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Training fatigue and recovery of Wushu Sanda athletes based on comprehensive environmental testing

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Abstract

Wushu Sanda is a practical fighting skill and a new modern competitive event. Under certain conditions, they use kicking, hitting and wrestling as the main means according to certain rules. A good Sanda athlete should have good physical quality and special skills. Given the continuous change and revision of Sanda rules, the means to reduce the number of injuries sustained by athletes, tap their potential and prolong their sports life has become an urgent priority. During the training process, the coaches should use a guided and inspiring educational model to enable athletes to think positively and rationally. It is necessary to clearly understand the physical conditions of the body, combine the special characteristics of the Sanda movement and adopt effective prevention and recovery methods. This paper takes the sports fatigue of Sanda athletes as the research goal. To this end, we use physical, biochemical and psychological indicators and means to comprehensively monitor athletes' sports fatigue. In order to improve martial arts training, improve the physical health of martial arts athletes and improve the athletes' competitive level.

Keywords: Wushu exercise; fatigue recovery; physical health

1 Introduction

Wushu Sanda is a practical fighting skill and a new modern competitive event. Under certain conditions, they use kicking, hitting and falling as the main means according to certain rules [1]. The project has strong antagonism, fierce competition, strong intensity of sport and varied movements. It has dynamic and non-periodic characteristics [2]. For most athletes, sports injury is inevitable. Even if Wushu Sanda athletes insist on training with injuries, it is difficult for them to improve their technical level because they are affected by injuries [3]. This will in turn affect their entry into the ranks of Wuying athletes and narrow their development space [4]. Dynamic fatigue in the human body can be divided into physical fatigue and psychological fatigue. Fatigue is a complex physiological and psychological activity-process [5]. In recent years, the domestic research on

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the monitoring of sports fatigue of Sanda athletes has been mainly limited to physiological and biochemical aspects, while ignoring the psychological regulation [6]. As a result of inadequacy in the research delving into the psychological ramifications of sports injuries sustained by Sanda athletes in the course of combat, there is a lack of comprehensive and scientific judgment of sports fatigue. At high intensity, the athlete's speed, strength, ability to fight, dexterity, balance, etc. are quite high. Sanda athletes are more prone to sports fatigue and injury than athletes in other sports [7].

The Wushu Sanda movement is developing in a more intense and exciting direction. This puts higher demands on the athlete's physical and psychological qualities, which indirectly increases the incidence of sports injuries [8]. An excellent Sanda athlete should have good physical fitness and special skills. The acquisition of these qualities and abilities requires years of hard work, even decades [9]. Sports injuries often occur during training, disrupting the normal training and competition of athletes. Wushu Sanda is highly confrontational, with a high concentration of attention and a large proportion of nerve energy consumption [10]. At the same time, the energy consumption is high and lactic acid is increased. The increase of lactic acid and the decrease of glycogen can cause central fatigue. This paper takes sports fatigue of Sanda athletes as the research objective [11]. Using physiological, biochemical and psychological indicators and means, the athlete's sports fatigue is comprehensively and scientifically monitored [12]. The aim is to make full use of these modern scientific means to evaluate the physical and psychological fatigue of Sanda athletes in training, and to explore and discover the mechanism of athletic fatigue, in order to reduce the occurrence of injury accidents in training competitions, protect athletes' health and prolong their sports life.

Given the continuous change and revision of Sanda rules, the means to reduce the number of injuries sustained by Sanda athletes, tap their potential and prolong their sports life has become an urgent priority [13]. This paper studies the injuries associated with Wushu Sanda from the angle of training, aiming to explore the causes of injuries sustained by Sanda athletes, and the larger context of the combat rules against the backdrop of which they are typically sustained. Some training countermeasures and suggestions are put forward to provide a scientific theoretical basis for preventing and reducing sports injury and improving the effectiveness of training. In the investigation and study of sports injuries of Wushu Sanda athletes, many experts and scholars believe that the causes of sports injuries should be carefully studied, and means have been proposed to prevent sports injuries [14]. Exercise fatigue is manifested not only in the physical aspect but also in the psychological aspect. In addition to monitoring athletes' related physiological and biochemical indicators, psychological monitoring is also an important and indispensable link [15]. Wushu Sanda sports training includes different techniques such as boxing, leg method, wrestling and kicking. When athletes use these techniques intensively, it imposes a strain on different parts of their body, in addition to causing generalised muscle fatigue. Only an in-depth analysis of the main causes of athletes' sports fatigue, as well as an understanding of various recovery methods and methods of dissipating sports fatigue, can facilitate the scientific development of sports training programmes. In order to more effectively improve the performance of Sanda athletes and the level of competition of Sanda athletes, it is imperatively necessary to carry out such an analysis.

