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Review

Application analysis of sports biomechanics in sprint physical training

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Abstract: Sports biomechanics is a multidisciplinary applied discipline for studying the human motion mechanics, which plays a key role in the scientific research and scientific guarantee of competitive sports. Integrating biomechanics into physical training can better help students master sports skills, complete sports exercises more easily, and minimize the possibility of sports injuries. The application of sports biomechanics is combined with every movement in students' sports activities, which plays an important role in physical exercise, sports training and teaching. This paper mainly studies the application of biomechanics in sprinting through literature analysis, summarizes the training experience and skills summarized by predecessors using biomechanics in sprinting, and provides athletes and coaches with the best training methods to improve athletes' understanding and practice of the essentials of movement, thereby improving performance.

Keywords: biomechanics; physical training; sprint; application analysis

1. Introduction

Sports biomechanics is a multidisciplinary applied discipline for studying the law of human motion mechanics, and it is the basic discipline of sports science. In foreign countries, as a part of human kinematics (Kinesiology), the study of mechanical principles and methods to explore the law of human movement began in the late 19th century. In the 1960s, the term biomechanics (Biomechanics) became popular in the international academic circle, and movement biomechanics gradually developed as a part of the biomechanics discipline. In order to improve the performance of Chinese athletes in international competitions, China established the biomechanics research group in the Institute of Sports Science of the General Administration of Sport of China in 1959, and began to study the biomechanics of competitive sports. In recent years, biomechanics research related to competitive sports at home and abroad has developed rapidly, with research fields broadened, research methods and means constantly updated, and more and more attention to innovation and interdisciplinary research. Using modern technologies such as artificial intelligence, big data and wearable devices, it has made important contributions to the improvement of athletes sports performance, the prevention of sports injuries and the research and development of sports equipment. Traditional motion biomechanics research methods can be divided into two categories: experimental test methods and theoretical analysis methods. The experimental test method tests the relevant data during the movement of the athletes through the instrument, mainly including the kinematic test method, Dynamics test methods and surface EMG test methods, etc. The kinematic test method is usually video shooting 2D and 3D) and infrared motion capture system to obtain kinematic data, which is the most basic test method of motion biomechanics. The kinetic test method is to test

the external force during the human movement with internal force sensors. The common kinetic testing equipment includes force measuring table, plantar pressure measuring insole, pressure plate, constant muscle force testing system and various special force measuring equipment. Traditional motion biomechanical theoretical analysis method refers to the biomechanical modeling and simulation method. Because the essence of human movement is that the human musculoskeletal system is under the regulation and control of the nervous system, and the limb link follows the law of mechanics in the space movement. Therefore, biomechanical modeling and simulation methods use a computer software system to integrate the physiological and anatomical characteristics and mechanical laws related to movement to establish a biomechanical model of human movement and conduct computer simulation research. Biomechanical modeling and simulation methods are able to explain the interrelationship of kinematic, dynamics, and surface EMG data obtained by experimental tests, demonstrating how human movements move under muscle drive.

Physical activity is an important way to enhance the physical quality and promote the human health. People can develop good living habits and develop a positive and optimistic attitude through scientific sports, but the wrong sports habits may affect people health, and it is difficult to achieve the purpose of physical fitness. Therefore, it is necessary to comprehensively analyze the physical quality of athletes and provide scientific guidance on physical training. Sports biomechanics is a basic theoretical subject of physical education. As far as its basic knowledge system is concerned, it can not only use the basic mathematics, physics and physiology knowledge of middle and high school to explain some technical movements briefly, but also use high-tech means to conduct in-depth research and discussion on sports technology. So, it has a wide range of use value in sports. Therefore, it is a good means to use sports biomechanics knowledge reasonably and accurately.

Using biomechanics can indicate the training direction for sports athletes, it can not only through the analysis of relevant data, the effectiveness of athletes sports training test, can also be based on the general movement rules and individual sports mechanics parameters, realize its own function and scientific evaluation of sports load capacity, and discussed on the basis of the evaluation, provide data support for athletes subsequent training program [1,2]. In the practical application of sports biomechanics, athletes need to accurately capture the contraction force of their muscles with the help of isodynamic force measuring equipment, and judge the strength condition of muscles in the process of exercise according to the obtained data results, so as to provide scientific guidance for athletes in the subsequent muscle ability training. At the same time, sports biomechanics can also reveal the individual sports performance of competitive sports athletes in the actual training or competition process, and provide accurate guidance for the formulation of subsequent training plans and the collocation of nutritional meals.

