Velocity-Specific Motor Unit Contributions During Dynamic Constant External Resistance Leg Extension Repetitions-to-Failure

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Introduction

This study used wavelet decomposition and principal component analysis (PCA) to estimate the relative contributions of high- and low-threshold motor units of the vastus lateralis during dynamic constant external resistance leg extensions performed to task failure. Two conditions were tested: maximal intended concentric velocity (MaxV) and 50% of maximal intended concentric velocity (SubV).

Methods

Ten males (25.3 ± 3.4 yr, 182.3 ± 6.9 cm, 81.6 ± 8.2 kg) completed a one-repetition maximum (1RM) leg extension, followed by two repetitions-to-failure (RTF) trials at 70% 1RM, with all repetitions performed at either MaxV or SubV. RTF trials were separated by at least 48 hours. Surface electromyography (sEMG) was recorded from the vastus lateralis of the exercised limb during each RTF trial (Figure 1).

Wavelet decomposition and PCA of sEMG spectra were used to approximate contributions from high- and low-threshold motor units, with contributing weights relativized to total signal intensity (mV^2) within each condition's repetitions for more intuitive interpretation. A linear mixed-effects model analyzed changes in relativized contributing weights, with fixed effects for Condition (MaxV | SubV), Repetition (Initial | Final), and Spectra (High-threshold | Low-threshold), including interactions.

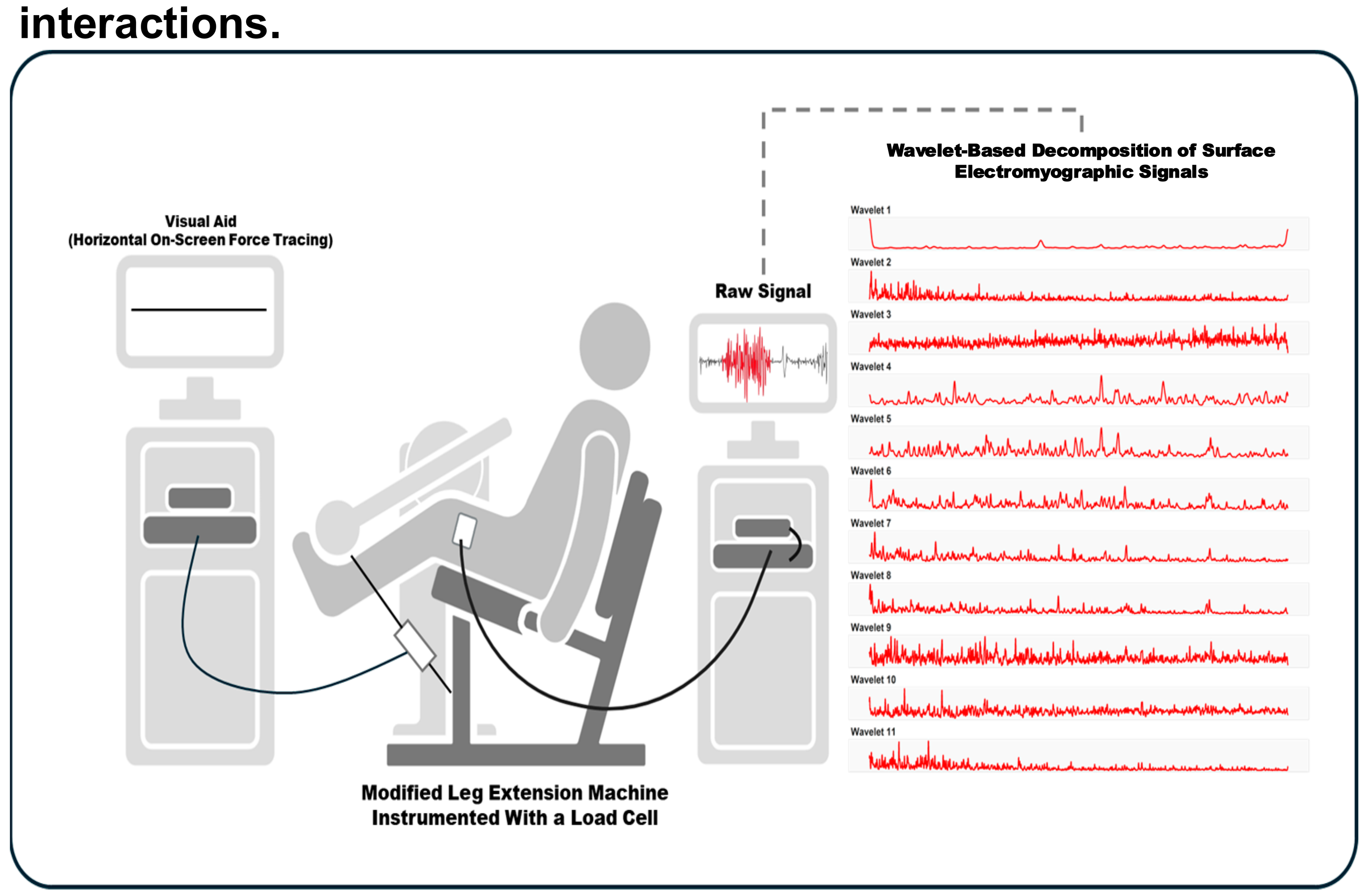

Figure 1. Experimental setup and partial signal processing workflow.

