Effect of knee flexion angle during isometric squat on electromyography decomposition parameters

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Summary

We have measured decomposition of surface electromyography during three isometric squats of 40 seconds at three different knee flexions (100°, 90° and 80°).

Introduction

Decomposition of surface electromyography (D-sEMG) is emerging as a promising analysis technique, as it can provide valuable information about muscle function after an intervention [1]. For example, it has been observed that during pain, the firing rate of synergist muscles can be reduced [2]. For this reason, it is relevant to evaluate whether protocolized functional tests (e.g., isometric squat) assessing D-sEMG could be useful to include in athletes' monitoring routines.

However, before exploring the capacity of this type of test to discriminate fatigue or pain, it is necessary to investigate whether D-sEMG is sensitive to posture during the squat. In this sense, the results could indicate the need to strictly control the posture (3D kinematics) or not (visually or by manual goniometry). Therefore, the aim of this study was to evaluate the effect of knee flexion during 40-sec of an isometric squat on the D-sEMG parameters of the vastus lateralis.

Methods

Eleven physically active volunteers participated in the present study (4 females and 7 males; 26 ±8 years old; 71.2 ±12.9 kg; 172 ±10 cm; 19 ±7% body fat). All participants signed an informed consent form and the study was approved by the Ethics Committee of the University of Valencia.

Firstly, participants performed a warming-up consisted on walking 5-min on a treadmill at 4 km/h and 10 squats. Then, they performed three repetitions of 40 seconds of isometric squats at different knee flexions (randomized) with 5 min of seated rest between them.

Knee flexions assessed were 100°, 90° and 80°. Knee flexion was measured in both lower limbs and controlled by 3D kinematic analysis with 6 infrared cameras at 100 Hz (Optitrack Flex 3; NaturalPoint Inc., USA),using 3 markers at each limb (greater trochanter, lateral epicondyle of the femur and lateral malleolus).

A D-sEMG sensor (Galileo, Delsys Inc., USA) was placed on the vastus lateralis. Skin preparation and electrode position followed SENIAM guidelines [3]. All signals were recorded with a sampling frequency of 2000 Hz and the decomposition of the electromyographic signal was performed through the NeuroMap System software (Delsys, USA). Total number of motor units recruited and maximum and mean firing rate during all the isometric test were obtained. Moreover, signal was also divided into low, middle and upper tertials [4].

Statistical analysis was performed by RStudio (version 2024.12.0). Differences between D-sEMG parameters in knee flexion were assessed by Kruskal-Wallis rank sum test.

Results and Discussion

D-sEMG parameters were not affected by knee flexion angle during the isometric squat execution (Table 1).

Table 1: *Mean (SD) of decomposition of surface electromyography parameters at three different knee flexions during isometric squats of 40 seconds.*

Parameter	80°	90°	100°	p-value
Nº of motor units	22 (9)	22 (11)	20 (11)	>0.9
All the signal				
Max. firing rate (pps)	22.5 (3.2)	22.1 (5.2)	20.9 (3.5)	0.6
Mean firing rate (pps)	11.29 (2.88)	11.12 (3.62)	11.38 (2.64)	>0.9
Low tertial				
Max. firing rate (pps)	19.8 (2.4)	19.6 (4.9)	19.1 (3.5)	0.8
Mean firing rate (pps)	10.51 (2.54)	10.44 (3.34)	10.50 (2.46)	>0.9
Middle tertial				
Max. firing rate (pps)	19.5 (4.3)	18.6 (5.5)	18.8 (4.7)	>0.9
Mean firing rate (pps)	11.31 (3.15)	11.05 (3.85)	11.42 (3.13)	>0.9
Upper tertial				
Max. firing rate (pps)	20.0 (4.1)	19.3 (5.6)	19.8 (4.3)	>0.9
Mean firing rate (pps)	11.61 (3.16)	11.24 (3.68)	11.91 (2.68)	>0.9

Our data do not suggest that the degree of knee flexion affects D-sEMG parameters, so 3D kinematic control does not appear to be necessary during the test. However, qualitatively, we believe it is advisable to ensure that the test is performed as close to 90º as possible, since 80º was perceived by the participants as more demanding and 100º as less.

Conclusions

A small variance of knee flexion (10º) during an isometric squat test does not affect the results of D-sEMG.

Acknowledgments

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