Mechanism of the Effect of Walking Walk on the Motor Function of Injured Muscles

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Abstract
To study the mechanism of the influence of walking walk on the muscle function of injured athletes. Methods: 10 athletes were selected as reference. The XX Management Center competed for male athletes (8) and a high-level walking athlete (2). Gas metabolism data and muscle electrical signal data were recorded using an active treadmill, a portable cardiopulmonary telemeter, and a surface electromyography collector. RESULTS: The changes in oxygen uptake of the subjects were almost the same as the changes in the intensity of the test protocol. They all increased in a stepwise manner. VO2 initially showed a rapid increase. The general time was between 15 seconds and 25 seconds. After that, VO2 will grow slowly trend. This is consistent with the trend of oxygen uptake in the study test; in the muscle electrical strength performance, each muscle involved in exercise, the number of movement units will be different, but from the overall trend of myoelectric strength It is on the rise; MPF will rise first, and later the decline in MPF may be related to the fatigue of fast muscle fibers and the extra recruitment of slow muscle fibers. Conclusion: By analyzing the indicators of athletes, it is found that the walking movement has a certain degree of influence on the muscle function of the injured muscles. Attention should always be paid to the prevention of various aspects of the athlete's body.

Key words: Injured Muscle, Motor Function, Surface Electromyography

1. Introduction
Muscle damage is more common in intense endurance and strength training (mainly in centrifugal exercise). The main manifestations of exercise-induced micro-injury are: muscle soreness, increased muscle volume, decreased joint activity angle, and reduced muscle strength. The most frequent feature is delayed onset muscle sore, usually 8 to 24 hours after exercise, peaking at 24 to 48 hours, and delayed by about 7 days. When these phenomena occur, the muscles’ working ability will decrease, which will limit muscle work. These problems are often encountered by athletes in training competitions, and sometimes last longer, affecting normal training competitions. Therefore, timely and effective evaluation of the injury and functional state of skeletal muscles after training and recovery of athletes is very important for the normal training and competition.

Many research teams have conducted in-depth research on various adverse reactions to muscle damage. The time course of recovery after exercise-induced muscle injury depends on the degree of initial muscle damage, which in turn is influenced by exercise intensity and duration, joint angle/muscle length and muscle groups used during exercise [1]. Exercises that are unaccustomed for long periods of time involve muscle elongation (eccentricity), which can lead to ultrastructural muscle destruction, impaired contraction coupling, inflammation, and muscle protein degradation. This process is associated with delayed onset muscle soreness and is known as exercise-induced muscle damage [2]. In [3], the authors analyzed muscle damage, lactic acid concentration, energy balance, perceived motor score (RPE), heart rate (HR), and heart rate variability (HRV) in order to determine biochemical and physiological changes in runners after the Super Endurance Mountain Race, body composition changes and jump performance. In [4], the author measured the weight and composition of the three-day multi-level super-endurance triathlon by measuring the body weight and composition by venous blood drawn hormones and muscle damage and blood sugar by hand stick. In [5], the authors used a double-blind and independent group design method. 34 runners consumed BTJ or an isotherm placebo (PLA) for 3 days after the marathon to verify whether the beetroot juice (BTJ) can alleviate the marathon. After inflammation and muscle damage. In [6], the authors diagnosed acute myocardial infarction or myocardial injury by raising the level of plasma cardiac troponin (cTnT) in patients with neuromuscular disease through 122 patients with Pompe disease. In [7], the authors adjusted the maximum speed obtained by the 30–15 Intermittent Health Test (V IFT) to assess acute response and exercise-induced muscle damage in five different high-intensity interval training (HIT) regimens. In [8], the authors disseminated exercise under normoxia, hypoxia and hypoxia (maximum oxygen uptake 70%), and evaluated the inflammatory parameters of vitamin E supplement (250 mg) after simulated hypoxia exercise at an altitude of 4200 m, and the effects of cell damage. In [9], the authors used two cross-study designs to evaluate 15 healthy male college students to assess the role of...
eccentric exercise intensity in the development and recovery of delayed onset muscle soreness (DOMS).