Results

The mean ± standard deviation for 1RM leg extension strength was 54.9 ± 10.6 kg. The number of repetitions performed was 15 ± 5 reps for MaxV and 14 ± 5 reps for SubV conditions. Statistical analysis indicated no significant three-way interaction among Condition, Repetition, and Spectra [$F(1, 51.650) = 0.146$, $p = 0.704$]. However, there was a significant two-way interaction between Repetition and Condition [$F(1, 52.470) = 6.113$, $p = 0.017$], suggesting a possible differential fatigue response.

Specifically, in MaxV, high- and low-threshold motor unit contributions remained relatively stable from the initial to the final repetition [β (CI95%) = -7.5 (-115.5, 100.4), $p = 0.890$]. In contrast, in SubV, both high- and low-threshold motor unit contributions appeared to increase in parallel from initial to final repetition [β (CI95%) = 175.9 (74.4, 277.3)], suggesting a progressive neuromuscular adaptation. These effects are visually illustrated in Figure 2.

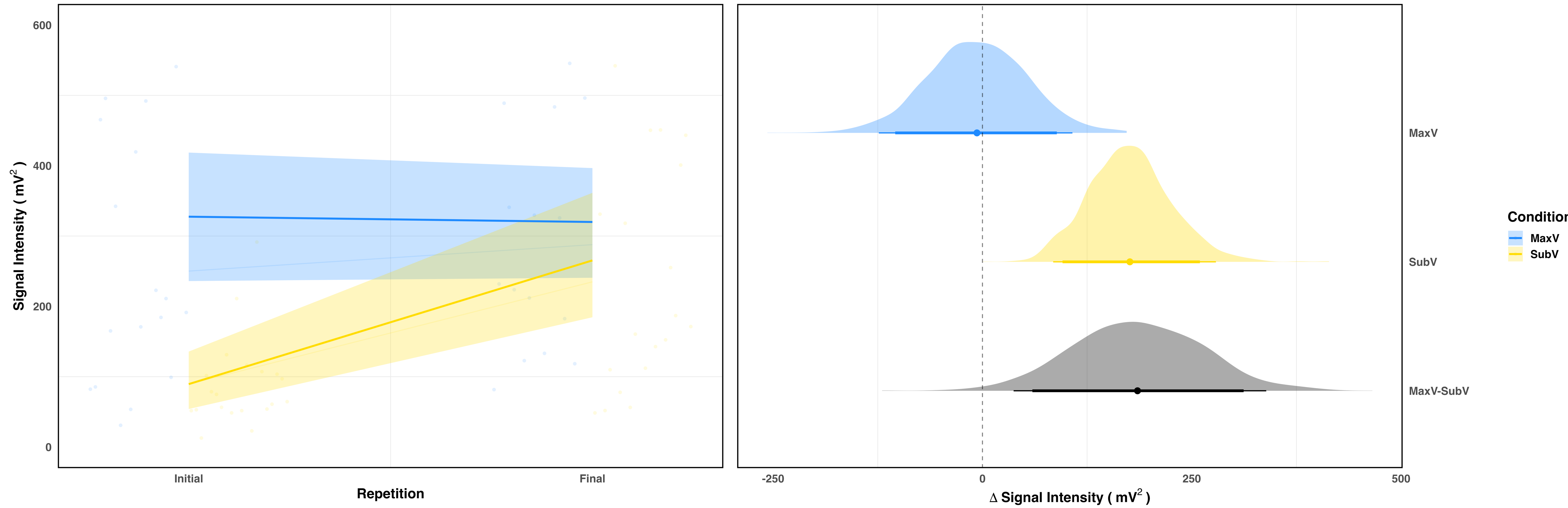

Figure 2. Left plot illustrates signal intensity (mV^2) for MaxV (blue) and SubV (yellow) conditions across initial and final repetitions. Shaded regions represent 95% confidence intervals. Right plot presents the distributional changes in signal intensity (ΔmV^2) from initial to final repetitions for MaxV (top, blue), SubV (middle, yellow), and their difference (bottom, black). Dots and horizontal lines represent means and 95% confidence intervals, respectively.

Conclusion

The relatively stable motor unit contributions in MaxV may indicate early and sustained high-threshold motor unit engagement, though maximal recruitment cannot be confirmed without direct measures of maximal excitation. In contrast, the progressive increase in motor unit activation during SubV may reflect compensatory mechanisms such as increased motor unit recruitment, firing rate, and synchronization with fatigue.

Practical Applications

If MaxV facilitates greater motor unit recruitment and earlier engagement of high-threshold motor units under load-equated conditions, then performing repetitions with MaxV may enhance resistance training adaptations related to power, rate of force development, and hypertrophy.