In this paper, we propose an athlete fatigue and recovery algorithm based on fatigue damage model, which is a new algorithm for the fatigue and recovery of martial arts athletes.

To summarise, our contributions are the following:

1. This algorithm is a new technology based on the comprehensive environmental test for the fatigue and recovery of Wushu athletes.
2. This paper puts forward a new model for Wushu athletes' fatigue and recovery. Using physiological, biochemical and psychological indicators and means, the athletes' sports fatigue is monitored comprehensively and scientifically.
3. This technology is widely used in athletes' fatigue and recovery. It can ensure a comprehensive physical and psychological evaluation of sports fatigue of Sanda athletes in training, and explore and discover the mechanism of sport fatigue of Sanda athletes.

2 Related Work

Mccall *et al.* [16] carried out a statistical analysis on the data collected by Wushu Sanda sports injury through questionnaires. The results showed that the incidence of contusion and bruising in toe, leg and knee joint was higher. Tang *et al.* [17] investigated 50 male students majoring in Sanshou in Wushu Department of Physical Education College. The location of injury was found in the order of wrist, knee, toe, ankle and finger according to the susceptibility. Most of the students are injured at the joints, the joints poorly tolerate the exercise and the exercise is excessive.

Senefeld *et al.* [18] used a special questionnaire survey to study the damage caused by the action of ‘whipping legs’ in Sanda. It was found that in the Sanda exercise, the types of injuries caused by the ‘whip legs’ were mainly sprains, strains and strains of the lower extremity joints, ligaments and soft tissues. Based on this, the corresponding countermeasures and suggestions are put forward. Bruton *et al.* [19] analyses the feasibility of the new rules and the impact on the development of Sanda by investigating the injuries of athletes in the competition [19]. The relationships between head injury and absence of head protector, trunk injury and technical movements, calf and dorsum injury and normal training were analysed. With the rapid development of Sanda, the amount and intensity of competition and training are increasing. The consequent sports injuries pose a considerable challenge to athletes’ normal sports training and restrict the further improvement of their competitive level. Frequent occurrence of injuries also affects the promotion of Sanda among the Chinese people and abroad.

3 Materials and Methods

The degree of sports injury is divided into acute injury and chronic injury according to the course of injury. According to the severity of the injury, it is divided into mild injury, moderate injury and severe injury. Massage – static stretch – jogging combination relaxation is a simple and easy way to eliminate fatigue. People don’t know enough about central fatigue. The current research has learned that the central fatigue should be more specifically restored, by regulating the central nervous system, reducing sympathetic excitability, increasing the excitability of the vagus nerve, strengthening the anabolic function of the body and allowing the body to recover as soon as possible. In the Wushu Sanda exercise, the combatant repeatedly uses the leg method to attack [20]. When landing, if the centre of gravity is unstable, or if the combatant’s bodily posture is tilted to one side or they have stepped on someone else’s foot, the athlete’s centre of gravity will be on the front and outside of the foot; this would result in varus and cause lateral collateral ligament injury. Among these susceptibilities for injury, the anterior talofibular ligament is the most vulnerable. If the strength of the anterior talofibular ligament is greater, the calcaneofibular ligaments will be injured one after another. If the external force of the injury continues to increase, the interosseous ligament between the calcaneofibular joint will be injured at the same time. Good and adequate sleep is the most direct, effective and economical way to eliminate fatigue. When the human body sleeps, the excitability of the cerebral cortex is the lowest, and the body’s metabolism is the most vigorous, which is conducive to the accumulation of energy in the body. Figure 1 is the recovery training after Wushu exercise fatigue.

In the Sanda competition, the athletes constantly kicked, beat and fell in 2 min to fight vigorously, and the muscles suffered a high impact. If an athlete fails to undergo timely and effective recovery but remains under constant tension, it will directly affect the athlete’s muscle movement. This will eventually lead to constant fatigue, resulting in a situation in which the body cannot continue to be competent for normal work and effective play. The prevention of Sanda injury should start from the field, strengthen the safety of the stadium and improve the willpower of the Sanda athletes. The increase of blood urea nitrogen (BUN) after exercise and the recovery after exercise are related to the duration, intensity, type of exercise, training level and gender of exercise load, and the change law can be used for the performance evaluation of athletes. It is generally believed that the BUN value of skilled fighters is the highest, and that of Sanda athletes is higher than that of other athletes. Through the inductive language, the practitioner can mobilise his limbs to move under the guidance of the idea. By hinting



Fig. 1 Recovery training after martial arts fatigue

at the advanced centre, the muscles are relaxed, the respiratory and circulatory systems are improved and the fatigue of the body is eliminated as soon as possible.

