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ELECTROMYOGERAPHIC WAVELET ANALYSIS OF LOWER EXTERMITY MUSCLES DURING SPRINT START AND TWO SUBSEQUNT STEPS

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The aim of this study was to identify muscle fiber activity based on the wavelet technique during the sprint start. Also, the influence of age, gender and anthropometric parameters was investigated. Sixty young elite sprinters volunteered. Bilateral electromyographic activity was recorded from the Gastrocnemius medialis (GAS), Rectus femoris, Biceps femoris and Gluteus maximus (GLU). During all phases of sprint start, the rear and front GAS muscles showed significantly higher frequencies while the GLU muscles presented lower frequencies than any other muscles. No significant differences were observed between boys and girls, however, the results showed that the older sprinters, the ones with a higher percentage of thigh and calf circumference and skeletal muscle mass have a better capability to recruit more fast twitch fibers, for instance in the GAS.

KEY WORDS: sprint athletes, wavelet analysis, anthropometrical parameters, sprint start.

INTRODUCTION: Surface electromyography is the method commonly used to evaluate the muscle activity in movements. A time frequency analysis based on wavelets is hereby an appropriate tool to study patterns of muscle fiber recruitment during the sprint start (Figure1). From childhood to adulthood an increased recruitment pattern of fast twitch muscle fibres is noticed (Petrie et al., 2004). As slow and fast muscle fibres have different frequencies (following the literature (Von Tscharner, 2000; Wakeling et al., 2001), in this study low frequencies between 40 -80 Hz were attributed to slow muscles and frequencies over 140 Hz to fast muscle fibers.), these myoelectric signals can be resolved into time/frequency space using wavelets in order to differentiate in-vivo between fibre types during specific movements (Von Tscharner, 2000, Wakeling et al., 2001).The purpose of this study was to analyze the electromyographic activity of the lower extremity muscle with respect to fast and slow muscle fiber recruitment. Also of interest in this study was the influence of several anthropometric parameters on this recruitment pattern.

METHODS: Sixty Flemish (30 boys and 30 girls) young elite sprint athletes (from 11 to 18 years old with a mean age of 14.7 ± 1.8 years and 14.8±1.5 years for boys and girls respectively) volunteered. Informed written consent was obtained from all subjects prior to testing. Ethics approval was obtained for all testing procedures from the university ethics committee. Anthropometrical measurements were used to calculate corrected thigh girth (CTG), corrected calf girth (CCG) and total body skeletal muscle mass (SMM) (Poortmans et al., 2005). Bilateral EMG signals of the Gastrocnemius medialis (GAS), Rectus femoris (RF), Biceps femoris (BF) and Gluteus maximus (Glu) were recorded with a Varioport datalogger (Becker Meditec) at 2000Hz during a sprint start and two subsequent steps. Electromyography of these muscles was recorded using disposable, self-adhesive, and ready-to-use surface electrodes (22 mm by 14 mm; Ambu Blue Sensor, NF- SO-K/EU). These surface electrodes were fixed along the longitudinal axis of the muscle belly, close to the motor point. In order to enhance electric conductance, the skin was cleaned and rubbed with alcohol before the electrodes were attached. Wavelet analysis of the EMG signals was performed with software from Biomechanics Research Corp (Canada).

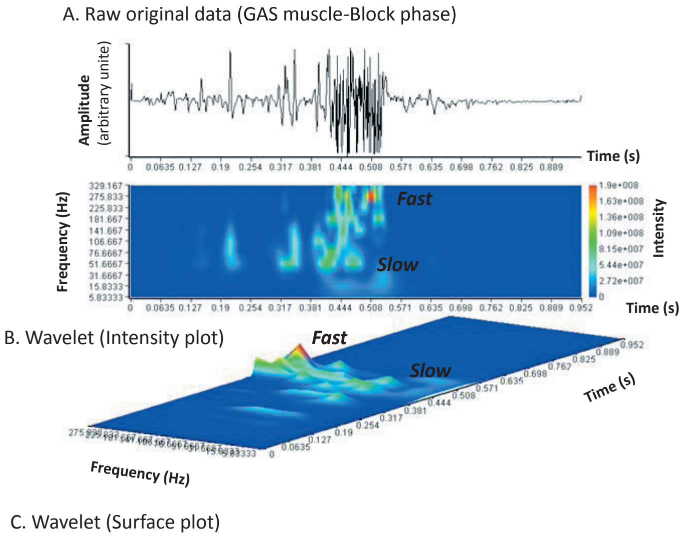
DATA ANALYSIS: For statistical analysis, the subject population was often divided in so called tertiles. In this way the subjects could be ranked as high (3rd tertile), middle (2nd tertile), and low (1st tertile), depending on their value for the selected anthropometric variable. Therefore, all sprinters were successively divided into three equal subpopulations according to their age, thigh girth circumference, calf girth circumference and skeletal muscle mass (Table 1). After applying the Kolmogorov-Smirnov test for normal distribution, ANOVA with Scheffé post hoc test was used. All statistics were carried out using SPSS 15.0. The significance level was set at α=0.05.

RESULTS: Anthropometrical parameters per tertile are shown in Table 1.