Compared with professional athletes, ordinary sports enthusiasts often have problems such as unscientific training, poor physical quality, weak preparation activities and finishing activities, and the protection of injuries and rehabilitation conditions. These are also likely to make China's long-distance hobby. The sports injury situation is unique. At present, there is still a large sample and large-scale epidemiological investigation on the sports injuries of Chinese long-distance runners. The long-distance running injury assessment system has not been established. Therefore, it is very important and urgent to conduct a series of related research on long-distance running injuries.

Many research teams at home and abroad have conducted in-depth research on the walking movement. Race walking refers to the movement of the knee from the first contact with the ground until the middle position [10]. In [11], the authors studied whether 15 experienced athletes competed on the treadmill at two different speeds (12.0 and 15.5 km/h) and studied the competition criteria and progress rate from the perspective of traditional and coordinated variation. How to influence the race walking kinematics, in [12], the authors examined 11 biceps nerve machines with internationally competitive runners (age 25±11 years old) walking and running on treadmills at speeds between 4.5 and 13.8 km / h. The length of the triceps muscle bundle, electromyography and kinematics data were also recorded. In [13], in order to study the biomechanical constraint model, combined with the advancement of gait analysis and sports learning, the author studies the invariant features and practice-related changes of gait during race walking (RW). In [14], in order to identify changes in kinematics of the proximal and forehead of the calf, the wireless motion recorder (MVP-RF8-BC) was used to estimate reliability during the asynchronous speed of barefoot running on the treadmill. In [15], the author asked 19 athletes to walk on an indoor track and contact two force plates (1000 Hz) while using high-speed camera (100 Hz) to analyze the ground reaction of world-class racial walkers.

In order to study the influence of walking movement on the function of injured muscles, this paper takes aerobic capacity assessment and muscle fatigue analysis as the main research subjects, taking the walking athletes of XX Management Center and a high-level walking athlete of a college as the research object, using active running platform and portable. Cardiopulmonary telemetry and surface electromyography collectors record gas metabolism data and muscle electrical signal data, and export, organize and calculate the recorded data. The athletes were tested for maximum oxygen uptake, and the surface EMG collector was used to collect the EMG signals of the main muscle groups of the lower limbs during the athlete's test. The maximum oxygen uptake is calculated from the data output from the portable cardiopulmonary telemeter and used as an indicator of aerobic capacity. The EMG signals collected by the surface electromyography collector were imported into Matlab for calculation. The EMG intensity index was used to analyze the recruitment of the exercise unit during exercise, and the MPF index was used to evaluate the muscle fatigue during exercise. Correlation analysis was also made between oxygen uptake, myoelectric intensity and MPF.

