

FATIGUE AND THE RECOVERY WAYS IN ATHLETE RUNNERS

FADIGA E SUAS VIAS DE RECUPERAÇÃO EM CORREDORES ESPORTISTAS

LA FATIGA Y SUS VÍAS DE RECUPERACIÓN EN CORREDORES DEPORTISTAS



ORIGINAL ARTICLE
ARTIGO ORIGINAL
ARTÍCULO ORIGINAL

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ABSTRACT

Introduction: With the continuous development of running, great changes have occurred in training media, equipment, and training concepts. Running fatigue and recovery have increasingly become the direction of research by scientists worldwide. **Objective:** In this paper, the mechanism, causes, and measures of biological recovery in athletes during training are discussed. **Method:** The effects of different interventions on athletes' recovery after training were analyzed through protocolized experiments. Effective methods of fatigue recovery were presented. The study compared the variables of the sprinter's morning heart rate, blood pressure, body temperature, CK, BUN, RPE, and other indicators to understand the recovery of middle and long-distance runners after training. **Results:** Recovery measures are effective when combined with exercise training based on the fatigue mechanism. **Conclusion:** Subjective sensory, physiological, and biochemical indicators are used to judge the intensity of fatigue in exercise training, and the fatigue recovery phase of exercise training is an important item to consider during training activities. **Level of evidence II; Therapeutic studies - investigation of treatment outcomes.**

Keywords: Recovery of Function; Athletes; Fatigue.

RESUMO

Introdução: Com o desenvolvimento contínuo da corrida, grandes mudanças ocorreram nos meios de treinamento, nos equipamentos e conceitos de treinamento. A fadiga e a recuperação da corrida têm se tornado cada vez mais a direção da pesquisa de cientistas em todo o mundo. **Objetivo:** Neste artigo, são discutidos o mecanismo, as causas e suas medidas de recuperação biológica nos atletas durante o treinamento. **Método:** Através de experimentos protocolados, foram analisados os efeitos de diferentes intervenções sobre a recuperação dos atletas após o treinamento. **Métodos eficazes de recuperação da fadiga foram apresentados.** O estudo comparou as variáveis da frequência cardíaca matinal do velocista, pressão arterial, temperatura corporal, CK, BUN, RPE e outros indicadores para entender a recuperação dos corredores de média e longa distância após o treinamento. **Resultados:** As medidas de recuperação são efetivas quando combinadas ao treinamento de exercício baseado no mecanismo de fadiga. **Conclusão:** Os indicadores sensoriais subjetivos, fisiológicos e bioquímicos são usados para julgar a intensidade da fadiga no treinamento físico, sendo a fase de recuperação da fadiga do treinamento físico um item importante a ser considerado durante as atividades de treinamento. **Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.**

Descritores: Recuperação de Função Fisiológica; Atletas; Fadiga.

RESUMEN

Introducción: Con el continuo desarrollo de las carreras, se han producido grandes cambios en los medios de entrenamiento, el equipamiento y los conceptos de entrenamiento. La fatiga y la recuperación en la carrera se han convertido cada vez más en objeto de investigación por parte de científicos de todo el mundo. **Objetivo:** En este artículo, se discute el mecanismo, las causas y las medidas de la recuperación biológica en los atletas durante el entrenamiento. **Método:** Mediante experimentos protocolizados, se analizaron los efectos de diferentes intervenciones en la recuperación de los atletas después del entrenamiento. Se presentaron métodos eficaces de recuperación de la fatiga. El estudio comparó las variables de la frecuencia cardíaca matutina de los velocistas, la presión arterial, la temperatura corporal, la CK, el BUN, el RPE y otros indicadores para comprender la recuperación de los corredores de media y larga distancia después del entrenamiento. **Resultados:** Las medidas de recuperación son eficaces cuando se combinan con el entrenamiento del ejercicio basado en el mecanismo de la fatiga. **Conclusión:** Los indicadores subjetivos sensoriales, fisiológicos y bioquímicos se utilizan para juzgar la intensidad de la fatiga en el entrenamiento con ejercicios, y la fase de recuperación de la fatiga del entrenamiento con ejercicios es un elemento importante que debe tenerse en cuenta durante las actividades de entrenamiento. **Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.**

Descriptor: Recuperación de la Función; Atletas; Fatiga.



