International Journal of Physical Education and Sports

Volume 4, Issue 1, December 2018

http://www.hknccp.org

Publisher: HongKong New Century Cultural Publishing House
Address: Unit E79, 3/F., Wing Tat Commercial Building, 97 Bonham Strand East, Sheung Wan, HK

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International Journal of Physical Education and Sports
ISSN: 2411-7242, Volume 4, Issue 1, December 2018

Study on Effect of Field Explosive Force Training on Ankle Joint Injury

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Abstract: The mechanical relationship model of field explosive force on ankle joint injury is analyzed, and the mechanical effect of field exercise explosive force training on ankle joint is analyzed, combined with the relationship model of limb movement chain of human body, the joint structure model of track and field explosive force training is constructed by using the seven-bar structure model, and a model of the influence of field explosive force training on ankle joint injury based on forward kinematics model is proposed. The stress model of each joint unit of human track and field explosive force training is constructed, and the expression method of ankle structure and kinematics model D-H is obtained, and the damage relation model of field sports explosive force training to ankle joint is designed. The effect of field explosive force training on ankle joint injury is analyzed by means of total joint analysis. The simulation results show that the method is accurate and reliable in analyzing the effect of field explosive force training on ankle joint injury, and the accuracy of the analysis of ankle joint mechanical performance is higher than that of track and field explosive force training.

Keywords: Track and field; Explosive force training; Ankle joint; Injury; Stress relation model

1. Introduction

Athletics mainly include sprint, long distance running, high jump, long jump and other competitive sports. Track and field is the full name of field events, track events and all-around games. The classification of modern track and field is different, mainly including walking, running, jumping, throwing, and the total of more than 40 items composed of running, jumping, jumping, and throwing. The track and field sports are in dividual, there is a wide range of mass. In addition to the relay and running, the track and field sports are all sports events taking part in the individual as a unit. The score of the group and the number of names is mostly determined by the score of the score of personal achievement and rank and the result of the relay race [1]. The track and field sport are the biggest item in sports, which includes many single items of five categories. It is the most important event in any large sports meeting, the most athletes participating in the events, and the most people who often participate in the track and field sports. The individual and omnipotent events in the track and field sports have different requirements for the human body shape, the main physical quality level and the psychological function, and the sportsmen should start from the personal reality and characteristics and choose sports events. Grasp the advanced and reasonable sports techniques with personal characteristics. The track and field sports have some damage to the ankle joint of the human body, study the effect of the explosive force training on the ankle joint damage, combine the mechanical analysis method, construct the mechanical relation model of the effect of the explosive force training on the ankle joint damage, and establish the track and field movement. The design of ankle joint injury control model is realized based on explosive force training [2].

The relationship model of ankle joint damage in track and field explosive force training is studied by the method of human dynamics analysis. The traditional human dynamics analysis is mainly divided into forward kinematics algorithm and inverse kinematics algorithm [3]. After the structure and parameters of the kinematic chain are determined, the modeling of the joint angle space is realized by the geometric control method. Geometric method, analytic method and iterative method are used, the model of ankle joint damage is simulated by the explosive force training of human body and field. The usual method is the joint angle space with forward kinematics algorithm, and the analytic method to calculate the inverse kinematics of the multi freedom is used [4]. The geometric method is used to solve the movement of the upper limb of the body with 7 rotational degrees of freedom. The inverse kinematics method of kinetic study first uses the CCD algorithm to make the reverse motion error between the virtual position and the position and the position of the current position, and it realizes the solving of the circular coordinate space of the ankle joint damage by the explosive force training of the track and field. The 6 degrees of freedom of the ankle joint is decomposed, and the dynamic mathematical modeling and dynamic analysis are carried out [5].

In this paper, the seven-link structure model is used to construct the joint structure model of the explosive force training in track and field, and a relationship model of the influence of the explosive force training on the ankle joint damage based on the forward kinematics model is proposed, and the full joint analysis method is used to realize the effect of the force training of the explosive force on the ankle joint damage. Finally, the performance test is carried out through the simulation experiment, which shows the superior performance of this method in optimizing the quantitative analysis of ankle joint damage.

2. Mathematical Modeling and Mechanical Modeling of Ankle Joint Injury Training in Track and Field Training

2.1. Dynamic modeling and analysis of track and field

In the course of track and field movements such as running and long jump, the body mainly consists of the ankle joint and the ankle joint as the support in the sagittal plane. In order to grasp the principle and characteristics of the force of the ankle joint scientifically and rationally, the modeling analysis of the ankle joint force dynamics is needed, and the mechanical analysis of the movement of the ankle and ankle joints of the pedestrian body is analyzed. In track and field model, the mathematical expression of human ankle dynamics model can be expressed as:

$$M(\theta)\ddot{\theta} + C(\theta,\dot{\theta}) + G(\theta) = T_s + t_H \qquad (1)$$

In formula, θ is the moment acting on the joint of the ankle joint supporting angle, T_s is the joint node. The dynamic modeling model of track and field motion is obtained as shown in figure 1.

