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Biochemical Index Monitoring of Sprinters' Pre-Competition Training Load in Forest and Functional State

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Abstract:

In order to analyze and compare the changes of biochemical indexes of Sprinters in pre competition training in forest , this paper studies the biochemical indexes of Sprinters' pre competition training load in forest and functional state with sprinters preparing for track and Field Championships as the research object. In order to evaluate the rationality and scientificity of pre competition training load and functional state, the biochemical indexes such as hemoglobin (HB), serum creatine kinase (CK), blood urea (BU) and serum testosterone (T) were tested and monitored during 8-week pre competition training. The results show that during the whole pre competition training period, the T value of male and female athletes decreased first and then increased steadily, which was at a high level before the competition. Therefore, the high-intensity special technical training is the main reason for the significant decrease of HB value of sprinters. Special quality training, especially strength training, is easy to cause the CK activity of sprinters to increase significantly. Large amount of special quality training is the main reason for the increase of Bu value of sprinters. From the analysis of Bu value changes of female athletes in the whole training stage, female athletes are not suitable for the coach's training plan and need to be adjusted. The athlete’s value is at a high level before the competition, which shows a good training effect.

***Keywords**: Sprinters, forest training, biochemical indexes, training load, functional status.*

I. INTRODUCTION

Human beings have a huge activity system, which is composed of muscles, joints, bones and nerves. This system helps humans accomplish many complex tasks. Muscle is the main component of human movement. Muscles, like other parts of the body, receive instructions from the brain and transmit electrical signals through nerves. This electrical signal commands the muscles to contract in a harmonic way. Any defect of the muscle system will affect the human movement and task ability. The main role of muscle in sprint makes the research focus turn to muscle and its function. Muscle strength and fatigue are two important muscle functions. These indicators can affect the probability of sports injury of sprint players [1]. However, how to measure or estimate these indicators. The appearance of electromyography (EMG) signals enables researchers to record electrical signals in muscles. This concept becomes the cornerstone of measuring muscle activity. However, processing the recorded EMG signals to extract muscle strength and fatigue has exposed many problems [2].

The assessment and extraction of muscle function plays an important and basic role in orthopedics doctors, biomechanists and physiotherapists. An important example of the nature of muscle activity is muscle stroke. Among them, stroke is mainly caused by disability in many countries [3]. In Hong Kong, 25000 kinds of stroke occur every year, resulting in 3000 deaths and severely disabled survivors [4-5]. In addition, there were 5.7 million stroke cases in the United States in 2004. In addition, according to the statistical data of the American Heart Association Council, the prevalence of stroke increased to 6.4 million in 2006 [6]. This example is evidence of most muscle activity in medicine. Over the past decade, muscle function has inspired researchers to develop effective methods to evaluate and extract these functions. These methods vary according to the algorithms and tools they use. However, all of these methods are constructed with EMG signals. EMG signals precede the data that can be analyzed and mined to obtain muscle function [7]. Electromyography (EMG) signals precede many information about muscle activity and can be used to analyze muscle function, such as muscle strength. Muscle strength estimation is important for orthopedics, biomechanists and physiotherapists because of joint contact forces. On the other hand, the analysis and classification of clinical biomechanics are often too complex to fully understand. Research Based on object debris has led to scientific progress [8]. Among them, it is easier to divide objects into smaller parts of subsystems. With the increase of the number of variables describing the object, the calculation is simplified by a manual method. These arterial approaches are used for different approaches and can solve difficult problems. Artificial method is an important way to solve biomechanical problems. Muscle strength and fatigue are the common functions of manual analysis. These two functions (strength and fatigue) are important in muscle activity because they are the opposite. Muscle strength is the strength of a muscle. However, fatigue is a degradation of power generation capacity. The study of these two factors may have a deeper understanding of muscle modeling methods [9].

Based on the evaluation method of artificial intelligence arm muscle strength and muscle fatigue using EMG signal, this paper discusses the sports injury model of sprint players' physical fitness training. Muscle fatigue index showed that muscle strength decreased during

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sprint. On the one hand, the new model is conducive to the estimation of muscle fatigue, on the other hand, it can also be used for any arm muscle. The model uses the original EMG signal without any signal processing steps, as in our previous model. However, it uses fuzzy logic instead of genetic algorithm.

