Study and Application of Stress Analysis Method of Human-Body Segment in Basketball

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Abstract — Objective: In order to improve the professional quality and sport skills of basketball players. Methods: Establishing a basketball training system based on the stress analysis method. Process: the article describes the development and characteristics of China's competitive sports, describes the finite-element motion principle, and establishes professional quality training system of basketball combining with the principle of physical fitness training. Result & Analysis: this paper studies the mathematical model of stress analysis of human-body segment, analyzes the relevant basketball training data, and finds that the basketball training system described in this article can improve the professional quality of the athletes. Result: the method of basketball training based on the stress analysis of the human-body segment is a scientific method, which can improve the quality and skills of basketball players.

Keywords - basketball training; physical fitness training; stress analysis; finite-element principle

I. INTRODUCTION

An important feature of competitive sports is to constantly explore the competitive potential of athletes, to continuously improve the technical level of sports. From the first Olympic Games to the present, the sports training has experienced four stages: natural development stage, new technology stage, large amount of exercise stage, multi discipline comprehensive utilization, namely scientific training stage. Every stage of progress and training are pursued by the target, it is all for the best way to improve the level of physical fitness, the competitive ability of the athletes to get the maximum development. With the continuous improvement of modern competitive level, competition is becoming more and more intense, as one of the main elements of the competitive capacity of the physical development level in the modern competitive sports status is becoming more and more prominent. Basic theory and method of developing athletes' physical ability, seeking the best theoretical model of physical training, make physical training more scientific, systematic and optimization, has become a modern sports training goal diligently strive after[1]. In recent years, many scholars at home and abroad have carried out many researches on physical ability, and made a lot of research results, but the overall point of view is still lagging behind the training practice, existing research has not formed a systematic and complete understanding. The basketball movement has passed through 110 years since 1891. After more than a century of evolution and development, the basketball game has gone from the United States to the whole world, from an indoor sports game, modern sports and sports, which has become a modern training, education, sociology, biology, medicine, economics, management, philosophy and other disciplines of knowledge and mutual cross penetration. Modern basketball sports in the United States as the representative of the professional basketball NBA, it is gradually from pure sports development to show people's essential power, promoting social and economic development and improving the cultural phenomenon of the progress of human civilization. Also due to the international politics of our country, the basketball movement in 1974 before, in addition to the limited number of friendly countries to participate in the competition, almost isolated, this has affected the development of the new China basketball movement in a certain extent. Chinese male, 1974 women's basketball team in the seventh Asian games, prelude to return to the international basketball China, after several generations of coaches, athletes' unremitting efforts, the level of China's basketball is constantly improving. However, throughout the basketball world, there is still a big gap between our various aspects, performance in the physical gap is particularly prominent, has become an important factor restricting the development of China's competitive basketball. Figure 1 (a) - (c) shows a different type of basketball.

Figure 1. (a) Juvenile basketball
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“Link stress analysis method” is the key to explain the new content of “Sports Anatomy” in recent years, the main research of the human movement of the anatomical mechanism, analysis of the law of muscle work during the movement of human body, is an important part of the teaching of physical education department[2].

II. MATERIALS AND METHODS

A. Force Analysis Model of Human Body

Equilibrium is a static state, the resultant force is zero, and the resultant force moment is zero. Bone lever is not the movement of the direction of the muscle pulling force, but not the movement or the relative motion. The conclusion is the "inverse agonist" can also be used to "slow" to carry on the analysis. The “ribs hanging leg raise” as an example, the starting position, the hands grip, straight overhanging, division of the action stage. The first stage “to raise the legs to 90 degrees”, (Table I), the second stage is “down reduction” (Table II).

![Women's basketball match](image1)

(b) Women's basketball match

![NBA basketball tournament](image2)

(c) NBA basketball tournament

![Figure 1. Different kinds of basketball sports](image3)

TABLE I. ACTION ANALYSIS UPWARD 90 DEGREES

<table>
<thead>
<tr>
<th>Joint name</th>
<th>Joint movement</th>
<th>Relationship with external force</th>
<th>The original move muscle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip joint</td>
<td>Bend</td>
<td>Opposite</td>
<td>The iliac muscle, rectus muscle</td>
</tr>
<tr>
<td>Knee joint</td>
<td>Stretch</td>
<td>Opposite</td>
<td>Unit four biceps</td>
</tr>
<tr>
<td>Foot joint</td>
<td>Bend</td>
<td>Opposite</td>
<td>Long flexor muscle, triceps toe</td>
</tr>
</tbody>
</table>

