Neuromuscular Fatigability Following an Acute Session of Neuromuscular Electrical Stimulation With or Without Blood Flow Restriction

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Résumé

Introduction. Neuromuscular deconditioning can affect anyone facing temporary or prolonged immobilization (e.g., musculoskeletal injury, trauma, or extended stay in intensive care). In such cases, contracting actively the muscles is essential to limit a loss in muscle mass and strength. Neuromuscular electrical stimulation (NMES) is an efficient method to maintain the muscle function in immobilized or frail individuals, by eliciting involuntary muscle contractions that generate both mechanical and metabolic stress. However, it is often underused or poorly implemented by healthcare professionals. Combining NMES with blood flow restriction (BFR) may enhance its effectiveness by amplifying metabolic stress through the induction of localized hypoxia (1, 2). Before applying this combined intervention to frail or critical patients, it is important to better understand its physiological impact on healthy individuals. Therefore, this study aimed to evaluate the effects of combined NMES and BFR intervention on acute neuromuscular fatigability to determine optimal application parameter and ensure effective outcomes within a safe context.
Methods. Eighteen participants (age: 23 ± 2 years; height: 174 ± 12 cm; weight: 69 ± 15 kg), with low experience in lower-limb resistance training, were recruited for this repeated cross-over design study. Participants visited the laboratory on two separate occasions to perform 40 NMES-evoked isometric contractions (75 Hz, 400 μs, 6 s on : 20 s off) combined with BFR (NMES-BFR) or without BFR (NMES). Stimulation intensity was self-adjusted throughout the protocol to maintain the maximum tolerable level. The BFR cuff was inflated to 80% of the arterial occlusion pressure. Neuromuscular function was assessed by measuring maximal voluntary contraction (MVC) and peak twitch (Pt) torques before (Pre) and immediately after (Post) the completion of the 40 contractions. Heart rate (HR) and peripheral oxygen saturation (SpO2) were continuously monitored during the stimulation protocol to ensure similar physiological responses between conditions.

Within each condition, paired t-tests were performed to evaluate the effect of NMES and NMES-BFR on neuromuscular fatigability. To evaluate whether differences were more important in one condition compared to the other, we used analysis of covariance (ANCOVA), with Post-values as the dependent variable, Pre-value as the covariate, and condition as the fixed factor.

Results. The mean torque produced over the 40 contractions was lower ($P < 0.001$, d

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= 1.58) in the NMES-BFR session (4 ± 5% MVC) compared to the NMES session (12 ± 8% MVC).

MVC torque was reduced following both sessions, but with a greater extent ($p < 0.001$, $\eta p2 = 0.30$) after the NMES-BFR session (–13 ± 7%, $p < 0.001$, $d = 1.43$) compared with the NMES (–4 ± 7%, $P = 0.008$, $d = 0.70$). Pt torque also decreased after both the NMES (–12 ± 3%, $p < 0.001$, $d = 3.23$) and the NMES-BFR sessions (–20 ± 4%, $p < 0.001$, $d = 3.01$), with this decrease being greater after NMES-BFR ($p < 0.001$, $\eta p2 = 0.45$).

We detected no differences in mean HR (35 ± 4 % vs. 36 ± 5 % of HRmax for NMES and NMES-BFR, respectively; $p > 0.05$, $d = 0.28$) and SpO2 values (98 ± 1% vs. 97.5 ± 1%; $p > 0.05$, $d = 0.27$) between the both protocols.

Discussion. We observed that acute neuromuscular fatigability was greater when BFR was combined with NMES, compared to NMES alone. This is consistent with previous findings (1), although slight differences in NMES parameters may exist. This enhanced fatigability may be attributed to the greater peripheral alterations seen after NMES-BFR, likely due to the rapid depletion of phosphocreatine in type I and II fibers under ischemic condition, which increases inorganic phosphate concentrations and disrupts the peripheral milieu (3).

Perspectives. These results of an exacerbated fatigue after an acute session of NMES-BFR suggest that the combined intervention may promote positive muscle adaptations with long-term use (2).

References.

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