Although the injury rate of Sanda athletes in the training ground is higher than that in the competition field, in a certain training cycle, the training time of Sanda athletes in the training ground is much longer than that in the competition. The beneficial structure of motor functional plasticity is shown in Figure 2.

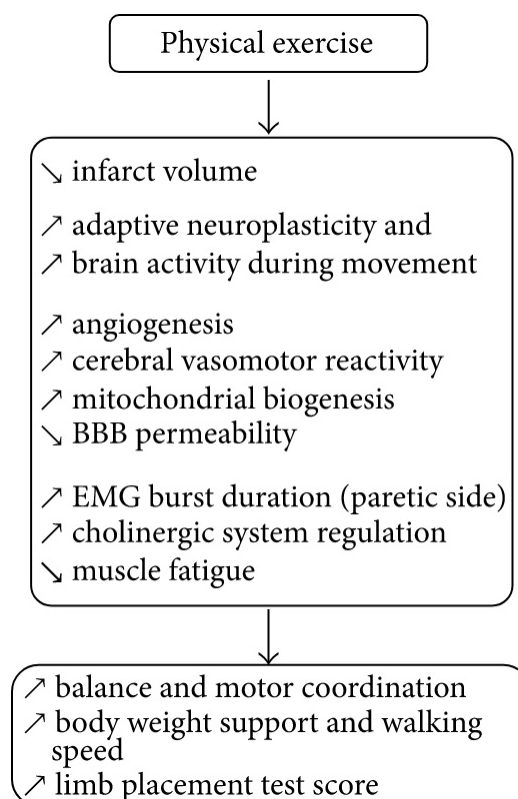


Fig. 2 The beneficial structure of the motor function plasticity

The diagnosis of sports fatigue is accomplished by coaches and athletes in coordination. It is an important part of scientific training plan to select suitable and simple methods to scientifically diagnose the occurrence and degree of Wushu athletes' fatigue. Fifty Wushu athletes were invited to participate in the experimental test. The basic data of the athletes are shown in Table 1.

Table 1 Basic data of athletes

Gender	Number	Age (years)	Height (cm)	Weight (kg)
Male	25	18 ± 1.64	176 ± 0.59	69 ± 2.14
Female	25	18 ± 1.31	162 ± 0.71	51 ± 1.95

Scientific improvement of dietary structure is the basic guarantee for improving physical fitness in Sanda training. It is an important aspect of athletes' training to reduce fatigue and eliminate fatigue as soon as possible once it is brought about. The critical fusion frequency of flash is often used as an index to judge exercise-induced fatigue. Visual acuity is a basic function of the eye and can be used as an index of visual fatigue and mental fatigue. Traditional Chinese medicine supplementation method is necessary to eliminate sports fatigue, and it also promotes the supplementation of nutrients. There are many ways of eliminating sports fatigue in traditional Chinese medicine. The use of one method alone can only lead to limited results. Only by comprehensive application can we achieve better results. Easy to digest food should be selected in the diet. To supplement protein, we can eat animal proteins such as eggs, sausages and fish. Some athletes defend their opponent's thighs or waist and abdomen by way of defending their opponents. They use their calves to lift their knees to defend their opponent's offense. The collision should be on the calf. Some athletes are accustomed to using dexterous dodge and guerrilla-like play to win, so that the frequency of using the ankle joint increases, the load increases and it is easy to cause damage. If the preparatory activities are insufficient, the functions of the athlete's central nervous system and internal organs will not be fully mobilised. The muscles are characterised by low temperature, poor elasticity, poor coordination of the body and poor flexibility of movement. As a result, athletes are prone to damage.

The human body system model provides a tool for studying the fatigue recovery of martial arts athletes, and increases the research scope of martial arts athletes' fatigue recovery. Model parameter identification assumes that a data observation point is obtained. The model is:

$$p(x,y) = \frac{\sum x_1 y_1 - n \bar{x} \bar{y}}{(n-1)s_x s_y} = \frac{n \sum x_1 y_1 - \sum x_1 \sum y_1}{\sqrt{n \sum x_1^2 - (\sum x_1)^2} \sqrt{n \sum y_1^2 - (\sum y_1)^2}} \quad (1)$$

We make the output of the model best predict the output of the system and obtain an estimate of the parameter:

$$d(x,y) = \sqrt{(\sum (x_1 - y_1)^2)} \quad (2)$$

The formula for calculating integral EMG is as follows:

$$T(x,y) = \frac{x \cdot y}{\|x\|^2 \times \|y\|^2} = \frac{\sum x_1 y_1}{\sqrt{\sum x_1^2} \sqrt{\sum y_1^2}} \quad (3)$$

In the process of detecting and evaluating the biochemical indexes of Wushu athletes, a data observation point is obtained under the assumption of model parameter identification. The model is:

$$\omega_j = d_j / \sum_{j=1}^p d_j = (1 - e_j) / \left(p - \sum_{j=1}^p e_j \right) \quad (4)$$

The amplitude of the signal in the motion test is reduced relative to the pre-test. The spectrum overlay recorded before and after the exercise at the end of the break and exercise is shown in Figure 3.

