World Confederation for Physical Therapy CONGRESS 2017 Cape Town

Manchester Metropolitan University

Increasing the Metabolic Stress of an Unweighted Knee Exercise via Blood-flow Restriction Training: A Potential Treatment Adjunct for Physiotherapists

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Introduction

Blood-flow Restriction Training [BfRT] involves the temporary, artificial reduction of blood flow through a limb, often during low-intensity resistance exercise. Following lower-limb injury or surgery, evidence suggests that BfRT can be used to minimise losses in thigh muscle size and strength or accelerate their return[1,2]. However, the restriction equipment used in BfRT research is often inaccessible to frontline clinicians. There is also little evidence as to the acute metabolic effect of adding blood-flow restriction to un-resisted, or 'no load', rehabilitation exercises.

Purpose

Using an inexpensive restriction device, this study investigated whether adding lower-limb blood-flow restriction to a rehabilitation-appropriate 'no load' knee exercise produced a significant change in the acute metabolic stress of the exercise session.

Methods

Design: Cohort study

Participants: N=16 healthy participants (n = 9 male) from Manchester Metropolitan University.

Intervention: Participants attended four sessions, each separated by >48 hours. Sessions consisted of a three-minute pre-exercise resting period, followed by three, one-minute sets of a single-leg, unweighted knee-extension exercise.

A 21cm-wide blood-pressure cuff was used around the thigh of the exercising limb *[MDF2090471; MDF Instruments®, California, USA]* [Figure 1]. At the first session, the cuff was not inflated [0mmHg]. At the remaining three sessions, it was inflated to 40/60/80mmHg [Table 1], immediately prior to exercise to restrict blood flow. It was deflated one minute after the final exercise set.

Outcomes: The % of popliteal arterial blood-flow volume remaining at each cuff pressure [**Popliteal %BfR**] was determined using Doppler ultrasound. To indicate local metabolic stress, near infra-red spectroscopy was used to record deoxygenated haemoglobin mass [**HHb**] and total haemoglobin mass [**tHb**] of the exercising vastus lateralis muscle before and during every exercise session. Heart Rate [**HR**] and a 10-point Rate of Perceived Exertion [**RPE**] were also recorded. Differences in **BfR**, **HHb, tHb, HR** and **RPE** were compared between sessions, using descriptive and inferential statistics.

Results

Figure 1: Thigh cuff placement

All participants completed all exercise sessions. Age 32.8 (4.3) years; Height 173.2 (9.7) cm; Weight 76.4 (16.7) kg; Body Mass Index 25.2 (3.9) kg/m².

Popliteal %BfR was statistically different across the four cuff pressure conditions (Repeated Measures ANOVA, p <0.0001, partial η2 0.845), decreasing as cuff pressure increased [Table 1].

During exercise, **HHb** values were statistically significantly different across the four cuff pressure conditions (Repeated Measures ANOVA; p <0.0001, partial η2 0.760). This was also true for **tHb** (Friedman Test; p <0.001) [*Table 1*].

HR increased during exercise, with no significant difference across the four cuff pressure conditions (Repeated Measures ANOVA, p =0.399). Session **RPE** was significantly different across the four cuff pressure conditions (Friedman Test; p <0.001) increasing as the cuff pressure used was increased. [0mmHg; 2.00, 40mmHg, 2.83, 60mmHg; 3.50, 80mmHg; 4.83). Overall, a higher Body Mass Index was associated with smaller changes in **HHb** of the exercising vastus lateralis during sessions in which cuff pressures were applied (Pearson r -0.794, r^2 0.630, p < 0.001).

Figure 2: Second-by-second changes in Cohort HHb of the Exercising Vastus Lateralis during Three Sets of Un-resisted Knee Extensions Performed at Different Thigh Cuff Pressures