In conclusion, in the field of modern competitive sports, the value of sports biomechanics is various and specific. The scientific application of the relevant research results can not only significantly improve the athletes own competitive performance, but also better protect the physical and mental health of athletes. Based on this, in order to further promote the construction of a Chinese sports power, it is

necessary to strengthen the research on sports biomechanics [3–5].

2. Biomechanics and physical education training

Biomechanics is a discipline that studies the biological laws and mechanical characteristics of human body in movement, including the load and state of bones and muscles and the metabolic status of human cells. It is an interdisciplinary discipline formed based on the theories of anatomy, mechanics and movement biology [6]. In the exercise state of different strengths and forms, the human body needs to mobilize the joints, muscles and bones of different parts to form forces to support the human body to make a variety of instantaneous movements, such as running, jumping, pushing and stretching, etc. The speed, Angle and quality of the human body will affect its technical movements. If the athlete does not fully grasp the essentials of the movements, the position and size of the muscle force are improper, which may lead to muscle strain and even bone damage. According to the relevant principles of sports mechanics, the parameters of the athletes should be determined first, and scientific guidance should be provided on the basis of analyzing their biological mechanism and state, which can effectively improve the performance and technical level of the athletes training and reduce the physical injury.

When athletes run, their starting speed, pace size, and breathing rate can all affect their technical movement level. According to the relevant analysis of sports biomechanics, the athletes should start by squatting, bend the front leg knee joint 90° –110°, and the bending Angle of the hind leg knee joint is controlled. In this way, the joint force formed between the horizontal and vertical direction of the knee joint is maximized, so that the athletes can start the fastest [7]. In the process of running, athletes should also adjust their pace reasonably according to the length of their legs, and the contact time with the ground and the distance between their feet should be adjusted according to the biomechanical knowledge, so as to avoid the reduction of running speed or increase the probability of knee injury due to mistakes such as dragging the floor and excessive pace [8]. In the process of curve running, athletes should pay more attention to the control of the body Angle and speed. According to their own quality and running speed, the centripetal force calculation formula to calculate the most scientific curve running movements, so as to ensure that the balance is always maintained in the curve running. The running movements obtained from the biomechanical analysis can effectively improve the running performance of the athletes.

3. Analysis of the application of sports biomechanics in sprint training

3.1. Sprint training

Sprinting is a popular event in school sports games. Before the competition, many teachers will judge whether the contestants can run fast based on their body shapes. They believe that people with well-developed thigh muscles are more powerful and will run faster. They also focus on training the thigh muscles during

exercise, but the results of the competition are not ideal. Many scholars have studied the theoretical mechanism of fast sprinting based on the different forms and functions of muscles and the relationship between muscle strength and speed. When running, the human body can be regarded as a non-substantial axis with a fulcrum. The running speed is the product of the step frequency and the step speed [9]. To improve the performance, you can increase the step length and step frequency.

In sports competitions, some famous players rely on the relevant knowledge and principles of sports biomechanics for targeted training. Such as sprinter Carl Lewis met a bottleneck in training, always difficult to improve sprint performance, so Lewis coach adopts the relevant knowledge of sports biomechanics, comprehensive analysis of the body structure, through the movement biomechanics, derived more suitable for lewis skill and mechanical posture, let him break the bottleneck in the game, created a good result [10]. Lewiss success also highlights the important role of sports biomechanics. Through sports biomechanics, teachers can master more scientific and effective PE teaching and training methods, and have a comprehensive understanding of students body structure and level. And through the relevant principles and knowledge of sports biomechanics, help students to improve the accuracy and physical quality ability of training, so that they can master the correct posture and appropriate exercise intensity in daily training and sports learning, so as to promote their physical and mental development, improve the safety of physical education teaching and training.

In sprint training, in order to understand the changes of the stride, we can make full use of the range formula: $s = \frac{v_0^2 sin2a}{g}$ find many factors that affect the stride. First of all, we can see from the form of the formula that the factors affecting the stride size of the body are the initial speed of the center of gravity, the rising Angle and the degree of gravity enhancement. Among them, the initial velocity appears in the form of square, so it has the greatest impact on the stride. How to increase this speed? Here we can imagine that the initial velocity of an object depends on the magnitude and time of the its force. The force of the human body in the air is the resultant force of the elasticity and gravity of the earth to the human body (not considering the air resistance), in which elasticity is the key, and the elastic effect depends on the strength and speed of the back of the leg, and depends on the contraction force and speed of the muscle itself and the coordination of various links of the body. In order to improve the rear pedal effect, we can use the practice of developing the rear pedal strength, swing strength and swing speed, as well as improving the coordination ability of each link of the body. This finds the meaning and purpose of some training means, and can also help us to improve and create some new methods and means. Through the application of this analysis method, the students can understand the physical activities on the basis of the existing theoretical knowledge, and improve the knowledge and scientific nature of sports.