Judging fatigue by subjective feeling alone is inaccurate and there is a certain error involved in making such subjective mental judgements. Coaches should also be able to – more accurately – understand the athlete's adaptation to training volume and training intensity through the detection of biochemical indicators. This would facilitate timely and accurate adjustment of the training program. Table 2 shows the results of testing the athlete's physical indicators.

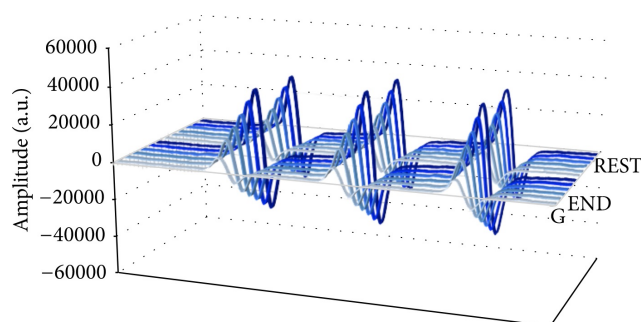


Fig. 3 Spectrum overlay image recorded at rest and end of exercise

Table 2 Test results of athletes' physical indicators

Index type	1 h before training	Immediately after training	6:30 the next day
Blood urea (mmol/L)	5.412	8.436	5.815
Blood testosterone (ng/dL)	742.9	701.8	744.5
Haemoglobin (g/L)	151.41	131.74	147.68

Sanda athletes' boxing, leg movement, wrestling and their combination training together constitute a fierce form of exercise. The sudden cessation or continuous movement after muscle burst exertion will affect human oxygen supplementation and venous blood reflux. It lowers blood pressure and causes adverse reactions. Athletes' load varies with their development, competitive level, health status, daily rest, psychological status and other factors. Athletes need tens of millions of repetitive exercises for each technical action in order to establish a good conditioned reflex and dynamic stereotyping. Athletes are engaged in both intense contact attack and defence, and defensive counterattacks [21]. If you are slightly negligent, you will be knocked down or injured. Athletes are required to have a high concentration of attention and the ability to withstand a high level of mental stress. Athletes consume a lot of nerve energy, which leads to fatigue. The load intensity using the continuous training method is relatively small, but the load is large. It stimulates the body more slowly, and the fatigue is slower. However, if you do not make positive adjustments after the load, it will cause physical fatigue and damage. Athletes should strictly abide by the prescribed work schedule and pay attention to food hygiene. They should also create good sleep conditions to improve sleep quality and overcome bad habits such as smoking and drinking.

4 Result Analysis and Discussion

Since there are many reasons for fatigue, and there are differences in individual participants' sports ability, the analysis of fatigue must be considered comprehensively. Fatigue should also be targeted for elimination in such a way that the means used for removing fatigue has taken into account the cause responsible for it. The causes for fatigue that occurs during participation in the Wushu Sanda sport are multi-directional and thus require a comprehensive analysis. Wushu Sanda is a direct contact and confrontation between the two sides. It is inevitable that injury occurs in the process of training and competition. If an athlete does not train or compete in the condition that the injury is not treated well, it will not only aggravate the original injury, but also enhance the likelihood for a repeated injury in the same region at a later point in time, since the injured region, although healed, would have become a near permanent vulnerability zone. Sugar, protein and fat are the three major energy sources for exercise. Athletes' intake of these three kinds of energy source should be based on the principle of high sugar, high protein and low fat. From the point of view of traditional Chinese medicine, the fatigue of Sanda athletes in sports is caused by excessive consumption of human blood and gas in sports. To eliminate fatigue as soon as possible, there is a need to accelerate the metabolism of the body, so that the

athlete's physical fitness returns to the original level. In addition to having to replenish the right amount of water and food, you must also add gas and blood. In daily training, the coaches should urge the athletes to carry out active treatments in order to ensure that the physical condition of the injured athletes does not get permanently affected, and this would go a long way in ensuring that a situation is avoided wherein the athletes are hounded by regrets of being unable to perform martial arts exercises for life.