2. Information and Methods

2.1. General Information

(1) Research object

The subjects of this study were male athletes in the XX Management Center and high-level walking athletes in a university. The basic information and physical parameters of 10 subjects are shown in Tables 1 and 2 (sub A, sub B, sub C, sub D, sub F, sub G, sub H, and sub I are XX management center walkers, sub E and sub J are high-level walkers in a university). There were no lower extremity injuries within 3 months prior to the test, no contraindications to exercise testing, and good health during the test. All subjects volunteered to participate in the experiment. Before the formal experiment, the tester will inform the subject of the contents of the experiment and the precautions in detail, and then agree to sign the informed consent form.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Training special</th>
<th>Training period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub A</td>
<td>5000m</td>
<td>9</td>
</tr>
<tr>
<td>Sub B</td>
<td>5000m</td>
<td>6</td>
</tr>
<tr>
<td>Sub C</td>
<td>5000m</td>
<td>4</td>
</tr>
<tr>
<td>Sub D</td>
<td>5000m</td>
<td>3</td>
</tr>
<tr>
<td>Sub E</td>
<td>5000m</td>
<td>3</td>
</tr>
<tr>
<td>Sub F</td>
<td>1500m</td>
<td>6</td>
</tr>
<tr>
<td>Sub G</td>
<td>1500m</td>
<td>6</td>
</tr>
<tr>
<td>Sub H</td>
<td>1500m</td>
<td>3</td>
</tr>
<tr>
<td>Sub I</td>
<td>1500m</td>
<td>3</td>
</tr>
<tr>
<td>Sub J</td>
<td>1500m</td>
<td>3</td>
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</tbody>
</table>
Table 2. List of basic conditions of subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Height</th>
<th>Weight</th>
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</thead>
<tbody>
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<td>Sub A</td>
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<td>170</td>
<td>60</td>
</tr>
<tr>
<td>Sub B</td>
<td>17</td>
<td>170</td>
<td>51</td>
</tr>
<tr>
<td>Sub C</td>
<td>18</td>
<td>182</td>
<td>66</td>
</tr>
<tr>
<td>Sub D</td>
<td>17</td>
<td>183</td>
<td>61</td>
</tr>
<tr>
<td>Sub E</td>
<td>23</td>
<td>179</td>
<td>62</td>
</tr>
<tr>
<td>Sub F</td>
<td>16</td>
<td>177</td>
<td>55</td>
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<tr>
<td>Sub G</td>
<td>17</td>
<td>182</td>
<td>62</td>
</tr>
<tr>
<td>Sub H</td>
<td>18</td>
<td>185</td>
<td>60</td>
</tr>
<tr>
<td>Sub I</td>
<td>16</td>
<td>175</td>
<td>55</td>
</tr>
<tr>
<td>Sub J</td>
<td>17</td>
<td>185</td>
<td>60</td>
</tr>
</tbody>
</table>

(2) Research methods

Before the formal test, the subjects performed a warm-up activity for 10 minutes, allowing the subjects to perform a warm-up exercise on the running platform to change the slope and fix the slope to change the speed, so that the subject warmed up and became familiar with the changing mode of the running platform. During the experiment, the subjects were running on the treadmill all the time. The cardiopulmonary function telemeter was used to detect the changes of respiratory metabolic gases during the test. The wireless surface electromyography was used to measure the main muscles of the right lower extremity during exercise. Surface EMG signal. The speed and slope will gradually increase until the end of the test.

1) Maximum oxygen uptake test (VO2max Test)

After all the equipments were installed and commissioned, the subjects performed a 5min conventional stretching and then a 6-stage fixed speed (4.5 km/h) to change the slope (initially 10%) of the treadmill warm-up movement, each stage being 20 s and the slope is increased by 2% in each stage, and then the 6-stage fixed slope (10%) is changed (4.5, 6.0, 7.3, 8.6, 9.4, 10.2km/h) to warm up the treadmill. After the preparation is over, connect the Contex MetaLyzer. The 3B portable cardio-respiratory telemeter was later tested on the treadmill.

2) Surface EMG signal

During the maximal oxygen uptake test, the surface EMG data of the main muscle groups of the right lower limb of the subject were collected synchronously. The computerized treatment has time and frequency values that are specific and sensitive to muscle function status, as well as high, medium and low muscle contractions, and are often used for the evaluation of muscle function. In medical experiments, it is used to test the effect of rehabilitation training after muscle injury. In the medical practice, the muscle function level test is combined with the test to test the rehabilitation training effect. The human body undergoes surface electromyography under the influence of muscle injury, muscle strength change and training degree. Test, the test results show surface electromyography changes.

2.2. Laboratory Equipment

Contex MetaLyzer 3B Portable Cardiopulmonary Telemetry (CORTEX, MET AYZER 3B), RUNNER (RUNNER, MDMTR-RUN74110/TR, Italy), Delsys Trigno Surface Electromyography (Delsys, Trigno TPM, 2000Hz, sampling rate) Built-in rectification filter), Polar heart rate monitor, height and weight meter for national physique monitoring (accuracy of 0.1cm and 0.1kg respectively), medical tape, sports bandage, medical alcohol, alcohol tablets.