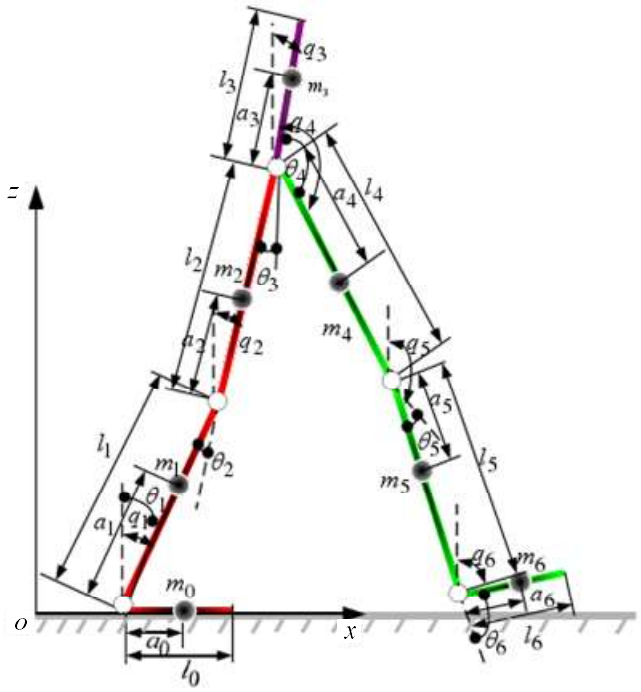

Figure 1. Dynamic joint model of track and field

According to figure 1, the joint structure model of field explosive force training is constructed by using seven link structure model [6], and the joint mechanics model of field explosive force training is obtained as follows:

$$x_{R3} = \alpha_6 - l_5 \sin\theta_6 + l_4 \sin(\theta_5 - \theta_6) - \alpha_3 \sin(\theta_4 - \theta_5 + \theta_6) \qquad (2)$$

$$\frac{m_{L3}}{m_{R3}} = \frac{x_{R3}}{x_{L3}} \qquad (3)$$

$$m_3 = m_{L3} + m_{R3} \qquad (4)$$

The homogeneous matrix ${}^{i-1}\mathbf{T}_i(q_i)$ between the athletic coordinate system i and i-1 of track and field athletes can be expressed as follows:

$${}^{i-1}\mathbf{T}_i(q_i) = \begin{bmatrix} c_i & -c_{\alpha_i} s_i & s_{\alpha_i} s_i & a_i c_i \\ s_i & c_{\alpha_i} c_i & s_{\alpha_i} c_i & a_i s_i \\ 0 & s_{\alpha_i} & c_{\alpha_i} & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad (5)$$

The moment of the bone joint is calculated, and obtain the equation of the longitudinal motion of the ankle joint, which comprises the following steps:

$$m\frac{dV}{dt} = P\cos\alpha - X - mg\sin\theta \tag{6}$$

$$mV\frac{d\theta}{dt} = P\sin\alpha + Y - mg\cos\theta \tag{7}$$

$$\begin{aligned} &J_z\frac{d\omega_z}{dt} + (J_y - J_x)\omega_y\omega_x \\ &+J_{xy}(\omega_y^2 - \omega_x^2) = M_z \end{aligned} \tag{8}$$

Thus, the dynamics model of track and field movement is constructed, and the model of explosive force relation of track and field movement is realized [7].

2.2. Joint structure model of explosive force training in track and field sports

The joint structure model of track and field explosive force training is constructed by using the seven-bar structure model, and a model of the influence of field explosive force training on ankle joint injury based on forward kinematics model is proposed, as:

$$\begin{aligned} x_0 &= x_a + a \\ x_1 &= x_a + a_1\sin q_1 \\ x_2 &= x_a + l_1\sin q_1 + a_2\sin q_2 \\ x_3 &= x_a + l_1\sin q_1 + l_2\sin q_2 + a_3\sin q_3 \\ x_4 &= x_a + l_1\sin q_1 + l_2\sin q_2 + a_4\sin q_4 \\ x_5 &= x_a + l_1\sin q_1 + l_2\sin q_2 + l_4\sin q_4 + a_5\sin q_5 \\ x_6 &= x_a + l_1\sin q_1 + l_2\sin q_2 + l_4\sin q_4 + l_5\sin q_5 + a_6\sin q_6 \end{aligned} \tag{9}$$

