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EMG CHARACTERISTICS AND FIBRE COMPOSITION : STUDY ON RECTUS FEMORIS OF SPRINTERS AND LONG DISTANCE RUNNERS

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Abstract : The study was conducted on 9 sprinters and 5 long distance runners to investigate the difference in power spectral characteristics of rectus femoris muscle and the feasibility of using electromyographic techniques in categorization of muscle groups in slow dominant and fast dominant types. EMG signal was recorded, after digitization at 4 KHz, from rectus femoris muscle during isometric knee extension (at maximum voluntary contraction level) until fatigue. Digitized signal was processed for Fast Fourier Transform and Root Mean Square (RMS) voltage. Significant difference (P<0.05) was found in RMS voltage between sprinters and long distance runners. Both groups showed decline in Mean Power Frequency (MPE) and rate of decline in sprinters was rapid. Normalized MPF showed better discrimination between the two groups. It is concluded that the EMG response observed in this study was possibly a result of differences in the muscle fibre composition of the athletes. EMG study using spectral characteristics would be useful in categorizing the sports persons in terms of suitability of the events.

Key words : fatigue pattern; athletes; RMS voltage; fibre composition; mean power frequency

INTRODUCTION

Muscle fibre composition had been a subject of investigation for the last few decades because of the possible role they play in determining the sports performance. Muscle biopsy was used to identify the percentage of slow or fast fibres in leg muscles of sprinters and long distance runners (1, 2, 3). However, biopsy can be of

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limited application due to the trauma it produces in the athlete. Alternate methods of characterization have also been tried through electromyographic techniques (4, 7).

Characteristic changes of the surface electromyogram (EMG) are found during muscle fatigue under sustained isometric contractions. Investigators have reported that the amplitude of the surface EMG changes with time during sustained contraction (5). Other investigators demonstrated that fatigue causes a shift in the frequency spectrum of the surface EMG towards lower frequencies, so-called "frequency lowering" phenomenon (6). Relative proportion of the slow twitch (ST) and fast twitch (FT) fibres in the muscle may affect these EMG responses. Biopsy studies have shown that elite sprinters contain higher percentage of FT fibres than elite long distance runners (3). It is fairly possible that the differences in fibre composition will show up in the EMG response also. One study had even attempted to predict fibre composition from Power Spectral Density function of EMG signal and blood pressure (7).

This study was conducted to investigate the differences in power spectral characteristics of rectus femoris muscle among sprinters and long distance runners and the feasibility of using electromyographic techniques in categorization of muscle groups in slow dominant and fast dominant types.

METHODS

The study was conducted on nine sprinters (Age 24.9 + 3.2 yrs; ht: 172.0 + 4.8 cm; wt.: 63.1 + 4.5 kg) and five long distance runners (Age: 25.8 + 1.3; ht: 172.8 + 4.1 cm; wt.: 59.4 + 5.6 kg). These volunteers were all top class Indian athletes. Each subject was positioned on a table according to the methods described by Kendall and Kendall (8). Rectus femoris muscle of the right leg was tested during maximal isometric contraction by knee extension at an angle of 150°.

At the time of recording each subject did hold MVC for 1 min. Bipolar Ag/AgCl electrodes (8 mm contact area) were placed longitudinally over the belly of rectus femoris keeping 5 cm inter-electrode distance. The reference electrode was placed on the forehead. EMG signals were recorded by Sensor Medics Dynograph (R612) using a coupler whose frequency range was 5.3 Hz to 1 Hz). Four signals were recorded from each subject: 1st – when the subject just reached MVC; 2nd – at 20th sec; 3rd – at 40th sec and the 4th – at 60th sec of contraction. The signal was digitized at a sampling rate of 4 KHz. For each signal 3000 data points were stored (9). The digitization rate of 4 KHz was used to widen the power spectrum, so that the differences between the groups are enlarged.

The data were processed with Fast Fourier Transform (FFT) software and Hamming window function. At a time 512 data points were analysed to obtain a power spectrum periodgram and five such consecutive periodgrams were averaged and used to calculate mean power frequency. Mean Power Frequency (MPE) was defined as the ratio between the spectral moments of one and zero (10). Root Mean Square (RMS) value of 3000 data points from each signal was also calculated.

RESULTS

When RMS values were plotted against time significant decline from 190.9 ± 84.3 to 133.5 ± 54.0 microV was noticed (P<0.05) in case of sprinters (Fig. 1). Long distance runners failed to show any noticeable changes during sustained MVC that fluctuated from 89.0 ± 21.7 to 92.4 ± 7.3 microV. However, a significant difference (P<0.05) was found in RMS voltage between sprinters and long distance runners.

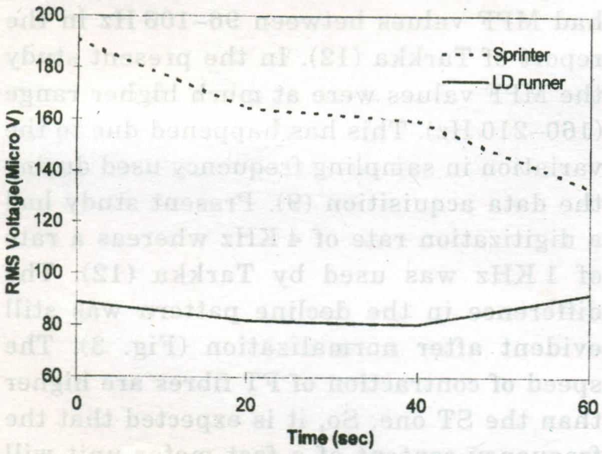

Fig. 1: Changes in RMS value of EMG during sustained MVC contractions of rectus femoris in athletes.