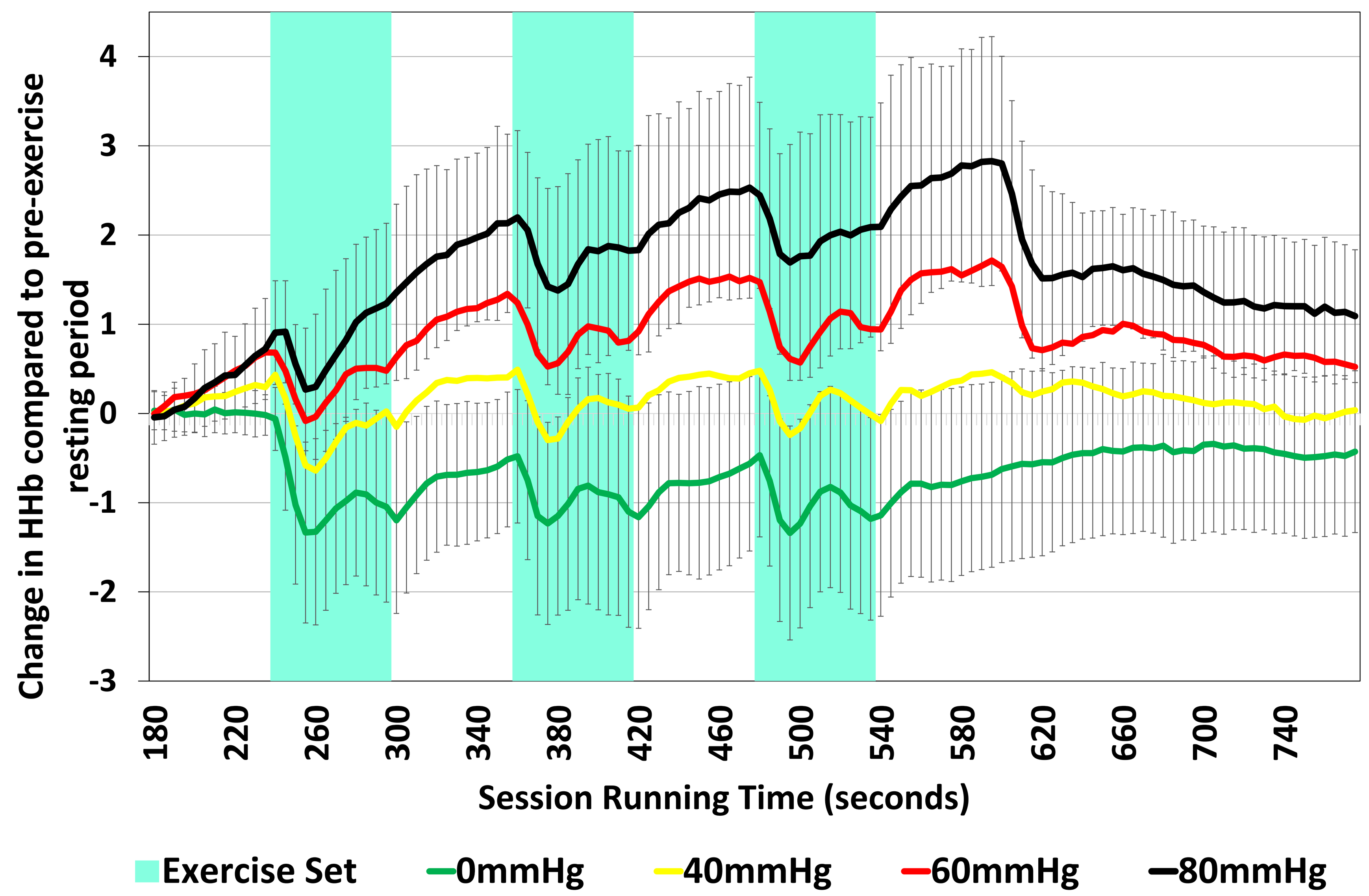

Table 1 – Pre-exercise (resting) values and in-session changes to study outcomes.

Pre-session Resting Values (Cohort Means & Standard Deviations)			
HHb [g/dL]	thB [g/dL]	Heart Rate [BPM]	Popliteal Blood Flow [ml/min]
4.04 (1.49)	11.95 (0.44)	75.08 (11.34)	42.57 (20.24)

Thigh Cuff Pressure [mmHg]	In-session Relative Changes (Cohort Means & Standard Deviations)			Popliteal %BfR Immediately Before Exercise
	HHb [g/dL]	thB [g/dL]	Heart Rate [BPM]	
80mmHg	+ 1.64 (0.85)	+ 0.218 (0.151)	+ 3.25 (3.74)	47.63% (8.79)
60mmHg	+ 0.91 (0.90)	+ 0.104 (0.153)	+ 1.78 (2.74)	61.1% (14.93)
40mmHg	+ 0.15 (0.61)	- 0.017 (0.099)	+ 3.10 (2.47)	73.13% (14.31)
0mmHg	- 0.75 (0.77)	- 0.114 (0.094)	+ 3.64 (2.83)	N/A

Conclusions

- Adding lower-limb blood-flow restriction significantly increased the local, acute metabolic stress and perceptual effort of a rehabilitation-appropriate knee exercise without the need to increase exercise load or repetitions.
- At cuff pressures up to 80mmHg, the degree of metabolic stress experienced during 'no load' BfRT differed between individuals and appears to be associated with their Body Mass Index.

Implications

- Using an inexpensive blood-pressure cuff, findings support the concept of using of lower-limb BfRT as a treatment adjunct following lower-limb injury.
- To deliver a consistent level of metabolic stress, clinicians may need to tailor the thigh cuff pressure applied based upon an individual's physical size or mass.
- Further research is required to determine the acute metabolic stress required to attenuate the effects of muscle disuse within injured populations.

References

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Acknowledgements

Ethics & PhD Scholarship: Manchester Metropolitan University

Presented at the WCPT Congress 2017, Cape Town

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Private Physiotherapy Educational Foundation