TABLE II. ACTION ANALYSIS DOWNWARD REDUCTION

<table>
<thead>
<tr>
<th>Joint name</th>
<th>Joint movement</th>
<th>Relationship with external force</th>
<th>The original move muscle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip joint</td>
<td>Stretch</td>
<td>Same(slow)</td>
<td>The iliac muscle, rectus muscle</td>
</tr>
<tr>
<td>Knee joint</td>
<td>Bend</td>
<td>Same(slow)</td>
<td>Unit four biceps</td>
</tr>
<tr>
<td>Foot joint</td>
<td>Bend</td>
<td>Opposite</td>
<td>Long flexor muscle, triceps toe</td>
</tr>
</tbody>
</table>

Explanation: “the process of ribs hanging leg raise exercise” in the development and strengthening of iliac muscle, the rectus muscle, femoral head four, triceps, long flexor muscles of toes muscle strength. In the above example analysis, knee joint is static, so the two forms can be filled in the “Bend” can also be filled out. Because the static is relative, the static, but it does contain the trend of movement. If you fill in “Bend” shows that the knee joint is not moving, but the movement of the link has a trend of bending. The external force is the gravity of the foot and leg itself, just as the movement of the leg of the link. Therefore, the direction of the movement is the same as the direction of the external force, in line with the principle of “slow down”; the muscle is the knee extensor muscles unit four biceps. Table I “joint movement” column if fill "extension", at this time, the knee joint is in a position, which indicates that the link movement is still in a static state, but it is kept in the position[3]. The direction of movement is opposite to the direction of external force, which is in accordance with the principle of “anti-same”, the muscle is still “unit four biceps”. The analysis of the static foot joint does not move. First look at the foot flexion. When the foot natural relaxation, the angle between the foot and the lower leg is more than 90 degrees, be still with the ground almost parallel, and tension and the toe of the foot back as far as possible and calf into line requirements differ very far. At the foot of the outside will not because of its natural gravitational droop to pointed toes. To overcome the external force to achieve full strength. The external force is not based on the gravity link, this external force is derived from the ground force. It is not difficult to analyze the passive resistance of soft tissue in the front of the foot joint. The muscle strength must overcome this resistance force to keep the joints on the toes. Link movement in the opposite direction and the direction of external force, in accordance with the “anti-gay” principle, the flexor muscle is covered[4].

B. Analysis of Stress Analysis of Human-body Segment

Due to the large number of human body, the structure of different structures, muscle in the limb section (bone link)
attached, the trend and distribution of each have their own characteristics. In explaining the link by force analysis method, encountered a lot of trouble. Sometimes I will review the anatomy of the anatomy. In teaching practice, we try to use the "link force model" teaching method, received a relatively good results. We know, link is mainly based on the prime mover and force exercise. The main work is characteristic of agonist contraction (active contraction and contraction). Link stress analysis method is mainly based on the link motion direction and force direction to determine the effect of contraction of the muscle[5]. Link stress pattern is according to the link motion direction and external force, the direction and the link between the state in time and space relationship, and this relationship marked on the patterns, the use of mechanics principle to analyze and find out the prime mover muscle. In the "link stress pattern", we label the segment as a line segment (usually the natural state of the joints between the segments, i.e., the non - bending state), will link direction of motion and force (including gravity, friction, equipment, elastic, etc.) direction respectively with the arrow a, b mark, prime mover muscle contraction direction with an imaginary line marking. The relationship between the direction of the movement direction and the direction of the external force is the main form of the following.

![Image of Force Pattern](image)

**Figure 2. Aspects of Force Pattern**

In Figure 2 (a) analysis: the part of the movement since the external force to do the opposite direction, so the direction of the movement of the A is bound to have a force greater than the direction of the force of the direction of the B to pull the link movement. In this model, the force can only be shown in several forms of Figure 2 (b). From Figure 2 (b) we can see: only after the line (agonist) contraction, link to the movement direction[6]. It is concluded that: the link to the external force to do the reverse movement, one side of the work only in the direction of motion agonist a. We put the “anti” (on behalf of the link motion direction with external force, the direction opposite) for this type of model, "with" two word to represent of Figure 2 (c) analysis: the direction of motion of the link a and external force Party B to the same. But because of the link to the external force to do the same to the deceleration movement, so there must be a, and the external force direction B. In contrast and is less than the force direction B force (agonist) in slow, the force in Figure 2 (d) mode can only in the following form appears. We can see from Figure 2 (d) only after the phantom (agonist) contraction (passive stretch) links to in accordance with the direction of movement of a slow down movement. From this: the part of the external force to do the same to the deceleration movement, prime mover only in the direction of movement of the anti-side link a. We put this type of pattern “reduction” that links the deceleration), "anti" (link movement direction opposite to the muscles for agonist) two words to express[7].

