Simulation Analysis of Foot Force in Athletes' Training Process Based on Sports Biomechanics

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Objectives: With the rapid development of sports biomechanics, a new frontier discipline, the modeling and Simulation of human motion, as one of the cutting-edge research topics of sports biomechanics, is receiving more and more attention..Methods: Based on this, this paper provides theoretical support for the analysis and research of foot stress in the process of training and applies it to guiding practice by using the analysis technology based on sports biomechanics and the method of foot pressure and simulation modeling and analysis system. Results:The results of the study showed that the injury of the athletes in the lower limbs accounted for about 46.7%, followed by the injury of the upper limbs and the injury of the trunk. In the lower extremity injury, the most common part of the foot joint is about 28.1%. Conclusion: Studies have shown that the changes in the force of the athlete's foot after fatigue have not had the good stability before, the duration of each stage of the completion of the movement is changing, and the control of the ankle joint is decreasing, which greatly increases the foot joint. The possibility of injury.

Keywords:biomechanics; foot force; training process

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In sports, ankle injuries occur frequently, and the probability of occurrence is [1]. Athletes'feet are the only organs that directly interact with the ground in running and jumping. That is to say, the resultant force of huge muscles produced by the human body must pass through the feet to finally act on the ground[2]. As an important supporting condition for static balance and dynamic movement of human body, its shape is affected by race, region, heredity, lifestyle and other factors[3]. With the intensification of athletes'training intensity, the athletes slip and fall because of their unbalanced body in the training process, so as to press the foot of the same team members, or directly constitute their own foot varus injury, muscle tear and fracture quite a lot [4]. The rapid changes of the joints of the lower extremities as well as the huge ground impact force during the movement. It is precisely because of the too many start-ups, landings and changes in the training process that athletes become an important cause of the lower limbs, especially the foot injuries [5-6]. The support force of the ground to the human body must also be transmitted to the human body through the foot, so that the body can move up or forward from the ground. Therefore, it can be said that the foot is the only bridge between the muscle action and the ground reaction force in motion, and it has a direct influence on the effect of human motion [7]. Relative to the individual, in the body support, balance and exercise, due to body weight, standing posture, exercise tasks and habits, exercise methods and strength, and shoes and other factors, the shape of the foot will also change [8].

Although the pain is not severe after the athlete's foot injury, local swelling and congestion often occur in the early stage. By understanding the characteristics of foot pressure distribution, it is possible to effectively optimize technical movements, reduce foot injuries, and improve the design of special shoes [9-10]. In previous studies, researchers used kinematics analysis or surface electromyography to analyze the stress of athletes during training [11]. In 2011, the research perspective of the effects of six-week endurance training on dynamic muscle control of the knee after fatigue training was proposed [12]. In 2013, a research perspective on the effects of neuromuscular fatigue on accelerometer loads on Australian elite football players was proposed [13]. In 2015, the study of the influence of juvenile runners' training shoes on running kinematics was put forward in [14]. In 2016, a study on the effects of preventive ankle tapping on basketball players'planned direction change, responsive agility and ankle muscle activity was proposed [15]. Combining with foot scanning technology, the regularity of foot shape of different special athletes is studied. According to the foot shape characteristics of different special athletes, personalized sports shoes design will become an important research content. It will expand new application prospects and research in clinical biomechanics, anthropodynamics and sports biomechanics. Direction [16-17].

In recent years, with the rapid development of social economy and politics, especially science and technology, it provides technical guarantee for quantitative analysis and timely feedback, and strengthens the convenience and effectiveness of quantitative research [18]. Establishing the simulation analysis model of foot force is the key step of the theoretical analysis method of sports biomechanics. This step is often referred to as the establishment of mathematical model or modeling, which is the core of the study of human motion and the most complex process [19]. In order to explore the law of motion of organisms, biomechanists in various countries have made great achievements in their research methods, which provide abundant materials for the Treasury of theory of sports biomechanics [20]. Due to the rapid development of human science, aerospace science and computer application in recent years, it has injected new vitality into the ancient discipline of classical mechanics, broadened its application range, and made the combination of mechanics and human science become a hot topic in contemporary research [21-22]. In the research sports, it broke the deadlock of the predecessors' periodic sports such as walking, jogging and deep jumping. The biomechanical study of the special action of the foot was carried out for the simulation of the athlete's foot force. The impact of the technology, this study intends to use the kinematics, dynamics and biomechanical methods to simulate the impact of the athlete's foot [23]. In order to use this information to make a reasonable explanation for the analysis of foot force, it provides a reference for scientific guidance exercise and reduce the possibility of sports injury [24].