INTRODUCTION

The improvement of athletes' training level is gradually realized through the cycle of training-fatigue-recovery-training-fatigue-recovery-cycle.¹ Therefore, training without fatigue is meaningless, and training without recovery from fatigue is harmful. If fatigue is not eliminated in time, it will accumulate into injuries, and injuries will become ill for a long time. This will not only do no good to the improvement of athletes' training level, but also may seriously ruin an athlete's sports career.² As the exercise continues, CP (creatine phosphate) immediately transfers energy to ADP molecule and generates ATP, which continues to decompose for 6 to 10 seconds.³ With the consumption of ATP and CP, the movement gradually supplies energy from the glycolysis system, while producing the metabolite, lactic acid. According to the requirements of the current competitive sports, there is a great challenge to the athletes' physical fitness. Whether it is competition or training, it will be in a critical state.⁴ The characteristics of this fatigue concept are as follows: (1) Combining the functional level of the tissues and organs in the body during fatigue with the exercise capacity to assess the occurrence of fatigue and the degree of fatigue.⁵ (2) It is helpful to select objective indicators to assess fatigue. For example, when heart rate, blood lactate, maximal oxygen uptake and output power work at a certain level, a single indicator or simultaneous change of each indicator can be used to judge fatigue.⁶

Sprint is a sport that consumes physical strength in a short period of time. The physical recovery of athletes in the process of training has a great influence on their competitive results.⁷ Therefore, the relevant personnel must increase the research on the training fatigue of sprinters. At present, there is a widespread problem of neglecting recovery and fatigue elimination. If this problem is not solved, the improvement of athletes' performance will be greatly affected.⁸ Therefore, it is very important to take the recovery and elimination of fatigue in training as an important part of training. But it is not easy to find a suitable and effective way to restore physical strength scientifically.⁹ Therefore, for a long time, although many experts have done a lot of research on the recovery after heavy training, many important problems have not yet been solved.¹⁰ Increasing the rapid strength increases the ability of the muscle to produce the highest contraction speed and maximum strength per unit time to overcome the resistance or reduce the time of muscle exertion.¹¹ The maximum strength depends on the intensity and frequency of the nerve impulses that are introduced into the muscle, depending on the internal coordination of muscle contraction and changes in joint angle.¹² The rapid buffering contraction force means that during the centrifugal phase of the brake, the muscle is actively elongated, and the accelerated restraint phase obtains a shortened centripetal contraction. Reasonable fatigue recovery measures have important practical significance for completing the training program and maintaining and improving the level of athletic competition. This paper makes some superficial discussion on the training fatigue mechanism of sprinters and various recovery measures.¹³

At present, in sprint strength training, fast strength training is mostly used, but there is still insufficient understanding of how to improve sprint strength by maximum strength training.¹⁴ Physiological and biochemical indicators are often used to determine the changes of heart rate, body temperature, blood urea, creatine kinase and other indicators to reflect the fatigue state of athletes.¹⁵ Analyzing the fatigue problems of sprinters after training and finding out the causes of their fatigue can help sprinters recover their physical fitness quickly after training to a great extent.¹⁶ Sprinters have a high training intensity and are extremely prone to fatigue problems during training. Small-range fatigue can be restored by simple rest.¹⁷ The performance of the whole run depends mainly on the reaction speed at the start, the acceleration at the time

of acceleration, the ability to maintain the highest speed while running on the way, and the quality of the technology.¹⁸ It affects the continuous improvement of athletic ability, and even induces the occurrence of sports injuries, which ultimately affects the performance of the game and even the body's athletic ability.¹⁹ Therefore, how to take effective measures to eliminate sports fatigue is a key issue in the development of competitive sports.²⁰ This paper aims to make some superficial discussion on the mechanism and causes of fatigue in athlete training, as well as biological recovery measures, so that coaches and athletes pay attention to this problem.²¹