Table 1
Anthropometrical parameters according to the three tertiles (Mean ± SD)

Parameters	Tertile 1 (n = 20)	Tertile 2 (n = 20)	Tertile 3 (n = 20)
Age (years)	12.9 ± 0.9	14.9 ± 0.5	16.6 ± 0.6
SMM (kg)	16.9 ± 2.0	21.6 ± 1.1	26.9 ± 3.0
CTG (cm)	45.7 ± 2.3	50.1 ± 0.7	53.2 ± 1.9
CCG (cm)	30.9 ± 1.5	33.5 ± 0.7	36.1 ± 1.2

The present study examined the frequency content in order to identify muscle fiber recruitment patterns during the sprint start including the set position and the two subsequent steps (the first and second contact after leaving the blocks respectively). As a first result, during block, first and second step phases, the rear and front gastrocnemius muscles for all sprinters showed significantly higher frequencies as compared to the other muscles. On the other hand, the gluteus muscles significantly presented lower frequencies than any other muscles during all start phases (Figure 2).



*Original picture has been captured from wavlelet package

Figure 1: Raw EMG analysed into time and frequency for one subject (Block phase- GAS muscle).

Moreover, rear and front muscles of the BF and RF also generated significantly higher frequencies than GLU during the block phase as compared to the first and second steps.
The influence of anthropometrical variables on the frequency content of the muscle activity was investigated for all three start phases. The results indicated that the GAS muscle produced higher frequencies in the second and third tertiles for all sprint phases. However, in the block phase the higher GAS frequency came mainly from the rear leg.

Comparing the frequencies of all muscle in between the three phases of the sprint start, both rear and front GAS muscles showed significantly higher frequencies during the block phase than during the second step phase**.** Moreover, the peak frequencies for four groups of muscles were compared in between rear and front legs during the block phase and the two subsequent steps. In this way, for the whole population during block phase, only the RF muscle generated higher frequencies in the front leg compared to the rear leg.

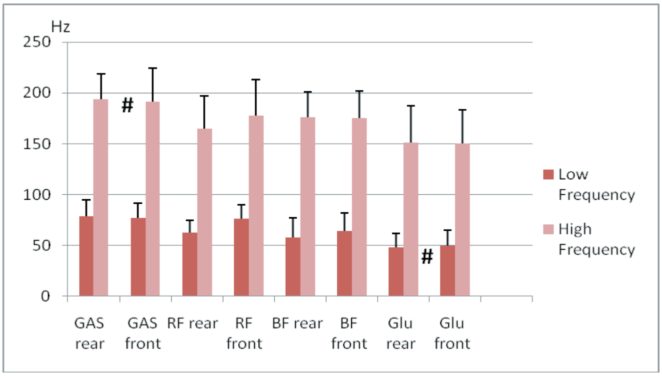


Figure 2: Maximum frequencies in rear and front legs of four muscles during the block (B) phase for entire subject population.

The influence of the gender on the frequency content of the muscles was also identified during the three phases of sprint. In this way, although, for the whole subject population, no significant differences were observed between boys and girls, however, comparison between boys and girls in every age tertile showed significant differences between the boys and girls, only in the third tertile. In this way, the rear and front muscles of the gluteus muscles in the boys recruited significantly more low frequency fibers than girls.

DISCUSSION: A key observation in our study was that, statistically significant differences were noted for all 4 muscles during the sprint start. The results indicate that the motor unit recruitment patterns change through each sprint phase and between muscles. Significantly higher frequencies were generated in the GAS muscle which delivers a short and powerful contribution to the push-off phase of these movements and especially during the block phase. This indicated the recruitment of high frequency muscle fibres during the sprint start due to the explosive nature of these movements in which a rapid and maximal force exertion needs to be delivered. In other words, the slow-twitch motor units, with the lowest threshold for activation, are selectively recruited during a lighter effort. These slow-twitch fibers are activated during sustained activities. Therefore it seems that the faster fibers of GAS muscle have been recruited during the powerful starting block, since frequencies in this muscle were significantly higher as compared to other muscles. On the other hand, the GLU muscle seems to contribute to a lesser extend to the power development in the sprint start since frequencies in this muscle were significantly lower as compared to other muscles. In other words, different frequencies content indicates that different populations of motor units are being recruited. Therefore, this preferential recruitment of faster fibers (GAS muscle) for faster tasks (sprint start) indicates that in some circumstances motor unit recruitment during movement can match the contractile properties of the muscle fibers to the mechanical demands of the contraction (Wakeling et al., 2006). In this way, one of the most mechanical demands in sprint start is the explosive nature of these movements in which a rapid and maximal force exertion needs to be delivered (Mero & Komi, 1990).

The influence of anthropometrical variables indicated that besides the importance of the fast twitch muscle fibers, especially of the GAS during sprint start, also showed athletes with low skeletal muscle mass and also low thigh and calf circumstances couldn't recruit as much fast fibers as the other sprinters. This is in agreement with the theory that children and adolescents have a lower ability in recruiting fast muscle fibres than adults (Petrie et al, 2004).

Moreover, the higher frequencies generated by the RF muscle of the front leg may be due to the longer contact time of the front leg in the start blocks and the asymmetric position of the two legs in set position.

Finally, the higher recruited of rear and front muscles of the gluteus muscles in the older boys indicates that this group seem to have a greater ability to produce more low frequencies of the gluteus muscle as compared to the girls.

CONCLUSION: The results indicate that the motor unit recruitment patterns change through each sprint phase and between muscles. Also, the recruitment of high frequency muscle fibres during the sprint start may be explained by the explosive nature of these movements in which a rapid and maximal force exertion needs to be delivered.

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