METHODS

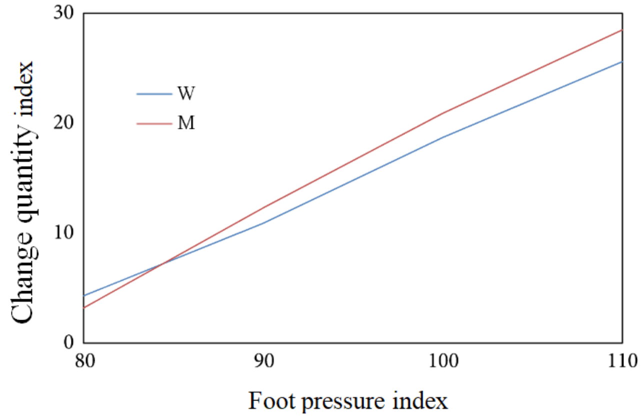
When a person is in sports, especially during a vigorous rotational exercise, the body will have obvious deformation, and large shear stress will be generated at both ends of the muscle. The plantar pressure measurement system can help researchers carefully study the time, force and pressure center movement characteristics of the foot landing, support and extension during the walking, running, jumping and other movements of the human or animal. It is accurate, A meticulous study of the dynamics of the characteristics of the tool. Athletes were tested for foot strength using the Rsscan (RSCAN Ltd Belgium) insole pressure test system. The insole collection frequency is 50 Hz, and each insole contains 66 sensors that allow the foot pressure zone data to be passed to dedicated software for analysis. Then study the stress of each unit under the action of external force, and then grasp the stress of each part of the human body in motion. This method is usually divided into three stages: establishing model, loading solution, observing and analyzing. During the test, the subjects placed one foot on the foot tester to ensure the upright position of the foot, and tested the force of the foot under different loads. Different speeds have the greatest impact on heels and feet. With the increase of speed, the peak pressure of heel and front of foot increased by 26%, while the strength of foot decreased. The constitutive equation of athlete's foot force is a very complicated process. In addition, due to the irregular geometry of organisms and the complex boundary conditions, biomaterials are highly nonlinear and time-varying.

The average maximum foot pressure (MMP) of athletes after weight standardization is shown in Table 1 and Figure 1. Transfer indicates the percentage of changes in the maximum foot pressure of athletes in the process of changing each step from back kick (TO) to front foot landing (TD).

Table 1
The Average Maximum Force Pressure of the Two Feet After Foot Weight Normalization is (N/kg * cm2)

Footwork number	Foot pressure (MPP)	Change quantity
W	0.036	3.878
M	0.147	2.619

Figure 1
The Average Maximum Force Pressure of the Two Feet After Foot Weight Normalization is (N/kg * cm2)

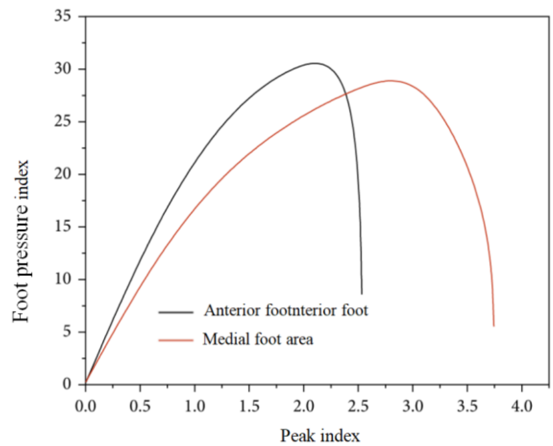


At the end of the foot's support, there is a distinct peak in the front of the footstep. The maximum pressure in each region showed a large difference compared with the first two movements, but at the same time, the front and inner regions were also the same as the first two movements, and their values were much larger than the medial area. The details are shown in Table 2 and Figure 2:

Table 2
The Maximum Pressure of the Plantar Regions Was Compared With Those of the Two Steps After Weight Normalization (N/kg * cm2)

Plantar regions	Peak value	Foot pressure
Anterior foot	0.339	0.012
Medial foot area	1.327	0.366

Figure 2
The Maximum Pressure of the Plantar Regions Was Compared With Those of the Two Steps After Weight Normalization (N/kg * cm2)



