ELECTROMYOGRAPHIC ACTIVITY OF ELITE 100M ATHLETE BEFORE AND AFTER BREAKING RECORD – A CASE STUDY

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The purpose of this study was through the fractal dimension analysis of an elite 100M ahtlete EMG signals before and after the competition. Results showed that the fractal dimension of athlete's EMG signals were apparently different at different training states. In addition the fractal dimension of athlete's EMG signals were identical at the different training loads. The fractal dimension of EMG signals from different muscle groups of the same athlete accomplishing the same movement were relatively stable. However the fractal dimension of EMG signals at different contractile states of muscles were apparently different at the same training phase.

KEY WORDS: EMG signals, training phase, fractal, fractal dimension

INTRODUCTION: There are a lot of training methods and specific exercises that can be selected in sprinter's training. But if they were implemented in a wrong way, it would produce negative effects. Therefore, the selection of training means generally conforms to the consistency principle of dynamics. But during training the identification and evaluation of dynamics consistency are mainly manipulated by athlete's movement, self-feeling and some kinematics parameters. Electromyographic activity (EMG) might reflect the conditions of muscular activities controlled by CNS, and muscles might impart the information of their changes in length and contractile speed to the brain via proprioceptors. Hence, the athletes' training states should be assessed by qualitative parameters of muscular work.
The athletes at different training levels have different electromyographic activity during muscles contraction, which is conclusion verified by experimental results of many people. When performing explosively muscular contraction, the high level athletes generally appear the phenomenon of synchronous discharge, but the people without training experience are often at the condition of asynchronous discharge.
, The purpose of this study is to apply muscular characteristics in the guidance of training using indexes of surface EMG. Surface EMG could assess the single muscular group's activity in the movement.

METHODS: In this study isokinetic device (Biodex, USA) which segmental moment equal-speed measuring system was employed to measure moment of the right knee extension. At the same time, EMG system (Cadwell sierra TM EMG/EP) was used to measure the surface electromyography signals of right leg's rectus femoris, vastus medialis, vastus lateralis. The knee extension moment and the surface electromyography signals were recorded.
The placement of surface electrodes was performed as follows: skin preparation, the Ag-AgCI electrodes were filled with conductive paste when alcohol dries up, then, the electrodes are fixed on skin with medical plaster. The diameter between electrode outer edges Φ=8mm, the distance between two electrodes d=20mm.
The isotonic movement of knee extension of subject is tested with four angular velocities: 60°/s, 120°/s, 180°/s, 240°/s.
The method used in the study is kinds of spectrum analysis with the needed datum characteristics of short data.
The corresponding energy's spectrum S(ω) of time-dependent signal with characteristics of fractal is generally in the following way:

$$S(\omega) \propto \frac{1}{\omega^{\alpha}} \qquad 3\text{-}1$$

α is a positive real number To one dimensional time sequence signal-fractal dimension can be denoted as the following

$$D_f = \frac{5 - \alpha}{2} \quad 3\text{-}2$$

Apparently, the bigger α, the energy is much more concentrated in lower frequency band, and the smaller corresponding fractal dimension

Getting logarithm from 3-1

$$\log S(\omega) \propto -\alpha \log \omega \quad 3\text{-}3$$

so 3-1 is in the way of general linear, then obtaining the slope in the form of average.

Electromyo-signal's fractal dimension. During the experiment, we organized the same tests on an elite athletes at different training phases. The pre-test was made before his breaking national record when he was at higher level of competitive form in specific preparative phase. The post-test was implemented after he broke the national record when he is at lower level of competitive form, in the state of fatigue and in transitional phase.

The athlete's electromyographic activities were apparently different at different training phases. The phenomenon reflected that when athlete is at higher level of competitive ability, the organism is in its optimum state, and the changes in electromyographic activity is also in exact timeliness, in which the athlete's agitation of layer of cortex is accurately and quickly concentrated in space and time. All of these reasons make a strict discharging regularity in electromyo-signal time-dependent. In this phase, the athlete's muscular activities are highly coordinated. When athlete makes explosive contractions, a large numbers of motor fibers are activated into activity at the same time, so synchronous discharges occur. At this phase, the time-dependent of electromyographic activity might be expressed as bigger pulse amplitude, the athlete's movement-associated motor nerves and their target motor units get close each other, so a large number of motor units can be activated. Further more, these motor units might receive nervous pulses at similar rhythms from motor nerves. Therefore, when athlete is performing speed-strength movement, the controlling ability of motor nerves is comparatively higher, and the electromyographic activity regularity on its time-dependent is higher too. In transitional phase, the athlete's competitive ability and the organism's functions are at their lower levels, the controlling ability of motor nerves is comparatively lower, so the majority of motor units could not be activated into or exit from activities. At this time muscle fiber's asynchronous discharge and smaller pulse amplitude of muscular discharge in the electromyographic activity in time-dependent appear, and the discharging pulse signals are in chaos.

In this study, fractal dimension calculations was made on the electromyographic activity at different training phases. The results showed that there are prominent differences in the fractal dimension of athlete's electromyographic activity at different training phases. The athlete has different electromyographic fractal dimension under the same load and movement at the different training phases.

Table 1 The Electromyographic Activity in Fractal Dimension of an Elite Athelets at different Training Phases

time	Training phases	$\bar{x} \pm S$ different loads
before competition	Specific preparation	1.6406±0.1057
after competition	Transition	1.9756±0.0835

As shown in Table 1, the functional level of athlete's organism reached higher level at the specific preparation phase before competition. At this time, athlete's competitive ability also reaches higher level. The athlete's competitive ability means that, the combinative ability of fitness, skill, intelligence and psychological competence also reaches higher level. The combinative ability out of the synergetic effect of competitive ability's various indexes, at this very time, exceeds the significance of maximum value of single moment index. When athlete’s competitive ability reaches higher level, the electromyographic activity in fractal dimension during concentric muscular contraction was lower. However, when athlete’s competitive ability is at lower level, e.g., at transition phase, the electromyographic activity in fractal dimension during concentric muscular contraction is higher.

Table 2 The Electromyographic Activity in Fractal Dimension of an Elite Athletes at Different Training Phases and at the State of Muscular Relaxation

time	Training phases	$\bar{x} \pm S$ (different loads)
Before competition	Specific preparation	7.2760±0.0915
After competition	Transition	6.8160±0.0562

As Table 2 shows, the athlete’s competitive ability was at its higher level at the specific preparation phase, and the muscular activity is at its state of relaxation, the electromyo-signal’s fractal dimension is higher. However, the athlete’s competitive ability is at its lower level at the transition phase, and the muscular activity is at its state of relaxation, the electromyo-signal’s fractal dimension is lower.

CONCLUSION: The electromyographic activity in fractal dimension of different loads was fundamentally identical. The electromyographic activity in fractal dimension was not affected by loading magnitude.

The athlete’s electromyographic activity in fractal dimension was lower at the specific preparation phase before competition, and in the state of muscular concentric contraction. However, the athlete’s electromyographic activity in fractal dimension was higher in the state of muscular relaxation. When athlete was at the transition phase, and in the state of muscular concentric contraction, the electromyographic activity in fractal dimension was higher. The athlete’s electromyographic activity in fractal dimension was lower in the state of muscular relaxation. The athlete’s electromyographic activity in fractal dimension could quantitatively describe athlete’s functional state at different training conditions.

The electromyographic activity in fractal dimension of different muscle groups of the same athlete performing the same movement were comparatively stable.

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