II. MATERIALS AND METHODS

Fifteen healthy male sprint volunteered to participate in this study. All the subjects didn't have any history of musculoskeletal complaints. Their age range (20-50) years, mean weight 84.75±15 Kg and mean height 175±8.5 cm. All the subjects were in good condition at the start of the experiments. Right hand, biceps brachii and triceps brachii muscles (Table 1) of each volunteer were included in this experiment. Differences in age of the subjects were chosen to investigate the effect of age on muscle fatigue. Differences in age of the subjects were chosen to investigate the effect of age on muscle fatigue, therefore according to the ages of our volunteers; we divided them into three groups as illuminate in Table 2.

TABLE I. Muscles location and their actions

MUSCLE NAME	LOCATION	ACTION
Biceps brachii	on the upper arm between the shoulder and the elbow	flexes the elbow and forearm
Triceps brachii	on the back of the upper limb	extends forearm

TABLE II. Age groups of volunteers

GROUP	AGE RANGE (YEAR)
A	20-29
B	30-39
C	40-49

All the exercise procedures carried out according to the Helsinki Declaration. The subjects consented to exercise after a fully explained about the purpose and procedures of the experiment. They gave written informed consent [10].

1. The surface EMG signals were obtained from the right biceps brachii and triceps brachii muscles;

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2. The skin was cleaned gently with alcohol and shaved carefully to improve the electrode-skin contact;

3. Six surface EMG electrodes (M-OO-S), were placed on the muscles according to standard procedures perpendicular to the fiber direction and away from the muscle innervation zone;

4. Two channels, two EMG preamplifier cables (ME6P) and EMG Bio-monitor (ME6000 8ch.) device were used to record the electrical activity of the muscles.

5. The signals were preamplifier, rectify and filtered using a band-pass Butterworth filter (l-500Hz) and 2000 Hz sampling rate.

Subjects were asked to perform two isometric exercises, each one for a muscle (biceps brachii, triceps brachii). After putting the surface electrodes on the right dominant arm, the experiment began by measuring EMG signals of each volunteer for lifting weight exercise (2.7 Kg), each exercise consists of three periods of which lasted 5 min, about 2 min of rest time was allowed between. The three periods represent the beginning, middle and final stages of lifting exercises of maximum voluntary contraction (MVC). Because there is no direct method to estimate muscle fatigue. Figure 1 shows the structure of arm muscle. We compare our results with the mathematic equations. Moreover, we ask our volunteers to repeat the exercise after one week to be sure of the data is still the same for everyone. The two exercises, shown in Fig. 2, can illustrate as follow:

Biceps-brachii muscle exercise: upper arm sits on a horizontal surface, as in Fig. 2A, the forearm flexed from the horizontal position to a 900 angle vertical on elbow point, carrying 2.7 Kg in the hand.

Triceps-brachii muscle exercise: upper arm fixed to the top, horizontal to trunk and parallel to the head, as in Fig. 2B, the forearm flexed backward from the vertical position to a 90° angle horizontal with the head, carrying 2.7 Kg in the hand.

An EMG signal was recorded from the subjects during the three-consecutive activity of the muscles (biceps brachii, triceps brachii). The three exercises represent the signal activity of the muscle at the beginning, middle and final of the experiment to show the difference in signals at constant MVC levels. Mean power frequency (MPF) obtained by programming it by MATLAB using the equations mentioned above.

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Our proposed Fuzzy Fatigue Model (FFM), as we have mentioned, consists of two parts (fuzzy network); the first part estimates the MPF from the EMG signals. This part or fuzzy network shows the change in muscle activity due to muscle fatigue according to changes in the frequency domain, the second part estimates the muscle fatigue index from the original signals (raw EMG) without any processing applied to it. The schematic architecture of our whole processing is depicted in Fig. 3.

Different number of nodes and layers, and different types of function were examined for the two networks of FFM. The configuration of the research model, the number of inputs, nodes, epochs, membership and type functions that were used in each part is shown in table 3.