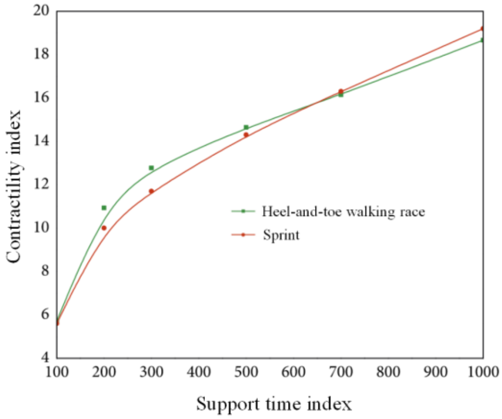
With the development of social economy and the influence of scientific research on daily training, plantar force measurement system has been widely used. Many scholars have published a large number of papers on the changes of gait and pressure characteristics in many academic journals at home and abroad from different perspectives such as clinical medicine, sports medicine, sports science and biomechanics. They have tested and analyzed the distribution characteristics of plantar force to reveal the variation law of plantar force under different conditions. In this way, the human body is simplified into a simulation model with finite degrees of freedom. When moving, the human body is subjected to complex external and internal forces, such as ground friction, equipment or ground support force, gravity and inertia force of each human mouth, muscle force at both ends of the joint, and so on. The human body accumulates energy through the rotation, creating a better final stage of the body posture, making the movement technology more coherent and natural, and providing more favorable muscle force conditions and body rotation angular velocity. To ensure the different load conditions of the subject, the special pressure display is above the instrument and the test is started when the instrument pressure data shows the specified load. When mobilizing, the knees are slightly bent, the heels are slightly raised, and the center of gravity is placed between the forefoot legs, maintaining a position that is quick to start. In order to obtain the force of the foot, the straight body and the knee are repeated, and the strength requirement for the foot is also increased.

The length of the foot support time of the walking and sprint reflects the ability of the subject's lower extremity muscle centrifugation and centripetal contraction from the biomechanical aspects of the exercise, which in turn affects the size and utilization of the lower limb muscle elasticity. The rate is high. Table 3 and Figure 3 show the support time of the foot and the sprinter's foot force.

Table 3
Athlete's Walking and Sprint Foot Force Support Timetable (s)

Project	Support time	Contractile force
Heel-and-toe walking race	13	31
Sprint	14	25

Figure 3
Athlete's Walking and Sprint Foot Force Support Timetable (s)

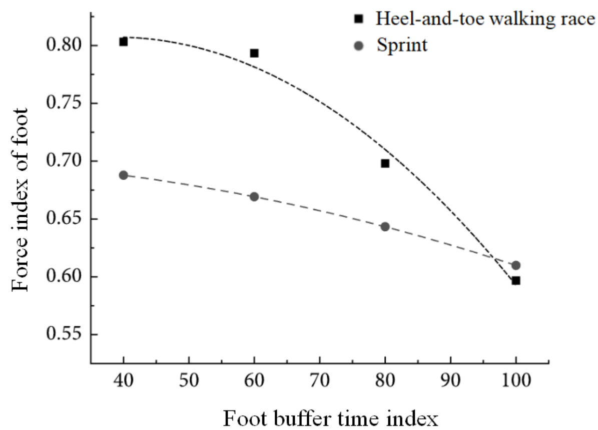


In the foot force stage of landing foot, during the whole support buffer period, the athlete first bears the impulse of the body forward and downward, then buffers the foot by bending the hip, knee and ankle joints in turn, and finally pushes the body forward rapidly. Table 4 below is the buffer schedule when the foot is forced to the maximum buffer time during the race and sprint. Figure 4 is the analysis result.