3.2. Analysis of the sprint movement biomechanics literature

Running is a periodic sport combining one-foot support and the air and kicking. Sprint is the extreme intensity exercise over a certain distance in the shortest time. Sprint is to complete the active down pressure of the swinging leg at high strength

and high speed to make the body quickly move forward horizontally, after the foot landing must achieve a strong push effect, so as to obtain a large ground reaction force. In order to obtain large ground reaction forces, the muscles and ligaments around the joint need to bear a large load, thus increasing the risk of injury. From the perspective of biomechanics and anatomy, greatly beyond the normal anatomical range of joints and muscles easy to cause sports injury, but it is beneficial to improve the competitive level of athletes, the key to solve the contradiction is the increase of the body under the ability of anatomical posture, maximum coordination of special the effectiveness and safety of the technical action, the athletes show special technical action mainly depends on its basic movement ability, and in order to accurately perform basic action ability, athletes need a high degree of control ability. In this way, the level of neuromuscular function and its control ability has become a limiting factor for athletes to safely and efficiently complete specific technical movements, especially in sprinting, emphasizing “nerve” training.

Some studies believe that the running support stage can be divided into landing stage and pedal extension stage. The pedal extension stage can also be divided into front pedal and back pedal. According to the working condition of the lower limb muscles, the back pedal can be divided into the back and back pedal segments. The anterior muscles of the posterior step work first, and then the posterior muscles undergo rapid centripetal contraction. The posterior knee joint of the posterior pedal is mainly composed of flexion muscles. The speed loss lost in the forward support stage of the run can be completely supplemented from the back pedal. Too close to the place is unfavorable to the vertical speed of the front support. The one-sided emphasis on the theory that the site is close to the projection point of the body will destroy the rationality of the movement.

The kinematic changes of the center of gravity of the human body should strictly follow the law of mechanics, that is, the movement should show a good mechanical matching relationship with the ground reaction force, that is, it should conform to the law of the law of movement of the center of mass. The kinematic data of the human center of gravity is usually calculated based on the analysis of the image by the human model. There is no individual difference, and the error caused by the simplification is not formed by the rigid body. On the contrary, the ground reaction force can be accurately measured by the force measuring table. On the basis of the force value data, the movement of the body center of gravity is reliable, and there is naturally a mismatch of mechanical relationship between the two.

At present, a large number of studies use high-speed video recording to measure the reaction force on the ground simultaneously, and to smooth the coordinates of the human center of gravity calculated by the integrated coordinate data, that is, the kinematic data of the center of gravity is reconstructed on the basis of the conventional analytical results, so as to solve the mismatch problem theoretically. So called integral smooth its principle is based on the known body center of gravity acceleration change law and the initial position of the body center of gravity, assuming an initial speed variable, get the center of gravity position motion function expression, further to the theoretical coordinates of the center of gravity and the coordinates of the least squares method fitting can get more correct initial speed, so that according to the known center of gravity acceleration completely according to

the law of mechanics of the body center of gravity speed and position.

3.2.1. Effect of step frequency and step length on sprint movement

To evaluate a sprinters skill, step frequency and step length are the simplest and most intuitive movement parameters, and step length and step frequency are also the two most important factors affecting running speed. The larger the stride length, the higher the stride frequency is, and the better the sprint result is. Therefore, how to improve the running speed of sprinters by increasing the step length and improving the frequency of their movements is the general guiding ideology of the coaches of various countries.

