayed aPP increase (+5.2 mmHg, $p=0.02$). No significant interactions were observed for aPWV ($F(3.0, 234.3)=1.39$, $p=0.245$) or aAix ($F(3.1, 238.1)=0.70$, $p=0.557$), regardless of group. Sex did not influence any of the results.

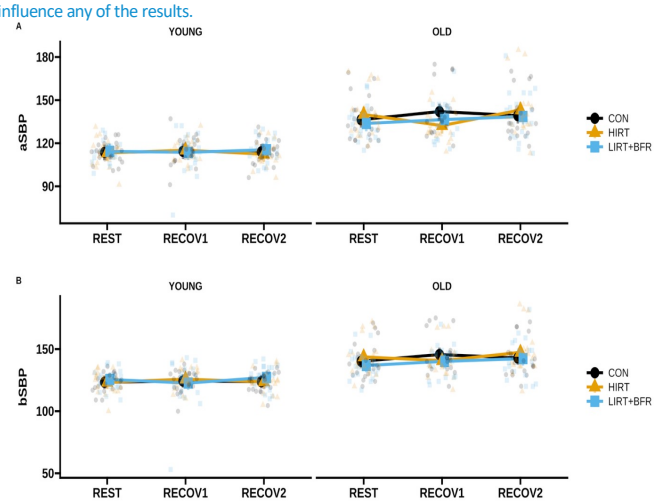

Figure 3: Changes in aSBP and bSBP from rest to recovery across conditions and age groups

CONCLUSION

Older adults demonstrated greater baseline vascular impairment and more pronounced post-exercise hemodynamic responses, particularly following HIRT, which induced transient elevations in central pressures.

LIRT+BFR did not acutely worsen arterial stiffness or central hemodynamics, supporting its short-term vascular safety.

However, due to potential discomfort from cuff pressure, BFR protocols should be carefully individualized and closely monitored in older populations to ensure tolerability and safety.

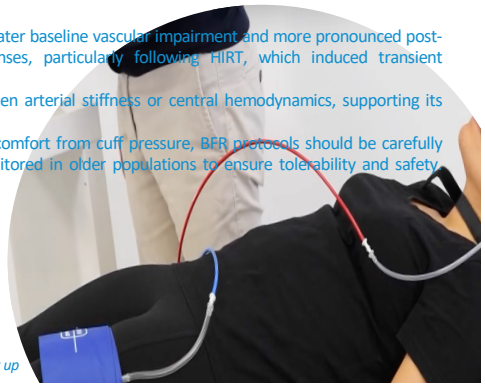

Figure 2: aPWV set up