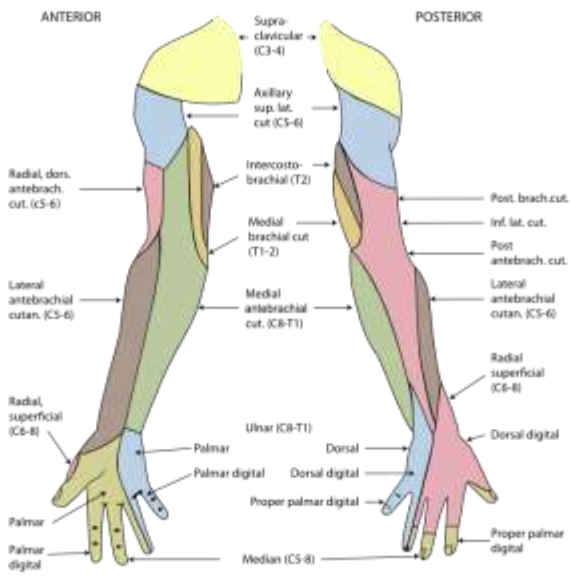

Fig 1: The structure of arm muscle

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Fig 2: Sprint experiment

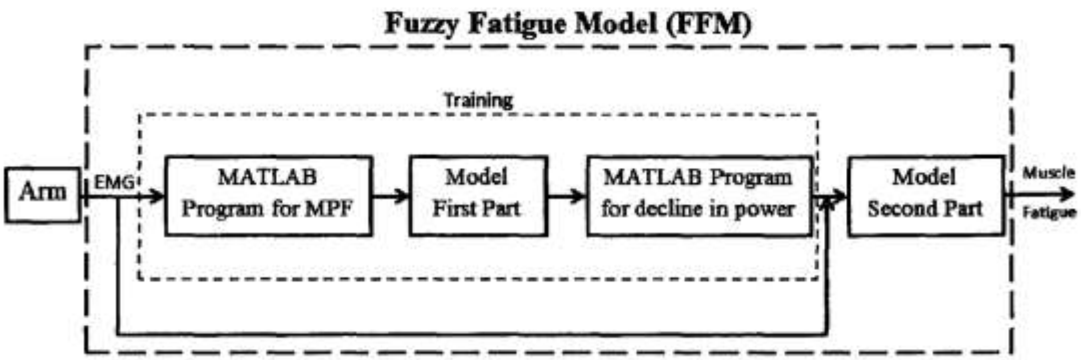

Fig 3: Our method schema

TABLE III. The configuration parameters of the FFM

CONFIGURATION	PART 1	PART 2
Number of inputs	2	3
Epochs	4000	5000
Membership	2	3
Nodes	3 in each member	3 in each member
Function	Gaussian, Generalized bell	Gaussian, Generalized bell, Gaussian

III. RESULTS AND DISCUSSIONS

In this section we will present our results and discussion according to the sequence of our work procedures. This section is divided into four parts, calculation of MPF, estimation of fatigue index, change in fatigue according to age, and qualification of our models. In fact of the raw EMG signal is stochastic in nature; it can used with the equations mention above to calculate mean power frequency (MPF).

Fatigue curves change between individuals depending upon the conditions that exist. Two different sites at least may cause impairment due to repeated contractions in muscular fatigue: transmission mechanism and contractile mechanism. As the mechanical response of the muscle fibers decline with fatigue, this can be affected by the number of active motor units and/or increasing the innervation frequency. Peripheral muscle fatigue reasons are mutated in the muscle conditions. These reasons are biochemical or the accumulation of metabolites. Biochemical can be illustrated as depletion of substrates (glycogen), compounds of high energy phosphate in the muscle fibers and terminal motor nerve branches acetylcholine.

The aim of this work is to distinguish or predict muscle fatigue degree at each time during a given task. In this chapter, we have deployed a new and easy Fuzzy Fatigue Model (FFM) that extracts fatigue index from raw EMG signal during the voluntary contraction. The proposed method consists of two networks; the first network estimates the mean power frequency (MPF) to represent the preceding background activity. The second network extracts fatigue index as demonstration of muscle power decline. The mean power frequency (MPF) is employed as an index to represent the background activity. Our model takes the EMG signal; convert it into muscle fatigue index without the complexity of converting from using mathematical equations. We used human arm in dynamic motion to predict the flow of EMG signals from the biceps and triceps brachii muscles. Finally, we have studied the relation between human age and muscle fatigue.

FFM consists of two fuzzy networks. The first fuzzy network educes MPF from EMG signal. The first fuzzy network impost the MPF curves, which can be used to locate shift points in MPF slopes. The second fuzzy network imposts the muscle fatigue index as the drop in muscle power for three periods of lifting task, by using shifting points in MPF curves. Our proposed model input is the raw EMG signal for three periods, which represent the beginning, middle and final stages of lifting exercises of maximum voluntary contraction (MVC).