Table 4
The Buffer Time (S) Table When The Foot Is Stressed to the Maximum Buffer Time During the Race and Sprint

Project	Foot cushioning time	Foot force value
Heel-and-toe walking race	13	24
Sprint	10	33

Figure 4
The Buffer Time (S) of the Foot Force and the Maximum Buffer Time During Walking Race and Sprint



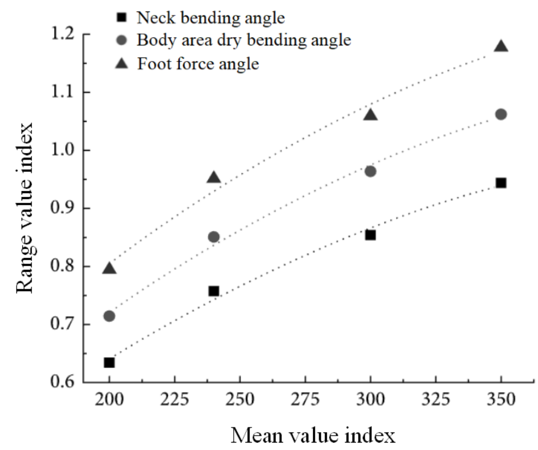
In order to get biomechanical characteristics of athlete's foot force. The difficulty of experimental research lies in how to induce fatigue and judge the fatigue degree of athletes, and how to produce fatigue in a way that is consistent with or similar to that of athletes in actual competitions. According to the purpose of actual simulation, only part of the force must be considered. According to the simplified mechanical model, a set of mechanical equations is established, and the motion equation is solved according to the number of forces on the foot and the initial conditions, and the parameters of the motion model are obtained. The maximum value of foot pressure and the integral time of foot force are calculated. The average of the three adjacent motion data in the quiet state is the first group of data; the average of the two motion data in the second half of the second half is the second group data. Rest until physical recovery after completing a set of actions. During the experiment, the pressure insole was placed flat in the shoe and the collected data was transmitted to the PC in real time via a wireless receiver. The motion of the object is consistent with the given constraints. In the process of solving the equation, the process is relatively cumbersome due to the involvement of the derivative and the differential equation. Some equations can only be solved by an iterative method. There are many simulation analysis methods for studying the stress of many athletes' feet. Each method has its own advantages and characteristics, and it also has its own limitations, so that no recognized best method has been found so far.

Based on the biomechanical analysis, the method of foot force simulation modeling is used to give the range of the force angle of each part of the human body during the training process, as shown in Table 5 and Figure 5.

Table 5
Force Angle Range

Content of measurement	Mean value	Range value
Neck bending angle	3.61	10
Body area dry bending angle	13.17	21
Foot force angle	10.95	12

Figure 5
Force Angle Range

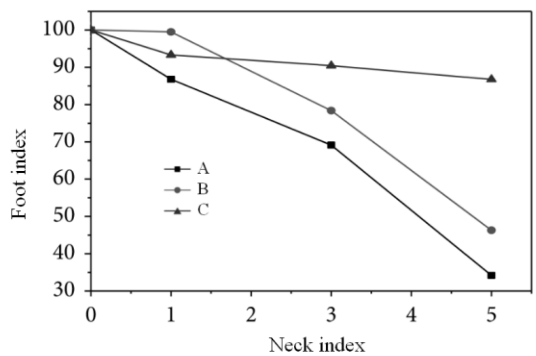


The range of the force angle is to reduce the error in the process of acquiring the EMG signal of the athlete's foot. Three athletes with more developed muscles are selected as the test subjects. The measurement data are shown in Table 6 and Figure 6.

Table 6
Athlete Measurement Data

Testers number	Neck (CM)	The foot (CM)
A	20	18
B	15	16
C	19	23

Figure 6
Athlete Measurement Data



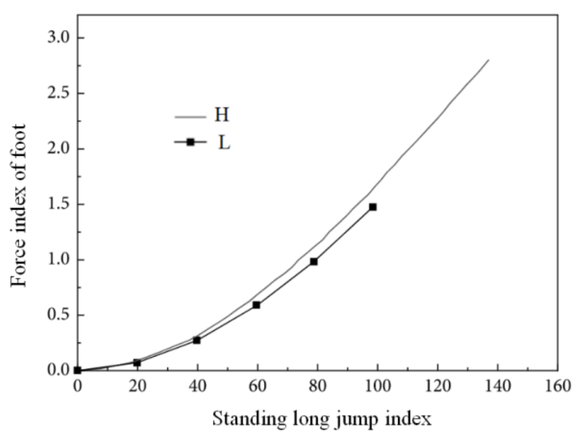
Athletes'foot force measurement technology not only has a great demand in medical treatment, but also has a wide application and development space in sports, such as the development of sports shoes function, the exploration of sports special technology and the prevention and treatment of sports injuries. According to the different structure of human and movement, although they are reversal injuries, the stages of occurrence are also different. The change range of left anterior field stride is also significantly larger than that of flexion angle, which also shows that the reversal direction of ankle joint injury is one of the most easily occurring injuries in sports. According to the appropriate control function and excitation signal, the muscle produces and moments, thus causing the movement of the stimulated part. This method not only obeys Newton's law of motion, but also fully considers the foot force of athletes. However, with the increase of the foot force to be controlled, the derivation of the control function of the executive mechanism becomes more difficult. The most important part is to combine the highest speed utilization of the take-off technology on the basis of high-speed running, and the last step of the take-off effect can be effectively reflected from the foot force measurement system, so the athletes take off the foot It is necessary to explore the long jump special technology. In addition to the short-term vacancy phase and transition phase, the athlete's foot force tends to increase with the movement. The foot has been exerting a large force in each action stage, and its pressure value tends to become larger as the support leg changes.