C. Basic Principles of Finite Element

Finite element method is a kind of mathematical and physical method in Engineering Science and technology, and then solve the problem by using a simple problem, used to simulate and solve various mechanics, electro- magnetism, heat transfer and other physical problems. The basic idea is to have a limited number of nodes or elements to approach into finite elements, an infinite number of nodes or elements are used to approximate the actual error, and by means of a node or element, this makes it possible to analyze and solve the problem. The core of the finite element analysis is the process of the approach, the more the unit decomposition, the more nodes, the result of the calculation is close to the reality. The corresponding relationship between the node displacement and the stress of the corresponding nodes is analyzed by the analysis of the elements. According to the known conditions, the finite element software is used to solve the algebraic equations, and the displacement of all nodes is obtained, finally, the stress and strain of the element should be obtained. This method is to analyze the complex structure and the stress of the knee joint, with unparalleled advantages[8]. The finite element method developed very rapidly, but its basic mechanics foundation is the elastic mechanics; Objects in any space are shown in Figure 3, there are 9 basic mechanical parameters in the three dimensional space, respectively: u, v, w three displacement components; \( \sigma_{xx}, \sigma_{yy}, \sigma_{zz}, \tau_{xy}, \tau_{yz}, \tau_{zx} \) this 6 strain components; the \( \epsilon_{xx}, \epsilon_{yy}, \epsilon_{zz}, \gamma_{xy}, \gamma_{yz}, \gamma_{zx} \) 6 basic parameters corresponding to the blank space, the 3 mechanical equations and boundary conditions are as follows:

![Image of Stress Component](image)

**Figure 3. Stress Component of Space Object**
\[
\frac{\partial \sigma_{xx}}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + \frac{\partial \tau_{xz}}{\partial z} + \tau_y = 0 \tag{1}
\]
\[
\frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \sigma_{yy}}{\partial y} + \frac{\partial \tau_{yz}}{\partial z} + \tau_x = 0 \tag{2}
\]
\[
\frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \sigma_{zz}}{\partial z} + \tau_z = 0 \tag{3}
\]
These 3 equations are called the equilibrium equation of the space object;
\[
\varepsilon_{xx} = \frac{\partial u}{\partial x}, \varepsilon_{yy} = \frac{\partial v}{\partial y}, \varepsilon_{zz} = \frac{\partial w}{\partial z} \tag{4}
\]
\[
\gamma_{xy} = \frac{\partial v}{\partial x}, \gamma_{yx} = \frac{\partial u}{\partial y} \tag{5}
\]
\[
\gamma_{yz} = \frac{\partial w}{\partial y}, \gamma_{zy} = \frac{\partial v}{\partial z} \tag{6}
\]
\[
\gamma_{xz} = \frac{\partial w}{\partial x}, \gamma_{zx} = \frac{\partial u}{\partial z} \tag{7}
\]
These 3 formulas do the geometric equation of space objects;
\[
\sigma_{xx} = \frac{E(1-\mu)}{(1-\mu)(1-2\mu)} \left[ \varepsilon_{xx} + \frac{\mu}{1-\mu} (\varepsilon_{yy} + \varepsilon_{zz}) \right] \tag{8}
\]
\[
\sigma_{yy} = \frac{E(1-\mu)}{(1-\mu)(1-2\mu)} \left[ \varepsilon_{yy} + \frac{\mu}{1-\mu} (\varepsilon_{xx} + \varepsilon_{zz}) \right] \tag{9}
\]
\[
\sigma_{zz} = \frac{E(1-\mu)}{(1-\mu)(1-2\mu)} \left[ \varepsilon_{zz} + \frac{\mu}{1-\mu} (\varepsilon_{xx} + \varepsilon_{yy}) \right] \tag{10}
\]
\[
\tau_{xy} = G \gamma_{xy}, \tau_{yx} = G \gamma_{yx}, \tau_{xz} = G \gamma_{xz} \tag{11}
\]
These 4 formulas are called the constitutive equation of space objects, \( E, u, G \) represent the elastic modulus, Poisson’s ratio and shear modulus of the object[9];
\[
u = \nu \tag{12}
\]
\[
v = \nu \tag{13}
\]
\[
w = \nu \tag{14}
\]
This formula is the displacement boundary condition of the space object, and it is in the space \( u \):
\[
\sigma_{xx} n_x + \tau_{xy} n_y + \tau_{xz} n_z = \overline{F}_x \tag{13}
\]
\[
\tau_{xy} n_x + \sigma_{yy} n_y + \tau_{yz} n_z = \overline{F}_y \tag{14}
\]
\[
\tau_{xz} n_x + \tau_{yz} n_y + \sigma_{zz} n_z = \overline{F}_z \tag{15}
\]
These 3 formulas are the boundary conditions of the forces of space objects, and they are all in the space \( P \).

