Blood flow restriction and electric muscle stimulation during 14-day unilateral limb immobilization does not protect against macrovascular structural and functional changes

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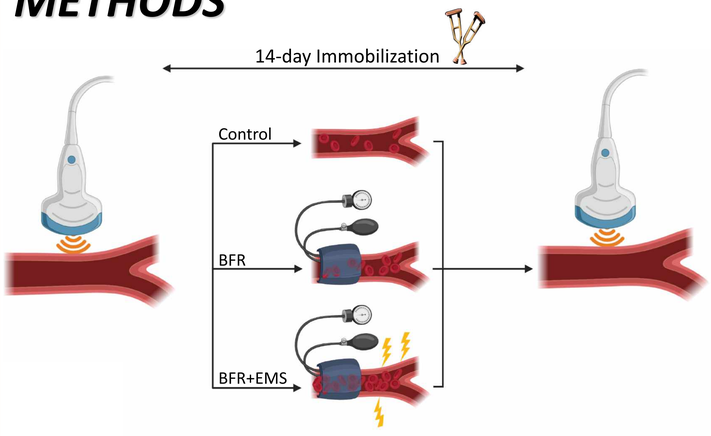
BACKGROUND

- Limb disuse or injury requiring immobilization cause a series of impairments to the affected macrovasculature.
- Macrovascular health is critical for athletes and patients alike, to support a quicker rate of recovery following injury.
- Shear-stress is known to modulate vascular function acutely.
- Thus, feasible shear-inducing interventions could help to maintain vascular health during immobilization.
- Blood flow restriction (BFR) and electrical muscle stimulation (EMS) are two passive modalities that can increase vascular shear-stress.
- **Purpose**: To investigate the effects of BFR+EMS during immobilization on macrovascular structure and function.

METHODS



- Participants allocated to Control, BFR or BFR+EMS groups
- Left leg immobilized in all participants for 14 days
- BFR and BFR+EMS left legs underwent intervention 2x/d (20 sessions)
- Superficial femoral artery diameter and flow-mediated dilation (FMD) measured pre and post

BFR: 3x5 min occlusion **BFR+EMS**: 3x5 min occlusion + 60Hz 15% MVC

Blood Flow Restriction

Electric Muscle Stimulator

RESULTS

Table 1: Participant characteristics.

	Control	BFR	BFR+EMS
n (M/F)	10 (6/4)	10 (4/6)	11 (4/7)
Age (yr)	25.2±5.3 *	20.8±1.3	21.2±1.3
Height (cm)	171.9±8.8	167.9±7.2	168.2±9.8
BMI (kg·m^{-2})	24.2±3.7	23.3±3.6	23.1±2.5
MAP (mmHg)	84.2±6	81.1±10	83.0±7
Resting HR (bpm)	61±10	67±13	64±10

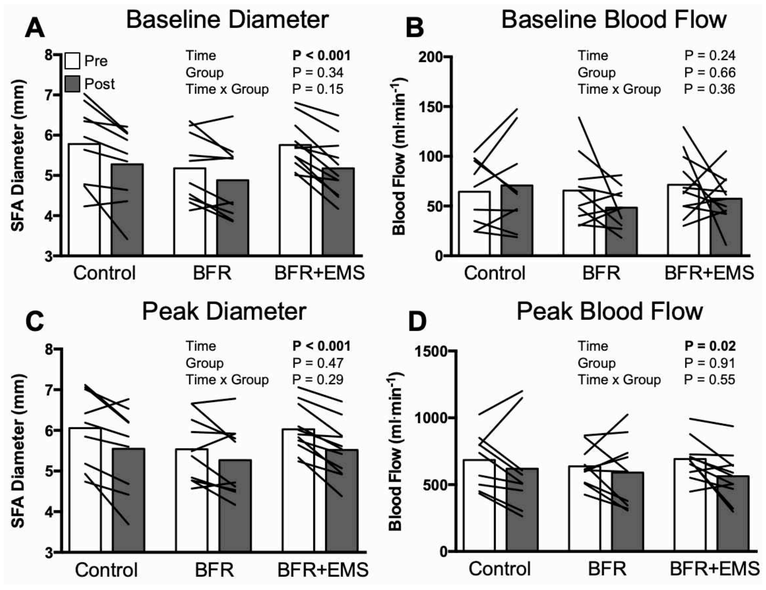


Figure 1: Baseline and peak values of immobilized limb superficial femoral artery diameter (A, C) and blood flow (B,D) measured at pre- and post- 14-day intervention phase. n=30 total. Bars represent group means and lines show individual data.