Two athletes were selected to measure their standing long jump performance and foot force accurately. The results are shown in Table 7 and Figure 7.

Table 7
Measurement Result

Athlete number	Standing long jump (m)	Foot force value
H	2.23	13
L	2.01	24

Figure 7
Measurement Result



RESULTS

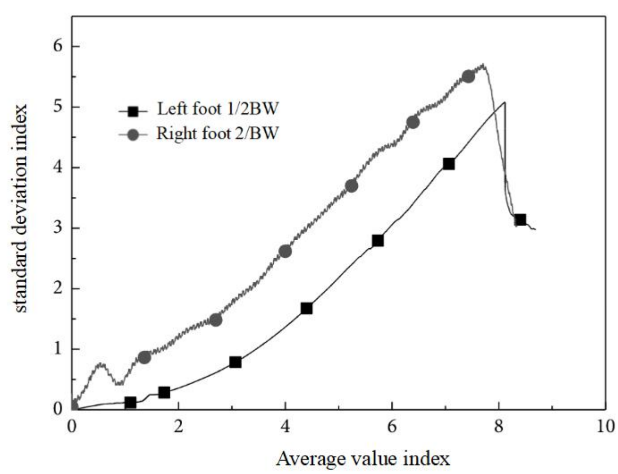
It is very difficult to simulate the actual situation of foot force when athletes complete their movements. Because the human body is a very complex system, it is impossible to establish a general simulation analysis model of foot force. At present, some research methods only simplify the human body model to varying degrees. In competitive sports, the athlete's special physical talent determines whether he has the innate advantage to achieve higher sports results, and hard work and scientific training are the cornerstones to help athletes reach this height. In the support stage of both legs, the athlete twists his body to the right and tightens his muscles to accumulate strength for the pre-swing. At this stage, the foot of the athlete is in a state of less force, and then increases gradually with the pre-swing, and decreases when the right foot leaves the ground. During the growth and development of athletes' feet, the shape of the feet is the earliest development and end of the human body. Foot morphological indicators usually refer to the size of the foot (foot length and foot height) and foot type. The foot length refers to the distance from the point to the point of the toe. The height of the foot refers to the vertical distance from the highest point of the scaphoid to the support surface. Except for the first toe high index, the medial longitudinal arch height index, the toe oblique width, and the foot force index, which do not obey the normal distribution under different load conditions, other length indicators, width indicators, circumference indicators, and area indicators. The data tends to be normally distributed under different load pressures.

When the athlete runs, the load increases, the foot is subjected to gravity sinking, and the length of the foot becomes longer, which is significantly larger than the length of the foot without load. The foot length indicator did not change significantly as the load continued to increase. Table 8 and Figure 8 show the analysis results of the force index of the foot under different loads.

Table 8
Stress Index of Foot Under Different Loads

Load condition	Average value	standard deviation
Left foot 1/2BW	99	16.33
Right foot 2/BW	98	18.19

Figure 8
Stress Index of Foot Under Different Loads



In analytical mechanics, Lagrange equation is an effective tool to establish the dynamic equation of a constrained particle system. The equation is as follows:

$$w(x,y,d)=\exp(-(\frac{d_g}{r_g}+\frac{d_c}{r_c})) \tag{1}$$

Construct a generalized inertial force, and derive the above equation from time to obtain the acceleration a of each particle. And the inertial force b of each particle, then the general inertial force d(x, y):

$$d(x,y)=ax+by+c \qquad (2)$$

The athlete's foot joint has more than two axes of motion and can be used for multi-directional movement. Most of the multi-axis joints in the foot joint belong to the ball and socket joint, and the motion constraint range of the joint can be judged according to the trajectory ellipse of the rotating shaft. This method can effectively solve the motion dependence problem of the joint, such as two consecutive Swing motion. Specifically, it can be calculated by the following formula:

$$D_{i+1}(x)=\frac{D_i(x)}{Z_i}\begin{cases} e^{-a_t} & h_i(x)=y_i \\ e^{-a_t} & h_i(x)\neq y_i, D_i(x)\le HW_t \\ e^{a_t} & h_i(x)\neq y_i, D_i(x)> HW_t \end{cases} \qquad (3)$$