Configure MetaSoft software with the RUNNER treadmill, the Contex MetaLyzer 3B portable cardio-diameter telemeter, then open the software to calibrate the instrument's oxygen and CO2 sensors with the flow meter, measure the height and weight of the subject, and the measured values are entered in the MetaSoft software. After the surface myoelectric sensor is fixed, it is wrapped and reinforced with a sports bandage. The Polar heart rate sensor section is wetted with water, and the Polar heart rate band is adjusted according to the subject's chest circumference to adjust the Polar heart rate band to the vicinity of the subject's heart. Finally, according to the face shape of the subject, a suitable breathing mask is selected, and after wearing, it is ensured that the subject is comfortable to wear without blocking the air inlet.

2.3. Main Test Indicators

Oxygen uptake (VO2): The amount of oxygen that the body ingests and is actually consumed or utilized per unit of time.

Carbon dioxide emissions (VCO2): The amount of carbon dioxide emitted by the body per unit time.

Ventilation per minute (VE): The amount of gas inhaled (or exhaled) per unit time.

Respiratory exchange rate (RER): refers to the ratio of the ratio of the volume of carbon dioxide released to the volume of oxygen absorbed by an organism at the same time, that is, the ratio of the amount of CO2 released
by respiration to the number of molecules absorbed.

Heart rate (HR): The number of heart beats per minute.

Duration of exercise (T): The time from the start of the subject test until exhaustion.

Ventilation threshold (VT): The amount of work (W) is plotted on the abscissa during exercise load, and the indicators such as lung ventilation are plotted on the ordinate, and the indicators such as lung ventilation and carbon dioxide exhalation increase sharply (or increase nonlinearly). Inflection point.

3. Results

3.1. Analysis of Aerobic Capacity of Muscle Cells Injured by Walking Athletes

Figure 1 (a) shows the trend of the absolute value of oxygen uptake of the subjects. The data is obtained after smoothing and interpolation. The oxygen uptake (absolute and relative) changes of all male long-distance runners went through a smooth and steady process, with 9 subjects completing the entire 12-minute test and 1 subject completing only 10 minutes and 30 seconds. Test. As shown in Fig. 1(b), in the subject, the absolute and relative values of the maximal oxygen uptake of the subject sub H were the largest, and the absolute and relative values of the maximal oxygen uptake of the subjects were different. Because each person's height and weight have individual differences, in order to eliminate the influence of body weight and facilitate the horizontal comparison of the maximum oxygen uptake between individuals, the relative value of the maximum oxygen uptake is more accurate, and combined with the data results, the maximum oxygen uptake is achieved. In terms of this parameter, the subject had the strongest aerobic capacity.

![Figure 1](image)

**Figure 1.** Change in oxygen uptake of muscle cells in walkers

In this paper, the pearson correlation analysis was performed on the oxygen uptake (absolute value, relative oxygen uptake value) and height, weight and age. The results showed that the subjects' oxygen uptake (absolute value, relative oxygen uptake value) and height, body weight and age were not significantly related. The appearance of this result may be related to each subject's special and training years. Different sports special items (5000m, 1500m in this test), and the levels of the test subjects are different. Each subject has different training years. Combined with the above factors, they may be caused. There was no significant correlation between oxygen uptake and height, weight, and age.

![Figure 2](image)

**Figure 2.** Changes in oxygen uptake rate of muscle cells in race walkers

In order to compare the rate of oxygen uptake of the subjects, the rate of increase in oxygen uptake per subject was calculated, as shown in Figure 2, which is the percentage of oxygen uptake with maximal oxygen uptake during the test. (%) rate of change trend graph. The growth rate of oxygen uptake was calculated for each subject to achieve 20% VO2max, 40% VO2max, 60% VO2max, 80% VO2max, and VO2max. Ten subjects had
the highest rate of oxygen uptake when they reached 20% VO2max, with sub G being the fastest oxygen uptake rate among 10 subjects and sub J being the highest oxygen uptake of 10 subjects. At the slowest rate of entry, the oxygen uptake rate of sub G is 3.8 times that of sub J. Among them, 9 subjects began to increase slowly from 40% VO2max, that is, the rate of increase in oxygen uptake was significantly slowed, and the rate of oxygen uptake by one subject (sub J) from 40% VO2max Speed up, the rate of increase in oxygen uptake from 60% VO2max slows down. As the exercise intensity increases, the rate of oxygen uptake by the subject increases slowly.