Related Work

Samaan M A et al. proposed in 2014 that massage can accelerate the body's blood circulation, regulate nervous system function, and accelerate the elimination of metabolites and the release of adhesion tissue. Low-cycle wave can cause muscle tremor, excite glial cells in spinal dorsal horn, and its warm-heat effect can promote telangiectasia, local blood and lymphatic circulation, and improve tissue nutrition metabolism. To achieve the purpose of eliminating training fatigue.²² Michał Chyrchel et al. studied the content and principles of physical training in 2015. It is considered to be a manifestation of the comprehensive physical exercise ability that athletes need to improve their athletic skills, tactical level and create excellent results. The most important physical exercise ability is physical fitness.²³

Leeners B et al. conducted extensive investigation and Analysis on the construction principles of the target system and index system of physical fitness training in competitive sports in 2015. The results show that the construction of physical fitness training target system should follow the principles of pertinence, orientation, emphasizing key points and operability. The construction of physical fitness training index system should follow the principle of "dominance" and make use of all kinds of internal factors. Principle of External Stimulation Development Potential.²⁴ In 2016, Jimenezreyes P et al. conducted principles for the physical training principles of sprinters. Eight principles of genetic superiority, progressiveness, individuality, specialization, creativity, feedback, incentive, and integrity were proposed. Highlight the improvement of special physical fitness and the cultivation of practical ability of comprehensive physical fitness. It is pointed out that the comprehensive specialization and integration of training methods and methods have become the main characteristics of the sports-oriented speed group training. The intensification of competitive sports competition emphasizes the high intensity and high efficiency in training. The training cycle is in the process of diluting the large cycle, strengthening and refining the development of small cycles.²⁵

MATERIALS AND METHODS

The study is Purely observational studies which no need to registry ID of ICMJE, and all the participants were reviewed and approved by Ethics Committee of Luzhou Vocational Technical College, China (NO. 2022011)

The accumulation of lactic acid and carbon dioxide in muscle tissues results in a downward trend of PH value in body function and blood, which hinders the transmission of excitation at the neuromuscular junction. It affects the speed of nerve impulse to muscle, inhibits the decomposition of glycolysis, and reduces the synthesis rate of ATP. Training experts believe that they include sports quality training, physical function training and special body shape training as well as comprehensive ability training. From the perspective of the relationship between physical training and special items, physical training has a phased nature, including basic physical training, special physical training and comprehensive ability training. The physical training content of the sprinters is shown in Table 1. The physical training diagram of the sprinter is shown in Figure 1.

Table 1. Physical Training Contents of Sprinters.

	Combination	Culture
Basic physical training	25.30	18.66
Special physical training	19.75	16.85
Comprehensive physical training	21.43	17.98



Figure 1. Physical Training of Sprinters.

Among the sports quality indicators, there are not only the factors reflecting the maximum speed of athletes, the factors reflecting the acceleration ability, but also the factors reflecting the overall coordinated exertion ability of the explosive force of athletes' legs. It also reflects the speed endurance of athletes. The body is vigorously exercised for a long time. As the metabolic products produced by tissues and organs greatly increase beyond the regulation capacity of the body, it will lead to metabolic acidosis. The pH value drops, and the water and salt metabolism is disordered, causing fatigue. Subjective feelings are judged as shown in Table 2. The judgment of exercise fatigue is shown in Figure 2.