The singular value decomposition method of matrix is the most commonly used method to solve the problem of force variation of athletes. Assuming that A is a matrix of n*m and its rank is T, A can be decomposed into:

$$[a,b,c]^T=(A^TA)^+A^TB \qquad (4)$$

Therefore, we can deduce the expression of the force variation of athlete's foot:

$$(x_{LT}^i, y_{LT}^i)=\sum_{j=1}^{k} w_j^i (x_{RT_j}^i, y_{RT_j}^i)$$
$$w_j^i=\frac{\frac{1}{(EP_{LR}^{ij})^2}}{\sum_{j=1}^{k}\frac{1}{(EP_{LR}^{ij})^2}}, j\in(1,k) \qquad (5)$$

It is assumed that the foot simulation model coefficient satisfies the constraint state in the initial state, that is, a=b. Then in order to maintain the constraint, we must ensure that the first derivative of D is zero, and the expression is:

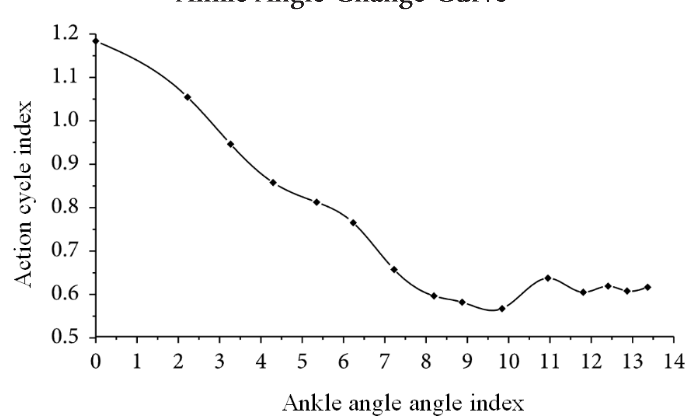
$$D_i=a+\sum_{j=1}^{n} b_j p_j + r_i Y + u \qquad (6)$$

Calculate the error of foot force change value of all athletes, and adopt weight strategy according to multi-task. Because there is no conflict, set the weight of each task as a, and then get D according to the following formula:

$$D_i=a+\sum_{j=1}^{n} b_j \ln(p_j)+r_i\ln(Y)+u \qquad (7)$$

Ankle angle is an important parameter to reflect the degree of foot torsion. It is the angle between the foot joint and the horizontal plane. In theory, the bigger the angle between ankle and upper body, the bigger the range of upper body turning to right side and the higher the degree of torsion, the longer the distance of pre-swing force acceleration. Figure 9 shows the curve of ankle angle.

Figure 9
Ankle Angle Change Curve



A thorough study of the simulation analysis of the foot force changes of athletes will simplify the establishment of the model to a great extent. At present, some biomechanics experts have established some human motion models, but the simulation results are not satisfactory. With the development of human beings, science and technology go deep into every corner of life. People also need more details in life. More and more standard quantitative indicators are sought for the description and diagnosis of athletes'special technology. The popularization of high-performance computers and the Internet, together with the development of scientific and technological hardware facilities, are also needed. The exhibition has made these demands possible. The angle between shoulder and hip is relatively stable in the initial stage, and suddenly increases to 25 degrees in the later stage. A bifurcated peak appears in the curve. At the end of the bipedal support stage, that is, before the right foot leaves the ground, the angle between shoulder and hip shows a gradual increase, which is due to the gradual opening of shoulder and hip, which can make better progress. Prepare for the single support stage. By comparing and analyzing the athlete's foot force index under different loads, it is found that different load weights have certain influence on the foot shape length index. Due to the traction and relaxation of the plantar ligament, the length of the arch changes under different load-bearing weights, which causes the change of the foot length index. Most of the human body movement is active, and its movement process is strictly controlled by the nerves. Therefore, how to simulate the control process of the motion center and quantify the closed-loop control of the body's control of the movement to form the movement is also necessary.

