Acute effects of neuromuscular electrical stimulation combined with varying degrees of blood flow restriction on muscular, cardiovascular and perceptual variables

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Purpose: Recovery from lower limb fracture, surgery or injury often requires a period of immobilisation, which leads to significant declines in muscular strength and size, ranging from 0.3–4.2% per day. A common technique used to attenuate muscle atrophy during immobilisation is neuromuscular electrical stimulation (NMES). However, a more recently utilised intervention is blood flow restriction (BFR). During immobilisation, isolated NMES and BFR have both been shown to reduce muscular atrophy, but not strength declines. Recently, NMES combined with BFR has been investigated and led to increased muscular strength and size in healthy participants and those with spinal cord injuries, compared with NMES and BFR alone. The mechanisms and safety of NMES combined with BFR is currently unknown. The aim of the present study was to discover the acute effects of NMES combined with varying degrees of BFR on muscular, cardiovascular and perceptual variables.

Methods: Randomised crossover design on 20 healthy volunteers (15 males, 5 females). Participants attended six sessions, two familiarisation sessions, before being randomised into four experimental conditions: NMES alone; NMES 40% BFR; NMES 60% BFR and NMES 80% BFR. NMES protocol; 50 Hz, 40 repetitions at maximum tolerable intensity, applied to the quadriceps for 8 mins. Outcome measures assessed pre and post experimental conditions were: knee extension maximal voluntary isometric contraction (MVIC), vastus medialis and lateralis muscle thickness (MTH), blood pressure (BP), heart rate (HR) and delayed onset of muscle soreness (DOMS). Evoked NMES force, rating of perceived exertion (RPE), pain and HR were also assessed during every experimental condition.

Results: Knee extension MVIC significantly declined post NMES with 40, 60 and 80% BFR ($p < 0.05$). NMES 80% BFR caused significantly greater Knee extension MVIC decline (−38.9 ± 22.3 Nm) than any other condition ($p < 0.01$). Evoked NMES force declined with increasing BFR pressures ($p < 0.01$). Vastus medialis and lateralis MTH significantly increased after every condition ($p < 0.05$), with NMES 80% BFR causing significantly greater increases than NMES alone ($p = 0.03$; $p = 0.03$, respectively). RPE significantly increased from set 1 to set 4 during NMES 60% BFR ($p < 0.05$). RPE was significantly

higher after set 3 and 4 of NMES 80% BFR compared with set 1 and 2 of NMES 60% BFR. Pain was significantly higher after set 2, 3 and 4 of NMES 80% BFR compared with all sets of NMES alone, NMES 60% BFR and set 1 of NMES 40% BFR ($p < 0.05$). No cardiovascular effects or DOMS were observed.

Conclusion(s): Adding 80% BFR to NMES induced significantly greater MVIC decline compared with every other experimental condition and MTH increase compared with NMES alone. NMES combined with 80% BFR caused higher ratings of RPE and pain compared with the other conditions. NMES combined with BFR was safe on the cardiovascular system, tolerated and caused no adverse events.

Implications: This intervention can be safely applied in clinical practice if patients appropriately screened, recommend protocols are followed and perceptual variables monitored throughout. It can be utilised to improve muscular strength and size when patients are unable or contraindicated to perform exercise.

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