On the Relationship Between Newton's Law and Sports

Taking Track and Field as an Example

Kehan Li[1], Enming Zhou[2(✉)], Fangzheng Tao[3(✉)], and Zhihao Du[4]

[1] Sports Science of Education, University Putra Malaysia, Selangor, Malaysia
[2] School of Physical Education, Sichuan University of Arts and Sciences, Dazhou, Sichuan, China
2940255673@qq.com
[3] Physical Education, University Putra Malaysia, Selangor, Malaysia
1458460327@qq.com
[4] Physical Education Teaching, Beijing Normal University, Beijing, China

Abstract. Newton's law can be said to be one of the greatest discoveries in the 17th century. Newton's law has not only been widely used in physics, but also emerged a large number of studies in physical education, extended the interdisciplinary disciplines such as sports biomechanics and sports human science, and promoted the more scientific development of sports. It is of great significance for athletes to master Newton's basic laws for the development of sports. This paper discusses the relationship between Newton's law and sports through the methods of literature, case analysis, data analysis and logical induction. Taking track and field events as an example, this paper empirically analyzes the application of Newton's law in sports. But how to better apply Newton's law to sports needs to consider some other factors such as sports angle.

Keywords: Newton's law · Athletic sports · Track and field sports

1 Introduction

Newton's law is one of the greatest discoveries in the 17th century. The discovery of Newton's law not only let us know gravity, but also opened a new chapter in the study of physics. Newton's law has not only been widely used in physics, but also a large number of studies have emerged in sports science, which extends the interdisciplinary disciplines such as sports biomechanics and sports human science, and promotes the more scientific development of sports.

In competitive sports, if you want to achieve good results, you cannot only rely on sports talent, but also rely on scientific training methods. Athletes are also required to have relevant sports knowledge in order to shine in the arena. Therefore, athletes, coaches and physical education teachers should pay attention to the physics knowledge involved in physical education. Among the physical knowledge, biomechanics is the basis for mastering sports skills, changing technical movements, creating scientific training methods and improving sports performance. The study of biomechanics is

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inseparable from Newton's basic laws. Therefore, it is of great significance for athletes to master Newton's basic laws for the development of physical education. Taking track and field as an example, this paper analyzes the relationship between Newton's law and kinematics, aiming at discussing track and field from the perspective of biomechanics, so as to promote the improvement of track and field technology.

2 The Relationship Between Newton's Law and Sports

2.1 Newton's First Law and Sports

Newton's first law mainly talks about inertia, and the size of inertia is related to the mass of the object, not to the speed and the roughness of the contact surface. For example, the greater the mass of an object, the greater the work to overcome this inertia. Similarly, the smaller the mass of an object, the smaller the inertia to be overcome and the smaller the work to be done [1]. The word mass appeared in Newton's first law. People sometimes confuse the concepts of mass and weight, or think that mass and weight are one concept. In fact, mass is defined as the mass contained in an object. Mass is a physical quantity that measures the gravitational potential energy and kinetic energy of an object at the same place. The mass units include milligrams, grams, kilograms, tons, etc. Weight is the downward force of an object under the action of gravity. According to the law of universal gravitation, objects of the same mass have different weights due to different gravity. The units of weight are Newton and kilogram. The quality of athletes participating in different sports is the same. However, the weight of athletes on the flat ground is different from that on the slope. The downward force on the slope is different from that on the flat ground, which is the difference in mass and weight.

2.2 Newton's Second Law and Sports

Newton's second law mainly describes the role and effect of force, the relationship between the acceleration of an object and the resultant force and mass of the object. When the force changes, the acceleration will also change, and they have the characteristics of identity, change and disappear at the same time. The resultant force of the object is in the same direction as the acceleration and inversely proportional to the mass of the object [2]. In sports, the quality of athletes or some sports equipment is constant and a fixed value, which is why many sports need acceleration links, such as run-up of long jump, slide step of shot put, run-up before gymnastics, etc., These are to obtain the maximum acceleration before completing the action, and use the acceleration to complete the resultant force, so as to achieve better sports results.

2.3 Newton's Third Law and Sports

Newton's third law mainly describes the relationship between the force and reaction between two interacting objects [3]. The force and reaction are equal in size and opposite in direction. This is the truth that the forces acting on the same straight line are interactive. Newton's third law also plays a great role in sports [4].