Athletes appear fatigue after a large amount of exercise training. We must improve the efficiency of fatigue recovery through active recovery measures to achieve the purpose of excessive recovery. According to the reaction of the athletes after the test, all the tested athletes showed some conscious symptoms, such as muscle stiffness, swelling and soreness, general weakness and mental retardation. The recovery of training fatigue should go through the process of automatic body repair and improvement. During the training process, they are most prone to hypoxia. Through these nutrients, timely oxygen supply can be achieved. In addition, these nutrients can accelerate the synthesis of ATP and prevent athletes from acidosis. The continuous innovation and scientific application of physical training methods play an important role in promoting the improvement of physical fitness. The statistics of commonly used physical training methods are shown in Table 3. The training method used is consistent with the special action structure of the 100-meter run and the stimulation of the nervous system, which can simultaneously develop muscle contractility and speed.

RESULT ANALYSIS AND DISCUSSION

According to the current study of physical fitness in sports training, the components of physical fitness training include body shape training and functional training. Sports quality refers to the various abilities of athletes' body in sports, mainly including strength, speed, endurance and so on, while strength, speed, endurance and other sports quality. In fact, it is a comprehensive manifestation of the morphological structure, function and metabolic status, and it is the overall sports function of athletes. In turn, the development of sports quality has a certain impact on the shape, structure and function of athletes. The cells in the body are mainly composed of proteins, which are involved in the renewal and repair of cells, and participate in a series of activities

such as transport, immunity, coagulation, memory, and recognition in the body. From the purpose of competitive sports, it is a matter of course for athletes to strengthen their physical strength through active training. The investigation of fatigue recovery measures for 100 athletes is shown in Figure 3.

Set sprinters' 100-metre performance as mother series and sport quality as sub-series, and calculate according to formulas respectively:

$$P_i = \frac{f_i}{\sum_{i=1}^N f_i} \quad (1)$$

$$Y_j(t) = \phi \left(\sum_{i=1}^n w_{ji} x_i - \theta_j \right) \quad (2)$$

Table 2. Diagnosis of subjective fatigue.

	Accuracy	Features
Self perception	0.21	1.52
Complexion	0.28	5.63
Sweat volume	0.32	4.78
Breathing action	0.19	4.59

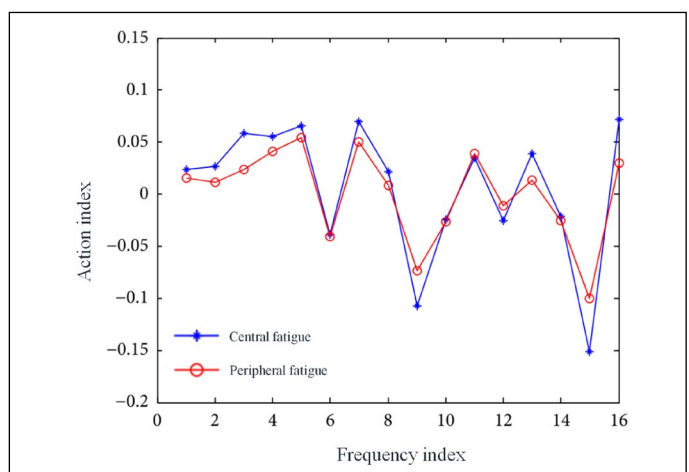


Figure 2. Judgment of Sports Fatigue.

Table 3. Statistics of Common Physical Training Methods.