The output from this operation was used in the first part of FFM training. As illustrated in Fig. 4, a comparison between the first part of FFM and theoretical calculations to extract the MPF curve of biceps brachii muscle. This curve showed the relationship between MPF and muscle fatigue. The area under the curve represents EMG power (muscle power) of the voluntary at maximum voluntary contraction (MVC). As clearly demonstrated in Fig. 4 the

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muscle power decreased with increasing of subject exercise periods. In a middle period curve, the area under the curve (muscle power) decreased with shifted to the low frequency range. Also in a final period curve, muscle power decreased more than the previous stage of lifting exercise when subject start feeling of fatigue. Fig. 4 illuminates a gradual shift of the muscle power from high to low frequency range as muscle activity continued.

Moreover, the success of our FFM (first part) to extract the MPF of the muscle from raw EMG signals, without the necessity of using the long mathematical operations. Fig. 5 shows the same results in Fig. 4, the only difference is MPF estimation was done on the triceps brachii muscle. On the other hand, it showed the decline in muscle power was more than the power drop of biceps brachii muscle. The main purpose of this work is to map muscle fatigue index. After MPF estimation from FFM (first part), the point of the start of frequency decline can be easily nominated in MPF curve, as shown in the dash line in Fig. 4 and Fig. 5. This data used in FFM (second part) training. FFM (second part) elicit three points assimilate the decline in MPF for the three periods of lifting exercise (beginning, middle and final). These three points represent the drop in muscle power, which mean the shift points in frequency, which known as muscle fatigue index.

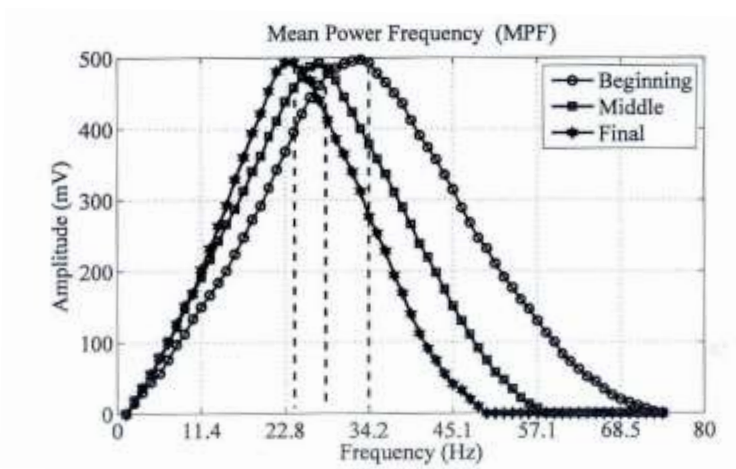

Fig 4: MPF outputs: comparison between FFM (first part) and theoretical calculation for biceps brachii muscle for the three periods of lifting exercise

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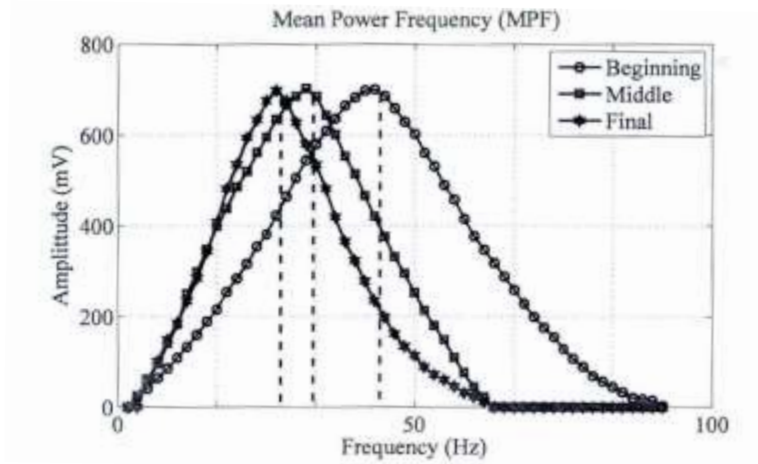

Fig 5: MPF outputs: comparison between FFM (first part) and theoretical calculation for trieps brachii muscle for the three periods of lifting exercise