By measuring the athlete's foot stress, a number of special technical indicators can be more detailed and quantified, and then summarized and summarized to provide data support for more scientific technical theories. During the one-leg support phase, the athlete's body center of gravity falls from the maximum shoulder-hip angle state of the double-support stage to the right foot off the ground. The acceleration action is active on the waist, abdomen, hip and leg muscle groups. If the coordination is completed, the athlete's foot force value will undergo dramatic fluctuations during the acceleration process. As the load increases, the foot is subjected to gravity sinking, and the length of the foot becomes longer, which is significantly larger than the length of the foot without load. Using a variety of testing methods to obtain the force information of athletes'feet, fusing multi-objective testing data, making comprehensive decision and evaluation, this will be a great supplement to the modeling of athletes' foot simulation analysis. When the foot is in the adduction state, it is easy to exert force in the braking and pedaling stage, and it is not easy for the body to slip when it is on the ground with abduction. However, the decrease of the strength of the adduction ankle joint is very easy to cause foot joint injury. When the human body walks normally in the bare foot state, the weight of the forefoot has no obvious change compared with the heel, but the weight of the forefoot lasts longer than that of the heel. It leads to the imbalance of foot force and the imbalance of external force caused by the transfer of force, so as to obtain the speed and acceleration of the whole and the link.

Motion biomechanical analysis involves the establishment of mathematical models. For the athlete's foot simulation analysis model, the Lagrangian equation is usually used to establish a mathematical model to solve the dynamic problem. The Lagrangian equation is derived from the general equation of dynamics, and the general equation of dynamics is:

$$\ln(D_i) = a + \sum_{j=1}^{n} b_j \ln(p_j) + r_i \ln(Y) + u \qquad (8)$$

Soft tissue is the power generating system, the engine of the sports system, including skeletal muscles, ligaments and so on. In reverse dynamics simulation, the learning unit can record the length of foot contraction under force, and then act as an exciter to reproduce the change of foot contraction under force in forward dynamics. In this way, it can fully reflect the function of active or passive contraction of soft tissue controlled by nervous system and surface system in motion. The mathematical model of foot force simulation system is as follows:

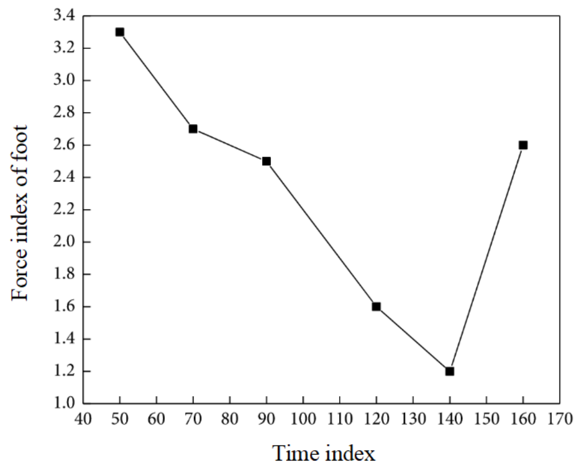
$$R_t(p_{1t}, Q_t) = p_{1t} \cdot \min(I_t + Q_t, D_t) - (p_{0t} \cdot Q_t + C_t \cdot AI_t) + R_{t-1} \quad (9)$$

The force signal of athlete's foot reflects the sum of muscle activity in a larger area of muscle. Like other bioelectric signals, the signal amplitude is smaller and the signal-to-noise ratio is not high. Assuming that the sampled foot electrical signal value is I and Q represents the length of the foot electrical test signal sequence, the following expressions can be obtained:

$$AI_t = \frac{(I_t + Q_t) + (I_t + Q_t - D_t)}{2} = I_t + Q_t - \frac{D_t}{2} \quad (10)$$

According to the changes of foot force and time curve and real-time pressure during the touchdown stage, when the athlete landed on the outside of the heel, the foot force would transit from the middle of the foot to the front of the foot. As shown in Figure 10.