MPF of the signal has been shown in Fig. 2 as absolute values and in Fig. 3 as normalized values to the maximum frequency were plotted. Normalization was done to avoid the difficulties of comparison, which arise in the case of absolute values.

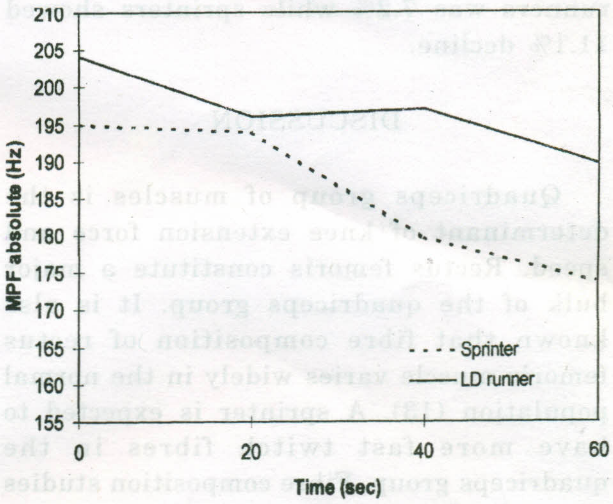

Fig. 2: Changes in MPF value of EMG during sustained MVC contractions of rectus femoris in athletes.

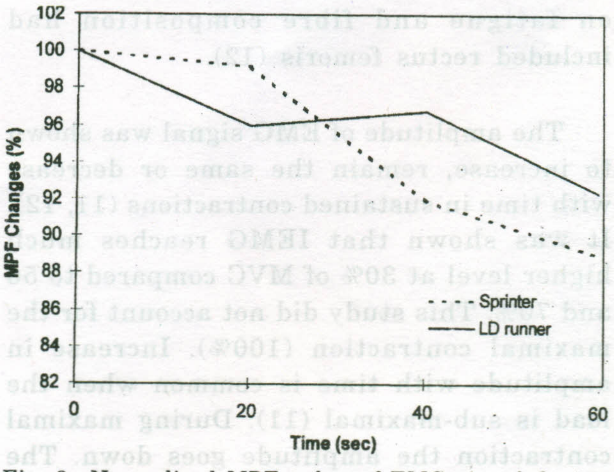

Fig. 3: Normalised MPF value of EMG signal during sustained MVC contractions of rectus femoris in athletes.

Both groups showed declining trend and more in the later half of the sustained contraction (after 30s of MVC) and diminution in sprinters was rapid. Normalized graph shows the differences in the decline pattern much more clearly. Overall reduction in MPF for long distance runners was 7.2% while sprinters showed 11.1% decline.

DISCUSSION

Quadriceps group of muscles is the determinant of knee extension force and speed. Rectus femoris constitute a major bulk of the quadriceps group. It is also known that fibre composition of rectus femoris muscle varies widely in the normal population (13). A sprinter is expected to have more fast twitch fibres in the quadriceps group. Fibre composition studies (through biopsy) in runners have dealt with this muscle occasionally, more attention was given to vastus medialis and vastus lateralis (1, 2). However, some of the EMG studies on fatigue and fibre composition had included rectus femoris (12).

The amplitude of EMG signal was shown to increase, remain the same or decrease with time in sustained contractions (11, 12). It was shown that IEMG reaches much higher level at 30% of MVC compared to 50 and 70%. This study did not account for the maximal contraction (100%). Increase in amplitude with time is common when the load is sub-maximal (11). During maximal contraction the amplitude goes down. The amplitude characteristics of the present study provides a similar observation. This fall in amplitude occur due to fatigue of the fast twitch fibres and a subsequent reduction in size and number of active motor units. Slower reduction of amplitude in long distance runners is possibly due to the less fatigability of the slow twitch fibres. A significant difference in the RMS voltage between sprinter and long distance runners is in correspondence to the higher force development (for acceleration) in sprinters.

A number of studies on different muscles have shown that MPF decline coincides with the appearance of fatigue during isometric contractions (14, 15). Viitasalo and Komi (11) had reported that decline in MPF is faster at 70% MVC than 50% and 30% MVC. It was also shown that the rate of decline in MPF is much higher in the muscles containing more than 50% of FT fibres. The same trend was shown by other workers (4, 16) in fatigue studies on biceps muscle, which is normally referred as fast muscle (rich in FT fibre). The MPF decline pattern of the present study is well matched with the previous studies. Rectus femoris muscle had MPF values between 96–106 Hz in the report of Tarkka (12). In the present study the MPF values were at much higher range (160–210 Hz). This has happened due to the variation in sampling frequency used during the data acquisition (9). Present study had a digitization rate of 4 KHz whereas a rate of 1 KHz was used by Tarkka (12). The difference in the decline pattern was still evident after normalization (Fig. 3). The speed of contraction of FT fibres are higher than the ST one. So, it is expected that the frequency content of a fast motor unit will be at higher side. MPF at just the beginning of contraction has not shown any significant difference between sprinters and long distance runners. This may happen when more number of fast MU's were recruited at the beginning of contraction and then shifts to slower units as soon as the fast unit become fatigued.

Although muscle biopsy was not done in the present study careful selection of the subjects from elite Indian runners did ensure some distinction in muscle composition between the groups. It is more than possible that the EMG response observed in this study was a result of differences in the muscle fibre composition of the athletes. It could be said that EMG study using spectral characteristics would be useful in categorizing the sports persons in terms of suitability of the events. However, it needs further research to form a norm of the decline pattern for such categorization.

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