The EMG value was measured for two groups of different martial arts athletes. An independent sample test was performed on the EMG values of the two groups, and the data of the two groups were found to have very significant differences. The maximum EMG values of different groups of martial arts athletes are shown in Table 3. The electromyogram values of the various stages of the subjects in different contraction modes are shown in Table 4 and Figure 4.

Table 3 Maximum EMG values of different groups of martial arts athletes

	Weight (kg)	EMG value
Group 1	71.12 ± 2.08	146.11
Group 2	69.79 ± 1.95	159.54

Table 4 EMG values of each stage of the two groups of different contractions

	Stage 1	Stage 2	Stage 3	Stage 4
Dynamic contraction	0.231	0.224	0.259	0.227
Static contraction	0.139	0.174	0.152	0.163

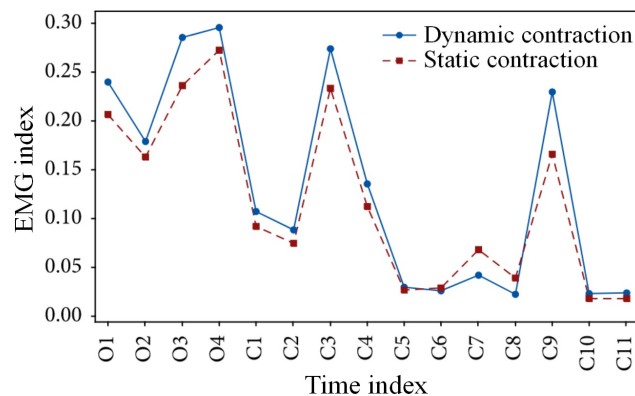


Fig. 4 EMG values at various stages of the subject in different contractions

The monitoring of exercise fatigue should take into account the large differences between individual athletes. Maintaining the right skills and tactics and body posture is an important part of preventing sports injuries. Incorrect technology implies that athletes violate the physiological structure of the human body, the laws of various organ activities and the principles of motion mechanics due to technical defects and errors. People's attention will be disturbed by the external environment, and they will be disturbed because of the emotional fluctuations in the heart. This is the psychology of ordinary people. Sanda athletes may also be inattentive due to factors such as personality. Attitudes of audiences can hinder concentration; and impatience, neglect of enemy combatants and over-consideration of individual gains and losses can also distract athletes' attention. Psychological training is an important part of Sanda training, because Sanda is a fighting sport that combines boxing, leg movement and wrestling with the opponent under high intensity physical exertion and mentally stressful conditions. It is necessary to improve the level and intensity of athletes' psychological activities and their ability of emotional

regulation through psychological training. It is also necessary to help athletes master and improve their motor skills and eliminate their physical, mental and psychological fatigue.

In Wushu sports training, the representation model of joint proprioception changing with time can be expressed by polynomial function.

$$LnGDP_t = \alpha_0 + \alpha_1 Trend + \alpha_2 D_{1t} + \alpha_2 D_{2t} + \alpha_3 D_{3t} + \mu_t \quad (5)$$

In the actual analysis process, it is only necessary to obtain a number of joint active activity measurement data under the intensity of martial arts training. The corresponding joint flexion activity and the activity of varus and eversion in the dynamic equilibrium state can be obtained, as follows:

$$i_t = (1 - \rho) [r^* + \pi_t + \alpha(\pi_t - \pi^*) + \beta(y_t - y_t^*) + \gamma e_t + \delta m_t] + \rho i_{t-1} + \xi_t \quad (6)$$

The following formula is used to express the deformation of each joint surface at the joint position under inertial load:

$$E_{RME} = \sqrt{\frac{1}{P} \sum_{p=1}^P (E_p)^2} \quad (7)$$

The haemoglobin value can be used as an indicator for determining the amount of exercise. Generally, when the exercise is intense or the load is too strong, the haemoglobin is temporarily decreased. The connection weight between the input layer, the hidden layer and the output layer neurons and the neuron closure value are assigned initial values. We randomly select input and output data and submit these to the network. The output of each neuron in the hidden layer is calculated as follows:

$$i_t = r^* + \pi_t + \alpha(\pi_t - \pi^*) + \beta \tilde{y}_t \quad (8)$$

If haemoglobin returns to normal after a break, the body can adapt to training. The response of the output layer neurons is calculated as follows:

$$i_t^* = r^* + \pi_t + \alpha(\pi_t - \pi^*) + \beta(y_t - y_t^*) + \gamma e_t + \delta m_t \quad (9)$$