3.2. Analysis of Surface Electromyography Signals of Muscle Cells Damaged by Walking Athletes

The myoelectric intensity of each of the three muscles of each subject was calculated separately, and the intensity of 8 to 10 minutes was taken as the maximum value, and the other myoelectric intensity values were homogenized. In the calculation process, the three muscles of the 10 subjects did not all show an upward trend, which may be related to the muscle strength distribution of the subject during exercise and the muscle strength of each person. The following were selected muscles with increased muscle strength in 10 subjects and their trend graphs were obtained.

![Figure 3](image_url)

**Figure 3.** Changes in myoelectric strength of the rectus femoris and medial femoral muscles

As can be seen from Figure 3(a), the RF electromyography intensity of 9 subjects in the subject showed an upward trend, and the horizontal axis was the time period in which each person’s total test time was divided into 10 equal durations and calculated. The average value of the myoelectric intensity of each time series, the RF electromyography intensity of sub C reached the maximum at the 5th to 6th stages of the total test time, and the RF electromyography intensity decreased slightly in the later stage; and the sub H was at the total test time. The first 7 stages are all at a small value, and the myoelectric intensity has a large increase in the last 3 stages; the RF electromyogram intensity of sub A and sub I is a process of rising first, then falling and then rising; for RF, each is the subject's upward trend is not the same, not always rising, but the overall trend is rising.

As can be seen from Figure 3(b), the vitreous strength of VM in 9 subjects showed an upward trend, and the muscle myoelectric intensity of sub H showed a slight decrease in the last stage of the total test time. The first nine stages showed an overall step-up; the VM electromyogram intensity of sub A and sub G showed a significant first rise in the entire 10 stages, and then a small decline stage and finally rose again; VM electromyography intensity of other subjects Overall, there is a step-up trend.

![Figure 4](image_url)

**Figure 4.** Variation of myoelectric strength of soleus muscle

As can be seen from Figure 4, the electromyography strength of SO in 8 subjects showed an upward trend, and the SO electromysity of sub F and sub J showed a trend of increasing first and then decreasing, especially sub F. The trend of SO myoelectric intensity is more obvious; the SO electromyography intensity of sub B does not increase much from the fifth stage, and is in a balanced state as a whole; sub J shows a trend of rising first
and then decreasing slowly; other subjects The SO electromyography showed an overall upward trend.

3.3. Change in Mean Power Frequency (MPF) of Surface EMG Signals

Previous studies have shown that MPF exercise fatigue will show a significant downward trend during exercise fatigue. Based on this conclusion, it is determined whether there is fatigue in the muscles of MPF in 3 muscles of 10 subjects. The following selections were made in 10 subjects with a decrease in myoelectric MPF (two types, one with a constant decline, and the other with a rise and then decreased) and a trend graph of them.

![Figure 5. Average power frequency changes of the rectus femoris and medial femoral muscles](image)

It can be seen from Fig. 5(a) that the average power frequency (MPF) of RF in 6 subjects showed a downward trend, in which the MPF of the RF of sub B and sub F increased first and then decreased, and the RF of sub B The MPF rises to the second stage, while the MPF of the subF's RF rises to the third stage, and its subsequent stages show a downward trend. The other subjects experienced a slow decline in the previous stages, and the subsequent declines in the 5th to 10th stages were relatively large. From the overall trend, the MPF of the RF in the subjects showed an upward trend.

As can be seen from Figure 5(b), the MPF of VMs in 5 subjects showed a downward trend, with sub H decreasing first in the 1st to 3rd stages, rising in the 3rd to 4th stages, and the last 6 stages presenting The decline trend, while the sub H decline is also the largest among the 5 subjects, and the frequency of MPF is also the largest; sub C shows a slow upward trend in the 1st to 7th stages, and a slow trend in the 8th to 10th stages; sub E, sub G and sub I showed a slow downward trend, and the five subjects showed a downward trend as a whole.