By using inverse kinematics transformation, the kinetic energy of ankle joint power explosion under Cartesian space track and field movement is obtained as follows:

$$K = \frac{1}{2}\sum_{i=0}^{6}[I_i\dot{q}_i^2 + m_i(\dot{x}_i^2 + \dot{z}_i^2)] \tag{10}$$

For the pose of the joint unit i and the pose of the joint unit j , the Lagrange dynamics equation of the ankle assistance motion is:

$$\frac{d}{dt}\left[\frac{\partial L}{\partial\dot{q}_i}\right] - \frac{\partial L}{\partial q_i} = T_i, (i = 1, 2, \cdots, 6) \tag{11}$$

In the upper formula, the torque of a $\frac{d}{dt}\left[\frac{\partial L}{\partial\dot{q}_i}\right] - \frac{\partial L}{\partial q_i} = T_i, (i = 1, 2, \cdots, 6)$ nkle joint is represented by T_i , the mass matrix of ankle joint is represented by M , and the gravity vector is represented by vector G , and the moment of joint is obtained under the dynamic model of ankle assist:

$$M(q)\ddot{q} + K(q, \dot{q}) + H(q) = T \tag{12}$$

The joint structure model of explosive force training in track and field is constructed, and the damage analysis of ankle joint is carried out by combining the force relation of explosive force.

3. Relationship Model of Impact of Field Explosive Force Training on Ankle Joint

The seven-bar structure model was used to construct the joint structure model of field explosive force training. In this paper, based on forward kinematics model, a model of the effect of field explosive force training on ankle joint damage is proposed. According to Cartesian space trajectory tracking theory, the stress relationship of ankle joint is obtained:

$\theta_1 = q_1$, $\theta_2 = q_1 - q_2$, $\theta_3 = q_2 - q_3$, $\theta_4 = q_4 - q_3$, $\theta_5 = q_5 - q_4$, $\theta_6 = q_5 - q_6$

The total joint analysis method is used to analyze the relationship between field and track explosive force training and ankle joint injury is obtained as:

$$\begin{aligned} x_{L3} &= l_1\sin\theta_1 + l_2\sin(\theta_1 - \theta_2) \\ &+\alpha_3\sin(\theta_1 - \theta_2 + \theta_3) - \alpha_0 \end{aligned} \tag{13}$$

$$\begin{aligned} x_{R3} &= \alpha_6 - l_5\sin\theta_6 + l_4\sin(\theta_5 - \theta_6) \\ &-\alpha_3\sin(\theta_4 - \theta_5 + \theta_6) \end{aligned} \tag{14}$$

$$\frac{m_{L3}}{m_{R3}} = \frac{x_{R3}}{x_{L3}} \tag{15}$$

$$m_3 = m_{L3} + m_{R3} \tag{16}$$

Combined with the above four formulas, the values of m_{L3} and m_{R3} can be calculated. The kinetic energy of the ankle joint is obtained as follows:

$$K = \frac{1}{2}\sum_{i=0}^{2}[I_i\dot{q}_i^2 + m_i(\dot{x}_i^2 + \dot{z}_i^2)] + \frac{1}{2}(I_{L3}\dot{q}_3^2 + m_{L3}(\dot{x}_3^2 + \dot{z}_3^2))] \tag{17}$$

By using joint constraint method, the modal relationship of stress damage is obtained as follows:

$$P = \sum_{i=0}^{2}(m_i g z_i) + m_{L3} g z_3 \tag{18}$$

Finally, the inverse kinematics model for ankle joint injury caused by explosive force training in track and field is obtained:

$$q_5 \equiv \theta_8 = \text{atan2}\left(\pm o_{ey}, \pm o_{ex}\right) \tag{19}$$

$$q_6 \equiv \theta_9 = \text{atan2}(-o_{ez}, -c_5 o_{ex}, -s_5 o_{ey}) \tag{20}$$

$$q_7 \equiv \theta_{10} = \text{atan2}\left(-s_5 n_{ex}, +c_5 n_{ey}, s_5 a_{ex}, -c_5 a_{ey}\right) \tag{21}$$

Based on the above analysis, the optimal design of the damage relationship model of track and field sports to ankle joint is realized.

4. Simulation Experiment and Result Analysis

In order to test the model of the effect of field explosive force training on ankle joint injury in this paper, the simulation experiment is built on the Matlab platform, and the computer vision simulation system is constructed by using ADAMS software. The simplified ankle limb model is built with Solid Works for mechanical loading and

program control. The simulation platform is shown in figure 2.