MAIN FINDINGS

- SFA baseline and peak diameter following immobilization were reduced 0.46±0.36mm
- Peak, not baseline blood flow following reactive hyperemia was reduced
- Multiple FMD indices were unchanged, independent of intervention group
- Immobilization resulted in less negative blood velocity
- Control group time-to-peak diameter trended towards a reduction relative to intervention groups

Table 2: Reactive hyperemic and baseline hemodynamic variables in the immobilized limb pre and post intervention.

	Control		BFR		BFR+EMS		*Time*	*Group*	*Time x Group*
	Pre	Post	Pre	Post	Pre	Post			
SR_{60AUC} (AU)	3060±915	3751±1367	4076±1543	4017±1102	2803±734	3614±824	**0.01**	0.16	0.097
Baseline Positive Blood Velocity (cm·s^{-1})	17.3±3.0	17.5±3.1	22.4±5.5	18.9±5.1	19.1±3.8	17.3±2.5	0.067	0.071	0.3
Baseline Negative Blood Velocity (cm·s^{-1})	-9.7±2.9	-7.3±3.2	-11.1±2.3	-9.8±4.1	-9.9±2.7	-8.1±2.6	**0.01**	0.2	0.8
Time-to-peak diameter (s)	90.3±74	55.7±18	61.5±25	53.4±24	106.1±59	89.5±67	0.12	0.7	0.056

Data represented as Mean±SD. SR_{60AUC}; Shear rate area-under-curve during 60s of reactive hyperemia.

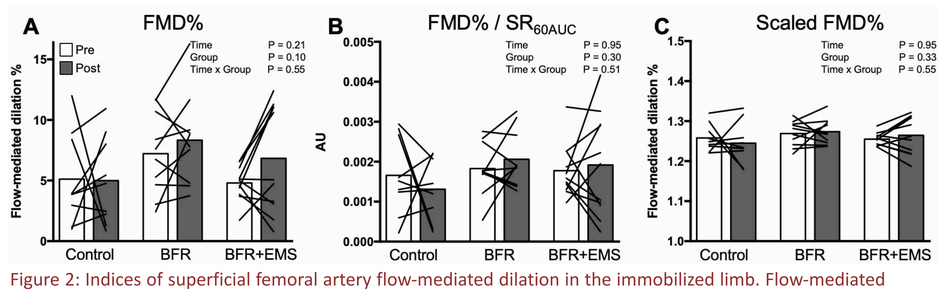


Figure 2: Indices of superficial femoral artery flow-mediated dilation in the immobilized limb. Flow-mediated dilation expressed in percent change diameter (A), relative to SR_{60AUC} (B) and, adjusted for baseline diameter via allometric scaling (C). n=30 total. Bars represent group means and lines show individual data.

CONCLUSIONS

We conclude that after a period of immobilization:

1) **Alterations to structural arterial properties are not mitigated by BFR or BFR+EMS**
2) **Arterial reactivity, assessed by FMD, remained similar despite increased shear stimulus**
3) **There is evidence of reduced retrograde blood flow with disuse, but this is unaltered with BFR or BFR+EMS treatment**

Studying the effects of a BFR and BFR+EMS intervention is important to understand the role of repeated hyperemic stimuli in preserving the vasculature during a period of disuse. Despite a lack of a measurable effect on macrovascular form or function, the potential role of BFR and BFR+EMS in modulating NO sensitivity and microvascular flow requires further investigation and may have implications for facilitating peripheral artery rehabilitation.

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