Using the given output data, we calculate the error of output layer neurons as follows:

$$i_t = (1 - \rho) i_t^* + \rho i_{t-1} + \xi_t \quad (10)$$

If haemoglobin is still at a low level after recovery training, it means that the body cannot adapt to the amount and intensity of training or has excessive fatigue or low level of physical function. We make the output of the model best predict the output of the system and obtain an estimate of the parameter:

$$i_t = \alpha_c + \rho i_{t-1} + \alpha_{\pi} \pi_t + \beta'(y_t - y_t^*) + \gamma' e_t + \delta' m_t + \xi_t \quad (11)$$

$$i_t = \alpha_c + \alpha_{\pi t} \pi_t + \beta_t'(y_t - y_t^*) + \gamma_t' e_t + \delta_t' m_t + \xi_t \quad (12)$$

There was a significant difference in the peak moment of metatarsal flexion muscle between the two phases. Comparisons of flexion moments at different joint positions and at different time periods are shown in Figure 5. The phase change of dynamic contraction EMG of the two groups of Wushu athletes is shown in Figure 6.

In the process of training, coaches should use the educational mode of guidance and inspiration to enable athletes to think positively and rationally. There is no linear relationship between the contribution of the three joints and the pressure, and the contribution does not increase or decrease linearly with the increase of the pressure, as indicated in Figure 7.

Owing to the many changes in body posture and complicated movements involved in martial arts during training, martial arts athletes generally require athletes to be full of emotions, focus, and internal and external

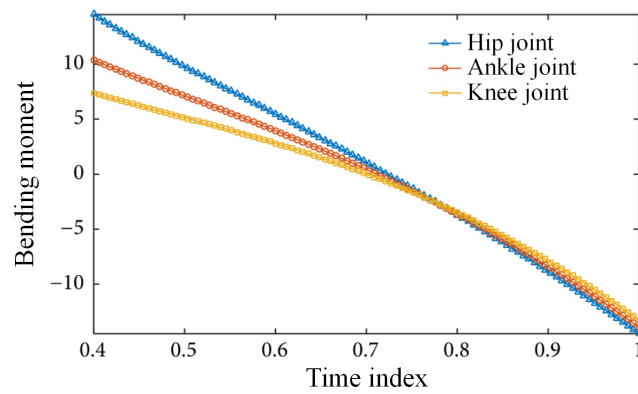


Fig. 5 Comparison of flexural moments of different joints at different time points

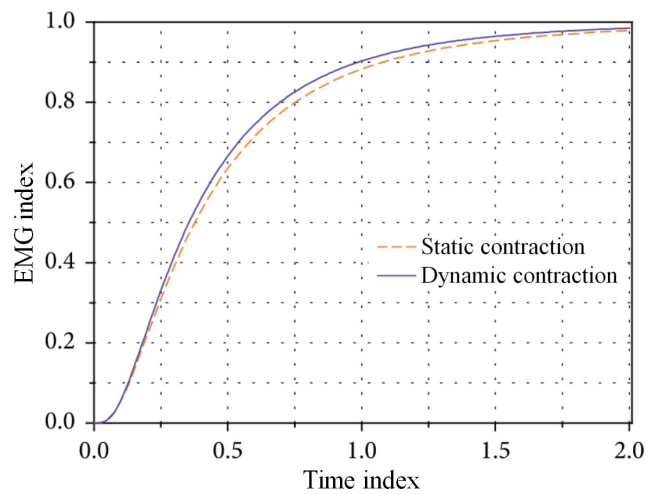


Fig. 6 Changes in the contraction muscle electrical value of two groups of martial arts athletes

