EVIDENCE FOR THE USE OF DYNAMIC MAXIMUM NORMALIZATION METHOD OF MUSCLE ACTIVATION DURING WEIGHTED BACK SQUATS

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Introduction

- Muscle activation is typically reported as a normalized electromyography (EMG) signal. In weighted exercises, EMG is most often normalized as a percentage of a maximum voluntary isometric contraction (MVIC). However, EMG can also be normalized to the peak EMG signal of the dynamic task being performed (DMVC)[1].
- Maximal loading is required for full activation of muscles in order to complete the back squat[2], which could suggest the use of a DMVC is a more applicable normalization for EMG signals during weighted exercise movements[3].
- The back squat presents a unique opportunity to simultaneously evaluate intra (normalization method) and inter (group) subject effects due to 1) the similarity in joint angles during the squat and MVIC setup and 2) the presence of back squats in nearly all exercise programs for all persons (i.e., males and females).
- Currently there is no universally adopted method for normalization of muscle activation during weighted exercises, likely due to the mixed results from previous comparisons between each scheme.

Purpose

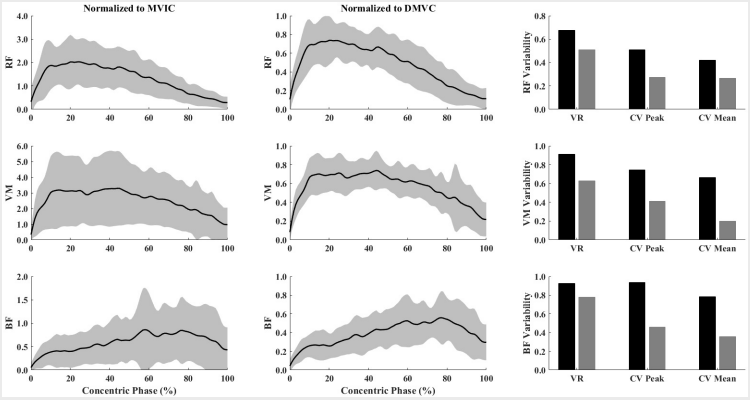
- The purpose of this study was to evaluate intra and inter-participant variability and reliability of muscle activations, in this case males and females, when analyzed using MVIC and DMVC normalization methods.

Methods

- Muscle activation patterns were collected at 2000 Hz using a Delsys Trigno Wireless EMG system (Delsys, Inc.), of 18 participants.
- MVICs of each muscle were recorded for 10 seconds. The rectus femoris (RF) and vastus medialis (VM) were performed seated with the knees flexed 60º [4,5]. The biceps femoris (BF) was performed prone with the knee flexed to 30º [4,5].
- Participants performed a 5-minute warm-up of their choice, followed by the NSCA 1RM back squat testing protocol[6].
- Squats were performed with a shoulder-width stance to full depth (contact between posterior thigh and shank).
- Recorded muscle activations from MVIC, 1RM (DMVC) and 80% 1RM (submax) trials were imported into Matlab (R2019b, The MathWorks, Natick, MA).
- EMG waveforms during the concentric phase (full depth to standing upright) were used for analysis[7].
- Peak activation from the DMVC and MVIC were extracted and used for normalization[3].
- All submax trials were normalized to the MVIC and DMVC.
- Inter-participant varability for both normalization techniques was assessed with coefficient of variation (CV%) and variance rations (VR) [8]. Test-retest reliability was assessed by intraclass correlation coefficient (ICC)[1].

Results

Figure 1. Ensemble muscle activation waveforms and inter-subject variability.



Note: Inter-subject variability (third column) measured by variance ratio (VR) and coefficients of variation (CV; peak and mean activations) are also presented for MVIC (black bars) and DMVC (grey bars). Both VR and CV variability measures are unitless.

Figure 2A. Peak BF interaction effects.

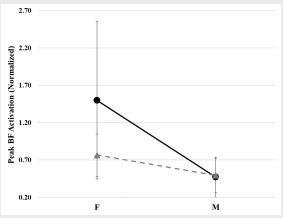
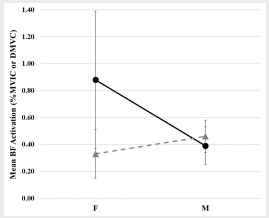


Figure 2B. Mean BF interaction effects.



Note. MVIC (solid black) presented with greater female than male activation differences than and DMVC (dotted grey).

Table 1. Comparisons of peak activation levels normalized to peak MVIC and DMVC: mean ± std.

	MVIC		DMVC		MMANOVA (F, p, η_p^2)		
	M	F	M	F	Interaction	Normalization	Sex
RF	2.93±1.39	2.22±1.18	0.91±0.28	0.93±0.23	2.217, 0.149, 0.081	46.163, <0.001, 0.649	1.679, 0.207, 0.063
VM*	3.47±3.08	4.69±2.94	0.69±0.20	1.09±0.39	0.049, 0.827, 0.002	98.135, <0.001, 0.797	5.474, 0.028, 0.180
BF*	0.47±0.27	1.50±1.05	0.49±0.23	0.77±0.28	9.260, 0.005, 0.270	4.772, 0.039, 0.160	18.793, <0.001, 0.429

Table 2. Comparisons of mean activation levels normalized to peak MVIC and DMVC: mean ± std.

	MVIC		DMVC		MMANOVA (F, p, η_p^2)		
	M	F	M	F	Interaction	Normalization	Sex
RF	1.37±0.53	1.29±0.61	0.43±0.11	0.55±0.12	0.779, 0.386, 0.030	56.860, <0.001, 0.695	0.024, 0.879, 0.001
VM	2.26±1.56	2.82±1.80	0.51±0.08	0.63±0.12	0.475, 0.475, 0.019	36.795, <0.001, 0.260	1.075, 0.310, 0.041
BF	0.33±0.18	0.88±0.51	0.39±0.14	0.46±0.12	8.48, 0.007, 0.253	8.762, 0.007, 0.260	17.077, <0.001, 0.406

Discussion

- The results of this study suggest the use of DMVC as a more reliable and superior normalization technique than MVIC.
- The DMVC normalization method demonstrated greater specificity (reduced inter-subject variability), with dramatically reduced variability in both peak and mean BF activations in females.
- Normalization to MVICs often produces values exceeding 100% of activation, indicating that the actual maneuver requires greater muscle activation than commonly present during an MVIC.
- The current study found BF activation was more sensitive to normalization methods in females than males.

References

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