![Figure 6. Change in the average power frequency of soleus muscle](image)

It can be seen from Figure 6 that the MPF of SO in 9 subjects showed a downward trend, in which the first 6 stages of the MPF of the sub D remained stable, while the MPF of the next 4 stages decreased. The magnitude is obvious. The MPF of SO in the other 8 subjects showed a slow downward trend overall, but the decline in SO's MPF was not too large.

4. Discussions

As shown in Figure 1, the change in oxygen uptake of the subject is approximately the same as the change in intensity of the test protocol, both in a stepwise manner. Oxygen uptake appeared in the final stage of the platform. As shown in Figure 3, the subject's rate of change in oxygen uptake as a function of percent (%) of maximal oxygen uptake during the test. According to the principle of oxygen uptake dynamics, the kinetics of oxygen uptake during exercise reflects the change of VO2 gradually to steady state after the start of exercise. VO2 initially increases rapidly, and the general time is between 15 seconds and 25 seconds. After VO2, there
will be a slow growth trend. This is consistent with the trend of oxygen uptake in this study.

The results of this study show that during the maximal oxygen uptake test, the exercise intensity increases with the increase of speed and slope. For the subjects tested, the myoelectric intensity of the three muscles increased with the increase of exercise intensity, but not the muscle strength of the three muscles of each subject showed a significant increase, and each rise in muscle mass is also different. Muscles with insignificant changes in myoelectric strength may be involved in exercise with little or no activity, and may be compensated by other muscles. In terms of myoelectric intensity, each muscle involved in exercise has a different number of recruiting units. However, from the overall trend of myoelectric strength, it is on the rise.

The results of this study showed that the MPF of the three muscles decreased with the increase of exercise intensity, but not every member of the three muscles showed a significant decrease in MPF, and the MPF of each muscle also decreased different. In some subjects, MPF showed a tendency to rise first and then fall. This may be due to the fact that mobilization of slow muscle fibers was the first, but with the increase of exercise intensity, more fast muscle fibers were needed to provide strength, so MPF will appear first. In the ascending situation, the subsequent decline in MPF may be related to the fatigue of fast muscle fibers and the additional recruitment of slow muscle fibers.

5. Conclusions

This paper studies and analyzes the influence of walking on the muscle function of injured muscles by adopting different ways of walking athletes, and draws the following conclusions:

(1) The aerobic capacity assessment of the injured muscle cells of the race athletes should be comprehensively analyzed from multiple indicators. According to the research results of this study, the athletes with the most prominent oxygen uptake and other indicators are not the same athlete. The overall aerobic capacity of athletes engaged in 5000m specialization is not large, and there is a certain gap in the aerobic capacity of athletes engaged in 1500m special. In the initial phase, sub G was the fastest rate of oxygen uptake in subjects, sub J was the slowest rate of oxygen uptake in subjects, and the rate of oxygen uptake by sub G was 3.8 times that of sub J. However, according to the statistical results of the maximum oxygen uptake, the maximum oxygen uptake of sub H is the largest, indicating that the rate of oxygen uptake does not mean that the maximum oxygen uptake is also high.

(2) In the incremental load exercise, the myoelectric intensity of the lower extremity muscle showed an increase with the increase of exercise load, and the oxygen uptake was significantly positively correlated with the myoelectric intensity. In the performance of myoelectric intensity, each muscle involved in exercise will have a different number of movement units. Therefore, some muscle units involved in exercise will have a significant upward trend in their electromyographic intensity. There was no significant change in the number of motor units involved in muscle involvement. However, from the overall trend of myoelectric strength, it is on the rise.

(3) In the incremental load exercise, the MPF of the lateral gastrocnemius and the soleus muscle of the lower extremity muscle decreased with the increase of the load. The MPF of some of the medial femoral muscles of the rectus femoris showed a downward trend, and the oxygen uptake and MPF were significant. Negative correlation. In addition, some subjects had a sustained downward trend in MPF in some muscles. This may be because more muscle fibers were mobilized from the beginning, and fast muscle fibers were not fatigue-resistant, in order to maintain the output of power, more slow muscle fibers were mobilized and there was a continuous decline in MPF.

References