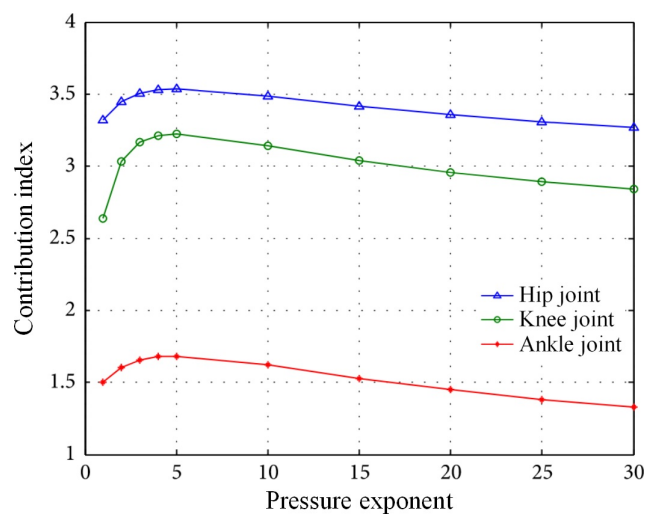


Fig. 7 Three joint contribution and pressure data

unity, both in form and spirit, consciousness and breathing. In this long-term monotonous training situation, athletes are under tremendous psychological pressure. It is easy to generate resistance to training and cause a downfall in training interest. In the long run, it is easy to cause psychological fatigue of athletes. After the intensive exercise, according to the diagnosis of the athlete's psychological fatigue phenomenon and the performance characteristics of the fatigue symptoms, the targeted use of the psychological fatigue recovery method has a positive effect on the timely elimination of the athlete's psychological fatigue [22]. Through positive and rational thinking, athletes can turn pressure into motivation and train more actively. In this way, by investigating the causes responsible for the sports fatigue sustained by Wushu athletes, we can train athletes to adjust their psychological state suitably, enabling them to alleviate and even eliminate fatigue.

It is also important to analyse how injuries take place. Athletes' injuries are mainly caused in the process of sports training, and their incidence was 78%, whereas the incidence of injury was 18%. Damage caused by other reasons in spare time accounted for 6%. Therefore, the prevention and treatment of sports injury focuses on the period of sports training, as shown in Table 5.

Table 5 Basketball player sports injury type data

Injury stage	Number of injured	Proportion (%)
Train	39	78
Match	9	18
Amateur	3	6

The coaches' accurate grasp of the main events of the athletes can ensure a perceptible improvement in the effect of training and inspire the athletes with complete confidence in the future development of their skills. And then, we need to stimulate the athletes' long-term and stable training motivation to achieve the effect of eliminating psychological fatigue. Wushu involves quick and forceful moves, especially in the waist and legs. Massage on these parts can relax muscles, improve local blood circulation, increase joint activity and promote the excretion of metabolites. Massage manipulation is mainly kneading, which can effectively reduce muscle tension, and eliminate muscle stiffness and athletes' fatigue. The recovery process is as important as the training process. The experiment found that some traditional Chinese medicine decoctions have perceptible effects on the recovery of sports fatigue of Sanda athletes. This holds good especially for athletes who are over-tired due to high-intensity, high-volume training and competition. By drinking traditional Chinese medicine decoctions, it is indeed possible to eliminate fatigue as soon as possible. The main purpose of recovery is to eliminate fatigue, and its progress is related to the athlete's physical condition and athletic ability. Training athletes to consciously adopt positive thinking helps them to overcome the physical and mental pain caused by sports injuries, and shortens the time required for rehabilitation exercises aimed at optimising their mental state and eliminating mental fatigue.

5 Conclusions

Every Sanda athlete should have a sense of self-prevention. It is necessary to clearly understand the physical conditions of the body, combine the special characteristics of the Sanda movement and adopt effective prevention and recovery methods, to improve the quality of training, performance and level of competition. Comprehensive monitoring of exercise fatigue using physiological and biochemical indicators and psychological indicators is better than a single use of physiological and biochemical indicators or psychological indicators. This paper reviews the development mechanism, diagnostic methods and restoration measures of sports fatigue of martial arts athletes. Let trainers and athletes understand the symptoms of fatigue at any time during training, and take timely and effective recovery measures to eliminate fatigue. To improve Wushu training, there is a need to improve the physical health of Wushu athletes as well as their competitive level, and such measures would

provide them with good help. In the process of Sanda training and competition, coaches and athletes must attach great importance to psychological fatigue, and create a tense and orderly, relaxed and moderate, positive atmosphere. The physical fatigue of athletes can be effectively eliminated by means of stretching exercises and massage, warm water bath, sleep and nutrient supplementation. Athletes' psychological fatigue recovery is achieved by means of conversation, objective training objectives and psychological recovery training. A good psychological state has a positive impact on delaying the emergence of sports fatigue and the recovery of fatigue.