	Function	Characteristic
Repeated training method	0.15	0.63
Intermittent training method	0.19	1.75
Circulation training method	0.22	1.36
Transform training method	0.21	0.98
Continuous training method	0.23	0.55

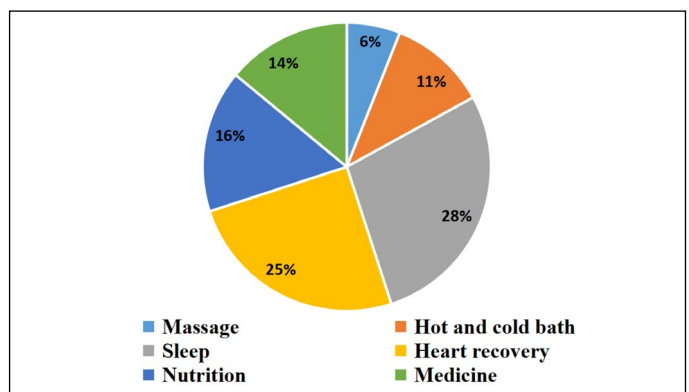


Figure 3. Measures for Athletes' Fatigue Recovery.

Dimensionless, using the mean method, the formula used:

$$o_j(t) = f\left(\left[\sum_{i=1}^n w_{ij} x_i (t - \tau_{ij})\right] - T_{ij}\right) \quad (3)$$

Differentiation Series Between Sports Events:

$$F(x) = \frac{1}{1 + e^{-x}} \quad (4)$$

Finding the Maximum and Minimum Based on the Formula:

$$w = (w_{\max} - w_{\min}) \times \frac{I_{\max} - I_i}{I_{\max}} + w_{\min} \quad (5)$$

$$Cr_{(t+1)} = k \times Cr_{(t)} \times (1 - Cr_{(t)}) \quad (6)$$

Find the correlation coefficient, the formula used is:

$$f_i(x) = \sum_{i=1}^{D-1} \left[100(x_{i+1} - x_i)^2 + (x_i - 1)^2 \right] \quad (7)$$

Calculate the degree of relevance, using the formula:

$$P_i = F(Y_i) = \frac{e^{Y_i}}{1 + e^{Y_i}} \quad (8)$$

According to the formula, the index correlation index reflecting the maximum speed and speed endurance is obtained:

$$Y_i = \alpha + \sum_{j=1}^k \beta_j \cdot X_{ji} \quad (9)$$

Fast power is made up of strength and speed. Available formula:

$$u_1^\beta = y(m_1 + c) + (1 - y)m_1 = m_1 + yc \quad (10)$$

Training content and exercise load change trend according to formula:

$$u_2^\beta = xm_2 + (1 - x)m_2 = m_2 \quad (11)$$

According to the formula, whether the sprint coach has reasonableness in selecting indicators and normalize it:

$$F(x) = 1 / \sum (x_i - x_i^0)^2 \quad (12)$$

Experiments have shown that the step size for the development of the accelerated running phase is mainly to accelerate the running on the slope. The step of the running phase is to set the single step length. The slope is used to advance the center of gravity of the body, so that the

athlete can increase the running speed with a larger step and a higher step frequency. However, the survey found that the coaches rarely use the up and downhill acceleration. The determination of the optimal speed training distance should be based on the athlete's ability to accelerate and the time at which the maximum speed can be maintained. Current research shows that sprinters generally reach maximum speeds 5-6 seconds after starting, that is, when they run to a distance of 30-80 meters. Athletes with high levels of training can maintain a maximum speed of 5-10 meters while on the way. Therefore, we believe that the optimal distance for developing athletes' absolute speed should generally be around 65. But each athlete's ability to accelerate, as well as the ability to maintain maximum speed, is different. The change in speed is shown in Figure 4.

Exercise fatigue is a synthesis of many factors. The change of one or several factors at the same time will interact, leading to fatigue. Therefore, catastrophe theory takes the consumption of energy and material in cells during exercise. When these factors reach a certain level, in order to protect the body from exhaustion, they are manifested in the form of fatigue. Therefore, catastrophe theory is characterized by simple energy consumption. The relationship between energy release and motion is shown in Figure 5. Training methods should be diversified, using different rhythms and different frequencies to complete an action. The same training purpose uses different training methods to practice, so that the central nervous system can establish flexible and diverse conditioning. In order to delay the advent of speed obstacles, fully exploit the development potential of speed quality. The development of speed quality has entered a stable stage. At this time, the corresponding training means will be reduced, which will not only be affected by the speed obstacles, but also help the athletes to combine their own characteristics. This is an important feature of high-level athlete training.

