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MUSCULAR FATIGUE ANALYSIS IN DYNAMIC AND ISOMETRIC CONTRACTIONS PERFORMED IN AN INCREMENTAL RUNNING PROTOCOL

[1,2] Carina Helena Wasem Fraga, [1]Roberto Bianco, [1]Aline Abreu Scolfaro Crema, [1]Júlio Cerca Serrão, [1]Alberto Carlos Amadio and [2]Mauro Gonçalves.
[1]School of Physical Education and Sport, Universidade de São Paulo (USP), São Paulo/ Brazil
[2]Laboratory of Biomechanics, Universidade Estadual Paulista (UNESP), São Paulo/ Brazil;
wcarina_helena@hotmail.com, web: http://citrus.uspnet.usp.br/biomecan/index.htm

SUMMARY
Incremental running protocols on treadmill are often used to evaluate muscular fatigue. The alteration on electromyographic signal may occur due to an increase of running speed or to muscular fatigue development. Eleven recreational runners took part in this study. It was determined that the electromyographic signal obtained at dynamic contraction increased with the increment of running velocity for the muscle *Rectus Femoris*, whereas there were no significant changes on the electromyographic signal obtained on isometric contractions performed at the intervals between incremental stages. Hence, it can be inferred that the electromyographic signal increase could be more specifically determined by a higher intensity exercise than by muscular fatigue development.

INTRODUCTION
Muscular fatigue represents an indicator of strength and power decrease that might occur whilst performing prolonged and/or high intensity exercises [1]. Incremental running protocols are often used as a fatigue evaluation method, because the exercise intensity alteration could evince metabolic and neuromuscular adjustments derived from the beginning of a fatigue process [2,3].

However, alterations with the characteristics of the electromyographic signal (EMG) during incremental running are not clearly indicative of whether those changes came from a velocity increase, or as a consequence of a fatigue process. In order to properly attribute these alterations to fatigue development, it has been proposed that isometric contraction should be done at intervals between incremental stages [3].

The aim of the present study was to analyze isometric and dynamic contractions to determine muscular fatigue from an incremental running protocol performance.

METHODS
Eleven recreational male runners took part in this study (24,2 ± 6,1 years; 70,3 ± 11,7 kg; 1.75 ± 0.04 m). These subjects trained for specific running competitions, with a training frequency of at least thrice a week, more than six months of experience at the sport modality, and a race performance of 10 km under 45 minutes. The present study was approved by the local Ethics Committee (Protocol 2771/2004).

At first, three maximal isometric voluntary contractions (MIVC) for the extensor muscle group of the knee were made with duration of five seconds each and an interval of three minutes between them. Three minutes after the maximal contractions, three isometric contractions at 50% of MIVC were collected for five seconds. The 50% of MIVC was controlled by a dynamometer.

The running protocol began with 10 $km.h^{-1}$ and the increments were of 1 $km.h^{-1}$ at every three minutes (stages) until exhaustion. At the end of each stage, there was a pause of two minutes in which an isometric contraction at 50% of MIVC was collected. The subjects were instructed to maintain this percentage of contraction during the data collection.

The EMG signals of *Rectus Femoris* (RF) and *Vastus Lateralis* (VL) were obtained by bipolar surface electrodes according to SENIAM [4]. The EMG was collected at 1000 Hz and they were amplified 2000 times. The signals were filtered with high pass (20Hz) and a low pass (500Hz) filter. The Root Mean Square (RMS) was calculated for the dynamic contractions using the mean value of the ten last strides of each stage of running. In isometric contraction, the RMS was calculated in windows of 1s with an overlap of 0.5s. The mean values corresponding to the intervals of 1 to 4s were analyzed. The RMS values of 60%, 80% and 100% of the maximal running speed. A one-way repeated measures ANOVA for repeated measures and *post hoc* of Bonferroni ($p < 0.05$) was used for statistical analysis.

RESULTS AND DISCUSSION

The RMS value obtained from dynamic contractions for *Vastus Lateralis* does not show alterations between analyzed stages. Nevertheless, the RMS value of dynamic contractions for the muscle RF increased with each speed increment (Figure 1).

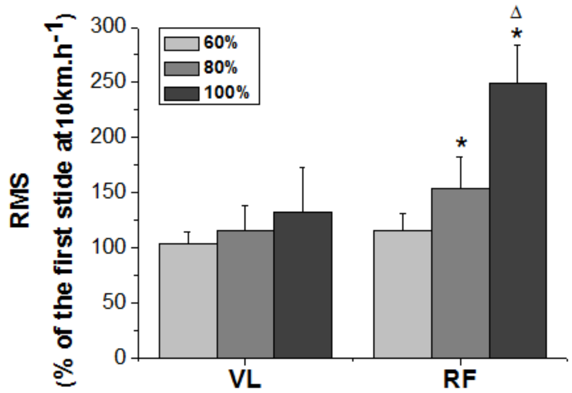

Figure 1: RMS values (mean e standard deviation) of VL and RF muscles to dynamic contractions. * indicates p<0,05 to 60% and Δ indicates p<0,05 to 80%.

No significant differences with the EMG signal were found on isometric contractions between different stages (Figure 2).

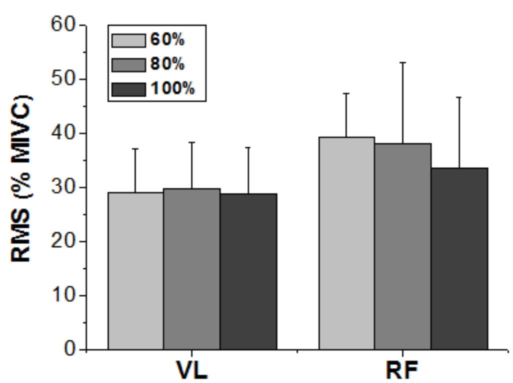

Figure 2: RMS values (mean e standard deviation) of VL and RF muscles to isometric contractions.

The increase of running intensity seems to induce specific responses depending on the kind of muscular contraction analyzed. Studies have reported increases at EMG signals obtained in dynamic contractions during incremental running protocols [2,3], which corroborates with the results observed by this study. This increase at signal amplitude could be related to new motor units being recruited due to an increase of exercise intensity [5,6].

However, these increases may occur as a result of both the intensity increment and the muscular fatigue development [7]. So that there is a differentiation between these possible causes of EMG signal changes, another study used a methodology similar to the present study [3]. The authors verified that the EMG signals of isometric contractions obtained between different stages of an incremental running protocol remained almost constant during the test, and significant signal amplitude changes were verified only at speeds higher than 18 $km.h^{-1}$. Those differences found at higher speeds were not verified by this study. This could be related to the distinct performance levels between subjects evaluated in both studies. The runners that took part in the present study reached a maximum speed of 18 ± 1,3 $km.h^{-1}$.

CONCLUSIONS

Therefore, it was determined that an increase in running speed led to an increase in RMS values only for dynamic contractions of the RF muscle, whereas no significant differences were verified between isometric contractions. These results indicate that the increase observed in RMS values could be more specifically determined by higher exercise intensities as opposed to the development of a fatigue process.

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