References

- [1] Liossis L D, Forsyth J, Liossis C, et al. The Acute Effect of Upper-Body Complex Training on Power Output of Martial Art Athletes as Measured by the Bench Press Throw Exercise[J]. *Journal of Human Kinetics*, 2013, 39(1):167-175.
- [2] Kim D Y, Seo B D, Choi P A. Influence of taekwondo as security martial arts training on anaerobic threshold, cardiorespiratory fitness, and blood lactate recovery.[J]. *Journal of Physical Therapy Science*, 2014, 26(4):471-474.
- [3] Jiang C, Olson M W, Li L. Determination of biomechanical differences between elite and novice San Shou female athletes[J]. *Journal of Exercise Science & Fitness*, 2013, 11(1):25-28.
- [4] Del Rosso A, Paoletti G, Calà, M, et al. THU0592 Efficacy of Rehabilitation with TAI JI Quan on Disability, Quality of Life, Pain, Psychological Distress, Sleep in an Italian Cohort of Patients with Fibromyalgia Syndrome[J]. *Annals of the Rheumatic Diseases*, 2015, 74(Suppl 2):412-415.
- [5] Juan R S, Mateo C, Pieter W. The effect of training on mood in Filipino national elite and varsity taekwondo athletes: A pilot study[J]. *Asia Life Sciences*, 2014, 23(1):311-315.
- [6] Jaber M Y, Givi Z S, Neumann W P. Incorporating human fatigue and recovery into the learning–forgetting process[J]. *Applied Mathematical Modelling*, 2013, 37(12-13):7287-7299.
- [7] Chen J, Davis K G, Daraiseh N M, et al. Fatigue and recovery in 12-hour dayshift hospital nurses[J]. *Journal of Nursing Management*, 2014, 22(5):593-603.
- [8] Oba T, Ishikawa T, Takaishi T, et al. Hydrogen peroxide decelerates recovery of action potential after high-frequency fatigue in skeletal muscle[J]. *Muscle & Nerve*, 2000, 23(10):1515-1524.
- [9] Ghasemi M, Bagheri H, Olyaei G, et al. Effects of cyclic static stretch on fatigue recovery of triceps surae in female basketball players[J]. *Biology of Sport*, 2013, 30(2):97-102.
- [10] Engebretsen L, Soligard T, Steffen K, et al. Sports injuries and illnesses during the London Summer Olympic Games 2012[J]. *British Journal of Sports Medicine*, 2013, 47(7):407-414.
- [11] Tabben M, Chaabane H, Franchini E, et al. The influence of karate practice level and sex on physiological and perceptual responses in three modern karate training modalities[J]. *Biology of Sport*, 2014, 31(3):201-207.
- [12] Jing M J, Wang J J, Lin W Q, et al. A community-based cross-sectional study of fatigue in middle-aged and elderly women[J]. *Journal of Psychosomatic Research*, 2015, 79(4):288-294.
- [13] Bartis E A J, Luan P, Knoll A J, et al. Polystyrene as a model system to probe the impact of ambient gaschemistry on polymer surface modifications using remote atmospheric pressureplasma under well-controlled conditions[J]. *Journal of Sol-Gel Science and Technology*, 2015, 64(3):711-717.
- [14] Alcaraz P E, Matinlauri A, Abedinmaghanagi A, et al. A Comparison of the Isometric force fatigue-recovery profile in two posterior chain lower limb tests following simulated football[J]. *British Journal of Sports Medicine*, 2017, 51(4):282-285.
- [15] Nakanishi T, Tomii Y, Hachiya K. Time-dependent photoluminescence fatigue-recovery phenomena in germanium sulfide glasses[J]. *Electrochimica Acta*, 2013, 100:304-310.
- [16] Mathieu Nédélec, McCall A, Carling C, et al. Recovery in Soccer[J]. *Sports Medicine*, 2013, 43(1):9-22.
- [17] Ge D J, Qi B, Tang G, et al. Intraoperative Dexmedetomidine Promotes Postoperative Analgesia and Recovery in Patients after Abdominal Colectomy: A CONSORT-Prospective, Randomized, Controlled Clinical Trial[J]. *Medicine*, 2015, 94(43):10-15.
- [18] Senefeld J, Yoon T, Bement M H, et al. Fatigue and recovery from dynamic contractions in men and women differ for arm and leg muscles[J]. *Muscle & Nerve*, 2013, 48(3):436-439.
- [19] Jan Lännergren, Håkan Westerblad, Bruton J D. Dynamic vacuolation in skeletal muscle fibres after fatigue[J]. *Cell Biology International*, 2002, 26(10):911-920.
- [20] Han K, Trinkoff A M, Geiger-Brown J. Factors Associated With Work-Related Fatigue and Recovery in Hospital Nurses Working 12-Hour Shifts[J]. *Workplace Health & Safety*, 2014, 62(10):409-414.
- [21] Coelho A C, Cannon D T, Cao R, et al. Instantaneous quantification of skeletal muscle activation, power production, and fatigue during cycle ergometry[J]. *Journal of Applied Physiology*, 2015, 118(5):646-654.
- [22] Hou C W, Tsai Y S, Jean W H, et al. Deep ocean mineral water accelerates recovery from physical fatigue[J]. *Journal of the International Society of Sports Nutrition*, 2013, 10(1):7-9.

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