CONCLUSION

Through this paper, we have a preliminary understanding of the training fatigue mechanism and recovery measures of sprinters.

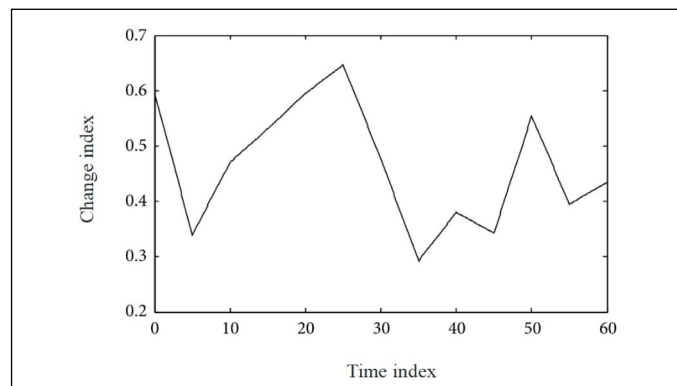


Figure 4. Change in speed.

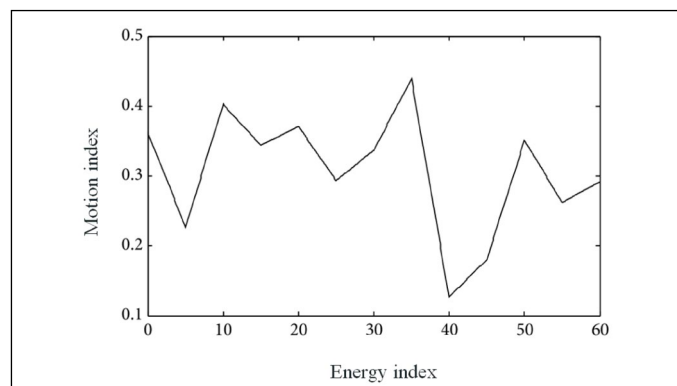


Figure 5. The relationship between energy release and motion.

The main causes of sprint fatigue are energy exhaustion, nerve fatigue, and accumulation of metabolites and micro-injury of muscles. Increase the proportion of physical training time, innovate physical training methods and means, and focus on strengthening the comprehensive physical training of athletes in psychological training and sprint recovery training. To promote the all-round development of athletes' special and comprehensive physical fitness and improve the quality of physical fitness training. Several training methods of fast strength exercises for increasing the number of obstacles and the height of obstacles within a specified time are provided. The idea of fast strength training for Juvenile Sprinters is valid. Through natural recovery, the recovery of training fatigue cannot be promoted, and enthusiasm recovery must be carried out to effectively promote fatigue recovery. It is important to arrange training reasonably. Other measures are only supplementary methods and means. Seeking new methods and ways to eliminate fatigue is a difficult problem in the development

of sports in the world today. It is worth emphasizing that long-term uninterrupted use of the same recovery measures will gradually adapt the athletes' body to reduce the rate.

ACKNOWLEDGEMENTS

The study was supported by the Key Project of National Research Center for Early Childhood Sports Development in 2021, Research on the Training of Physical Education Teaching Ability of College Students majoring in Preschool Education (No. YETY2021A02); Key project of Sichuan Rural Early Childhood Education Research Center, Research on the connection mechanism between pre-school education specialty group construction and preschool teacher demand from the perspective of supply and demand Balance (No. NYJ20210601).

The author declare no potential conflict of interest related to this article

AUTHORS' CONTRIBUTIONS: The author made significant contributions to this manuscript. Qunyng Zhou: writing and performing surgeries; data analysis and performing surgeries; article review and intellectual concept of the article.

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