Li and Huang [11] pointed out that there are 5 ways to improve the speed: (1) keep the step frequency unchanged and increase the step frequency; (2) keep the step frequency unchanged and increase the step length; (3) the step length is slightly reduced but the step frequency significantly increases the product of the two; (4) the step frequency slightly increases the product of the two. However, the relationship between step length and step frequency is a unity of opposites, especially on the basis of high running speed, the contradiction between step length and step frequency is more prominent, that is, after reaching a higher running speed, the excessive increase of step length will cause the decrease of step frequency, and the excessive increase of step frequency will also lead to the shortening of step length [12]. There is no consensus on which decisive role the step length and step frequency plays in sprinting. Studies say that step length may be greater when running at less than 8.5 m/s, and step frequency may be more important when running at over 8.5 m/s. Step length and step frequency are the comprehensive embodiment of athletes skills, physical quality and physical conditions, which undoubtedly have individual differences. Li and Xu claims that each athlete has an optimal step length at a specific speed. It is wrong to blindly pursue stride length or pursue stride frequency is too high [13]. Their final result is that the stride length and stride frequency cannot be highly coordinated and unified, leading to the deformation of technical movements, which seriously affects the sprint performance. We should find out the gap through the comparison between Asian sprinters with similar technical characteristics, and then find a solution, which will be more objective and representative.

3.2.2. Effect of hip movement on the sprint

Modern sprint techniques are characterized by high-speed swing on the hip axis. The pulp is the key link of human acceleration, and the pulp power is the main power source of the human body. It is the ability of the hip extensors to work. Good hip delivery technology can make the running movement coordination, relaxation, natural and labor-saving. Fast hip extension has a much greater effect on running speed than fast knee extension [14]. Wwing the leg in the ground can reduce the front pedal braking effect. Some scholars point out that improving the extension speed and amplitude of the support leg and hip joint plays an important role in reducing the ground angle and improving the extension ability and running speed. Therefore, the range and speed of hip extension are two important indicators to measure the level of sprint technique. The amplitude and speed of the hip of the high level athletes are significantly greater than those of the average athletes [15].

Therefore, athletes often want to increase the running speed by increasing the extension range of the hip and accelerating the speed of the hip.

3.2.3. Effects of thigh movement on sprinting

Modern sprints require more prominent leg-swinging skills, emphasizing the combination of pushing and pushing. A large number of scientific studies have shown that the reason for the high running speed is a strong leg swing rather than a quick push. And many scholars believe that the angular speed and swing amplitude of thigh movement is the best measure of sprint technology. Wang [16] once pointed out that the main reason for the slow pace of Chinese sprinters is the slow swing leg speed, to speed up the swing front swing and drop speed and pay attention to the swing leg height is the main way to improve the sprint performance in China. Liu [17] pointed out that the fast front swing leg is of great significance to the maintenance and increase of the human body in the support stage. The maximum swing speed of the swing leg is the key to affect the support time, and directly affects the running frequency and speed on the way. In the buffer period, accelerating the swing speed of the swing leg can effectively accelerate the forward speed of the center of gravity [17]. The amplitude and speed of thigh swing on the backpedal effect, the rapid forward of the center of gravity, the shortening of the support time, and he positive effect of the hip joint have been recognized by the majority of sports research workers, coaches and athletes. Although some scholars from the kinetic point of view, there is not necessary to fold the calf, but the sprint is a speed as the core sport, only from the kinetic point of view. Increasing the moment of inertia without requiring the folding and high pendulum of the big calf will affect the movement speed of the whole lower limb, thus affecting the rapid forward movement of the body center of gravity. Therefore, according to the law of conservation of momentum moment, the big leg should be required to fold fully to reduce the radius of rotation and speed up the angle of rotation.

4. Conclusion and prospect

In conclusion, sprinting performance is mainly affected by the sprinters ability to quickly swing the lower limbs in the air period and their ability to withstand the ground reaction force and the ability to produce the push reaction force quickly during the support period. Therefore, the interaction between the three links of the lower limb moment and their influence in the knee, hip joint research, is helpful to help us understand the sprint in the support period and empty lower limb muscle coordination, control movement function, and further understand the biomechanics of human joint movement control mechanism, provide the basis for technical analysis, technology. Recently, the biomechanics of sprint research has received much attention. Some monographs and papers illustrate the mechanical factors in sprinting, but most of the studies only focus on the local kinematic characteristics of the lower limbs, but do not study all parts of human movement as a movement system as a whole, which is also our key research direction in the future.

Finally, in sports training, the relevant theoretical knowledge and analysis methods of sports biomechanics are necessary to promote students to learn sports techniques and improve their performance. Based on the relevant knowledge of

kinematics and dynamics, combined with human anatomy and physiology, the biomechanical characteristics of excellent athletes during exercise are analyzed, and training methods to improve performance are summarized. Applying the knowledge of sports biomechanics to the practice of physical education teaching and sports training can not only enable students to gradually explore a set of sports skills and training methods suitable for their own body functions in long-term training, but also improve the comprehensive quality of physical education teachers themselves.

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