Fig. 6 and Fig. 7, shows the muscle fatigue index for biceps and triceps brachii muscles respectively. Moreover, it shows the drop in muscle power in triceps muscle more than the drop in biceps muscle. One of the important things to mention, our FPM mapping muscle fatigue index as output using raw EMG signal as only input, without any need of signal processing or utilization of mathematical equations complexity. Our input data for FFM divided into three part training, testing, and validation taken 60%, 20%, and 20% respectively. Qualification of Fuzzy-Model tested by root mean square error (MSE) and regression. Our FFM succeed to overpass 0.999 in the regression and 10-5 in MSE. FFM first part regression equal to 0.99998 and MSE = 1.064 * 10-8. FFM second part regression equal to 0.99955 and MSE = 1.11 * 10-6.

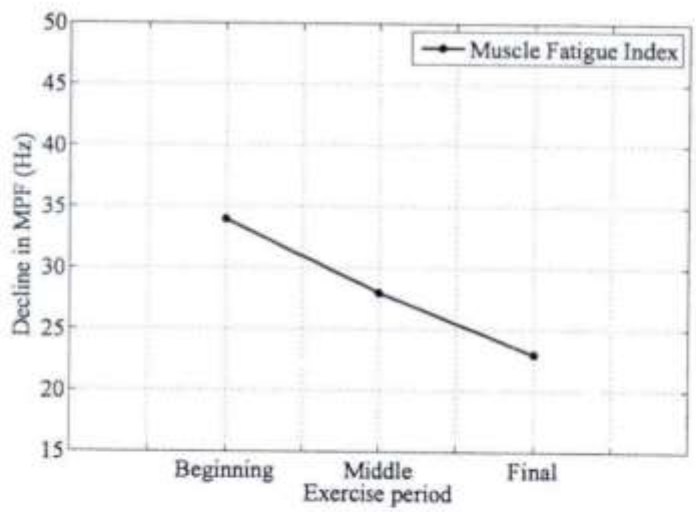

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Fig 6: Muscle fatigue index for biceps brachii muscle

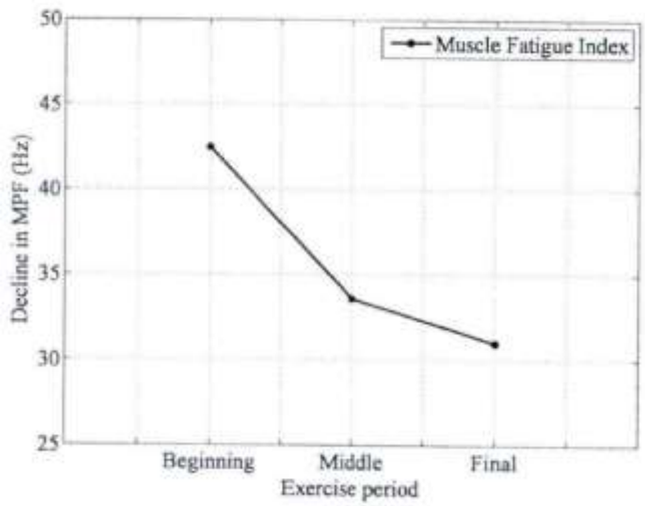

Fig 7: Muscle fatigue index for triceps brachii muscle

IV. CONCLUSION

In the past decade, utilizing EMG signal to estimate fatigue was widely speared large number of studies was conducted in this field. In this work we proposed Fuzzy Fatigue Model (FFM) which impost muscle fatigue index by mean of the raw EMG signal. FFM consists of two fuzzy networks. The first fuzzy network educes MPF. The second fuzzy network imposts the muscle fatigue index. Our proposed model input is the raw EMG signal for three periods, which represent the beginning, middle and final stages of lifting sprint exercises of maximum voluntary contraction (MVC). Muscle fatigue index showed a decline in muscle power during the periods of lifting exercise. Also describe the relationship between preceding MPF and downgrade in muscle power (fatigue degree) at each time of exercise. The novelty of our model it uses raw EMG signal as input without any necessity to normalize by signal processing. Moreover, impost muscle fatigue index as output without any mathematical operation requirement. Our results show that triceps is more likely to be injured because it is less used in sprint. Therefore, triceps brachii fatigue and injury risk is higher than biceps brachii. Older sprint players are more prone to fatigue than younger ones. The percentage of decrease of biceps brachii muscle strength was between 20% and 42%. The decrease rate of biceps was about 1% higher than triceps.

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