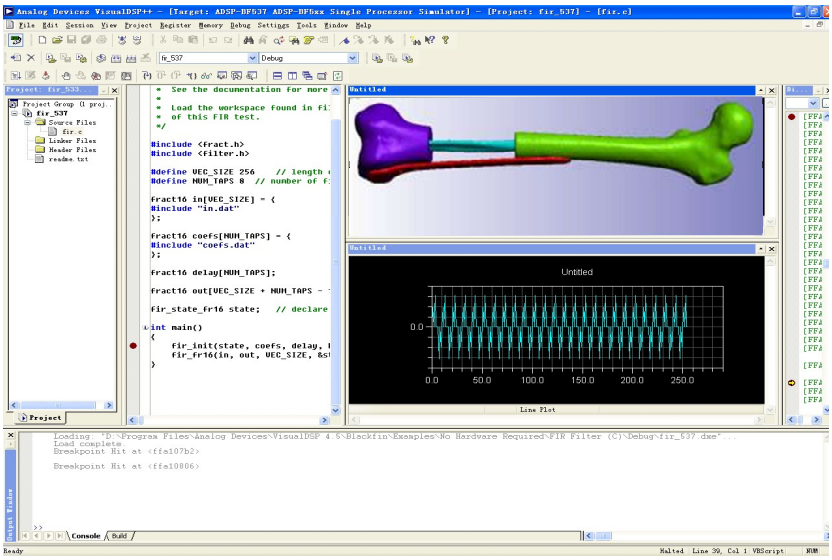

Figure 2. Simulation platform

According to the simulation platform of figure 2, the stress model of each joint unit of human track and field explosive force training is constructed, and the relationship between field explosive force training and ankle joint injury is analyzed, and the result is shown in figure 3.

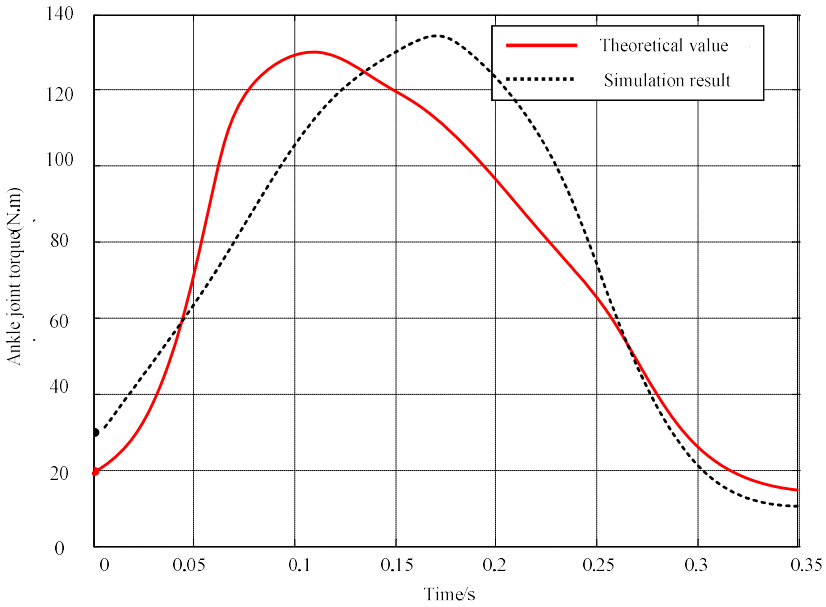

Figure 3. Relationship model of ankle joint injury caused by field explosive force training

Figure 3 shows that the method of this paper is accurate and reliable to analyze the damage relationship model of ankle joint by using the method of track and field explosive force training, and the accuracy of analysis of mechanical performance of ankle joint is higher and the fitting ability is better.

5. Conclusions

Combined with the relationship model of limb movement chain of human body, the joint structure model of track and field explosive force training is constructed by using the seven-bar structure model, and a model of the influ-

ence of field explosive force training on ankle joint injury based on forward kinematics model is proposed. The stress model of each joint unit of human track and field explosive force training is constructed, and the expression method of ankle structure and kinematics model D-H is obtained, and the damage relation model of field sports explosive force training to ankle joint is designed. The effect of field explosive force training on ankle joint injury is analyzed by means of total joint analysis. The simulation results show that the method is accurate and reliable in analyzing the effect of field explosive force training on ankle joint injury, and the accuracy of the analysis of ankle joint mechanical performance is higher than that of track and field explosive force training. It has good application value in track and field injury analysis.

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