D. Constitution of Physical System

On the constitution of physical fitness, many scholars have also carried on the discussion at home and abroad. Such as Larson (Larson) put forward ten major factors of physical fitness: Defensive ability; muscle strength; muscle transient force; softness; speed; agility; coordination; balance; skill; heart and lung capacity. Tian Maiju, etc., the athletes physical form, function, and quality of the three factors. Wang Xing et al. Three parts, such as individual athletic ability, sports ability, expression ability, etc[10]. Wu Zhengyao believes that the physical structure of modern high level athletes include: Body shape and structure, psychological structure, intelligent structure, strength quality, speed quality, endurance quality, agility quality, flexibility quality, etc. We can see that it is not hard to see a little bit of, these 8 contents can be divided into three categories, namely, physical, mental and physical quality.

According to the definition of physical fitness, that is, the physical structure of the body and the function of each organ system to actively adapt sports training, competition and the ability of daily life.

It can be seen that the human body shape and physiological function is the material basis of physical fitness, nature is an essential component of physical fitness[11]. From the performance mechanism, body shape structure and physiological function to meet the needs of the movement is mainly through the physical quality of the performance, therefore, physical fitness is an important part of the physical. According to the above analysis of the physical system, we agree with Tian Maiju and so on, the physical system of athletes is composed of three aspects, such as the physical structure, physiological function and physical quality.

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interaction and mutual dependence, and the organic whole with a specific function. According to the idea of system theory, we have to achieve a certain goal of basketball teaching, to achieve the basketball sports education, the teaching function of all kinds of education, teaching organization form of basketball teaching system. The basketball teaching system includes four basic elements, including teachers, students, teaching content and teaching media. These four elements are interrelated, interaction, mutual restraint, mutual coordination and the complex operation process between the input and output of the system. This is the basketball teaching process. The function of the whole system is reflected by the results of the basketball teaching process. There are six kinds of relations among the elements of the basketball teaching system[13]. The relationship between them is the key to the system. It should be noted that there is no two words between the teachers and the students to add two words, because once the teaching content is chosen in order to promote the development of basketball skills and tactics, the whole system constitutes a basketball teaching system. At this time the teacher is of course basketball teacher, students are also in order to learn basketball skills of students. By the teachers, students, basketball teaching content and teaching media four elements of basketball teaching system, in the form of a static structure, you want to give full play to the function of the system, also pay attention to the fact that the internal system is constantly interacting with each other and information flow, and the formation of teaching process. Only by optimizing the teaching process, can we have a good teaching effect, therefore, the basketball teaching system design should be based on the teaching process optimization[14].

III. RESULTS AND ANALYSE

At present, the height of male and female basketball players in our country has no significant difference with WNBA and NBA players, from the point of view of physical fitness, the biggest difference is in weight, so our basketball players appear too "slim", and the power shortage[15]. Of course, there is a human and genetic anthropolgy, but cannot all be attributed to this reason, or how to explain the success of the project? Visible more important or training cannot all be attributed to this reason, or how to explain the course, there is a human and genetic anthropology, but players appear too "slim", and the power shortage. Of WNBA and NBA players, from the point of view of physical fitness of athletes. Can be seen from Table 3, after the training, the difference between the weight and the weight of the basketball players in the country is reduced, the body fat rate decreased, and the standard deviation decreased obviously, the training effect is received through 6 weeks of training, the physical form of the athlete has been improved. But the results of statistical tests are not significant, this paper thinks that this may be related to the sample size too small.

IV. CONCLUSIONS

This paper describes a model of force analysis in human body, and combined with the physical training theory for the training of basketball, by analyzing the relevant training data that, physical training methods described in the paper on the changing form can play a good role, to improve the professional quality of basketball players.

### Table III. Changes in Body Shape Before and After Training of a Basketball Team

<table>
<thead>
<tr>
<th></th>
<th>Difference between the weight and the standard value</th>
<th>Body fat percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before training</td>
<td>After training</td>
</tr>
<tr>
<td>Mean value</td>
<td>5.50</td>
<td>4.01</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>4.67</td>
<td>3.99</td>
</tr>
</tbody>
</table>

Because of the height, arm length and other body shape indicators are not changed by training, therefore, physical training to improve the body shape of basketball players to adapt to the competition ability is mainly through the improvement of body weight and body fat rate and other measurable indicators to achieve the improvement of the body muscle ratio, ultimate goal of improving the physical fitness of athletes. Can be seen from Table 3, after the training, the difference between the weight and the weight of the basketball players in the country is reduced, the body fat rate decreased, and the standard deviation decreased obviously, the training effect is received through 6 weeks of training, the physical form of the athlete has been improved. But the results of statistical tests are not significant, this paper thinks that this may be related to the sample size too small.

REFERENCE