Figure 10
Force and Time Variation of Athlete's Foot



Based on the analysis model of the athlete's foot force, the research proposes the optimal EMG processor. The optimal EMG processor consists of a pre-whitening filter, a nonlinear detector, a smoothing filter and a weight. Construct a linearizer and so on. Where the nonlinear detector is v, the expression is:

$$AI_t = \frac{(I_t + Q_t)}{2} \cdot \frac{(I_t + Q_t)}{D_t} \quad (11)$$

The frequency domain analysis of the athlete's foot force signal can also provide valuable information about certain characteristics, such as the average power (MPF) and median frequency (MF) of the power spectrum of the foot force simulation. Its mathematical expression is as follows:

$$f(x) = sign[\omega^T x + b] \quad (12)$$

Where t and w represent changes in the muscle tissue of the foot including tendon and inactive muscle fibers, and the relationship between force and extension of these tissues can be expressed by the following expression:

$$w(t) = w_2 + (w_1 - w_2)\frac{T - t}{T} \quad (13)$$

The force moment of the foot can be calculated by the muscle force and the corresponding attachment and geometric position. The force moment of the whole foot joint will be the sum of the active muscle and antagonist muscle. The mathematical expression is:

$$p = \begin{cases} k & \sigma^2 < \sigma_d^{\ 2}, f(P_g^{\ t}) > f_d \\ 0 \end{cases} \quad (14)$$

At the moment when the athlete's foot touches the ground, the sole and heel almost touch the springboard at the same time. Therefore, the forefoot and heel landing first are relatively unsatisfactory springboard modes and techniques. In the stage of flight, the angle of shoulder and hip increases with the increase of the foot's strength. At this stage, after the left foot is off the ground, a low level flight occurs. After that, the right leg completes the hip-buckling action and lands quickly, accelerating the forward rotation of the body, and the left leg also draws close to the right leg quickly. Different loads have a certain effect on the stress index of the foot. The height of the medial malleolus, the lateral malleolus and the medial longitudinal arch are easily changed due to different loads. The change in the indicator of the medial malleolus reflects the change in the height of the medial longitudinal arch. For competitive sports, the success of an action depends first on whether the athlete has a reserve of exercise, that is, sufficient muscle contraction ability; then it depends on whether he can obtain better foot strength. The changes in the ankle joint are not only the ankle but also affected by other links. As the force of the foot changes and increases, this effect may continue to increase, which further leads to a decline in the ankle joint control ability, and produces acute and chronic damage. The load on the inside of the forefoot increases, and the pressure on the outside of the heel begins to appear. At the landing stage, the distribution of plantar pressure is concentrated in the hallux and the first metatarsal area. Therefore, during the process of gradually accelerating the running of the athlete, the thigh is actively pressed down. When the thigh is pressed down, the knee joint and the hip joint are kept as relaxed as possible. The natural hem of the lower leg is simultaneously exerted by the buttocks and the hip muscles to increase the center of gravity and actively before.

DISCUSSION

During the training, the athletes are always in a rotating state. When the angle between the shoulder and the hip is the largest, the discharge of the external oblique muscle of the athlete is large, which may be the key muscle to control the body torsion. Different load pressures have an effect on the shape change of the foot. After the fatigue, the subject's movements have not had the good stability before, the duration of each stage of the completion of the movement is changing, and the control of the ankle joint is reduced, increasing the possibility of ankle injury. The medial temporal region of the anterior region and the maximum pressure of the big toe and the 2nd to 4th metatarsal areas are higher than other parts; when landing, the squat step concentrates the plantar pressure on the heel and the lateral side of the foot for buffer braking and twirling. The take-off step concentrates the pressure on the big toe and the first to second metatarsal areas. In training, long-distance athletes should avoid the consciousness of intentionally exerting force downward when taking off, but cultivate the instantaneous support ability of the take-off leg after fast pedal and the strength and stability of the metatarsophalangeal joint and ankle joint on the basis of higher run-up speed. The stress on the lateral foot of the athletes increases accordingly. The tibialis anterior muscle and gastrocnemius muscle may be the key muscles to control the lateral foot. At the last stage of exertion, all the muscles measured show strong discharge characteristics. Therefore, the power arm is also long and labor-saving, which is conducive to take-off. Foot force is also a very meaningful indicator, and sufficient height has a great relationship with running and jumping ability. The indexes such as medial longitudinal arch length, lateral longitudinal arch length, first metatarsal toe height, dorsum height, hallux deflection angle and foot force change obviously in a certain load range, but no longer change with the increase of load when the load exceeds the load range.

Human Subjects Approval Statement

This paper did not include human subjects.

Conflict of Interest Disclosure Statement

None declared.

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