3 Application of Newton's Law in Track and Field

3.1 Application of Newton's First Law in Track and Field

The complete action of the fast jump is divided into four parts: run-up, take-off, take-off and landing. The run-up link is to improve the motion acceleration. The faster motion acceleration will bring greater inertia [5]. After taking off, the inertia brought by the run-up can be used to get a long time of body take-off, and the longer time of take-off can make the landing distance of the long jump longer, To get better sports results. It is not difficult to find some phenomena of Newton's first law in sports. In the process of long-distance running, when maintaining a speed to keep the strength constant, athletes can persist for longer and feel more labor-saving. If athletes suddenly accelerate or decelerate in the process of running at a constant speed, they will make athletes more tired, Changing the original speed will consume more physical energy, while maintaining a uniform speed will save more effort. This is the role of inertia in long-distance running. In China, there is an old saying that "one drum up, decline again, and exhaust three times." A good explanation can also be found by applying it to sports and biomechanics. For example, push ups. 30 push ups are divided into 3 * 10 one-time exercises and group exercises. Athletes often find it more difficult to adhere to group exercises, which is the reason for inertia. When athletes do 30 push ups at one time, they often use inertia to help complete the second half of the movement. However, in group practice, athletes often feel more tired or even unable to complete after a short rest, and the physical energy consumed by group practice is often greater. It is relatively difficult for the movement to obtain a large speed from the rest, but it is easier to maintain or further improve the original speed.

3.2 Application of Newton's Second Law in Track and Field

In the track and field 100 m dash competition, athletes need to use an auxiliary equipment called starter, because 100 m dash is a speed sport. In this sport, athletes should overcome the factors of gravity and quality, maintain acceleration throughout the whole process, and rush across the finish line at the fastest speed to achieve the success of the competition. The function of the starter in the competition is to help the athletes get a greater resultant force through the back pedal of the starter at the beginning to improve the athletes' initial acceleration, which is applied to the resultant force of Newton's second law. The same is true in throwing events. In the throwing stage, the body tilts backward to push the ground, which is also applied to the resultant force of Newton's second law. After the athlete pushes the ground, he receives the force from the ground and forms a new resultant force with the force of his own arm to push the missile, so that the missile can be thrown farther. The greater the resultant force, the greater the acceleration. This is also an example of Newton's second law applied to sports. In Newton's second law, the application formula is $F = ma$, where F is the force, that is the resultant force, a is the acceleration, and m is the mass. In fact, the resultant force is the net force, which can also be called the sum of all forces, that is, the final result obtained by adding the size and direction of all forces is the resultant force (net force) [6]. As shown in Fig. 1, we can see that $F = F1 + F2$, where F is the resultant force of F1 + F2, and F1 and F2 are the components of F. We can also put it another way and the vector sum of multiple

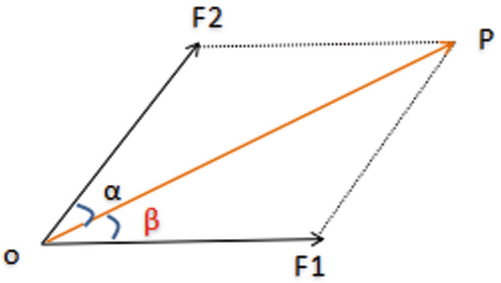

Fig. 1. Resultant force diagram of Newton's second law

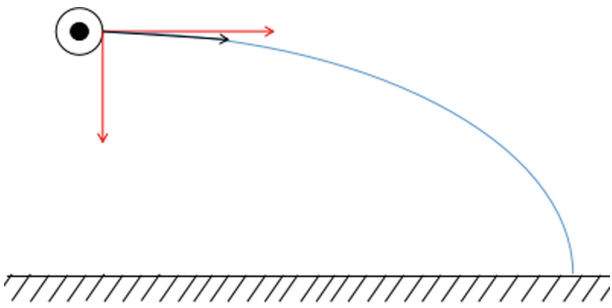

Fig. 2. Newton's second law throwing diagram

forces acting on the same object. The acceleration of an object is directly proportional to the resultant force and inversely proportional to the mass of the object, that is the same acceleration will change the resultant force on different masses. The greater the mass of the object with the same acceleration, the smaller the resultant force, and the smaller the mass of the object, the greater the resultant force. As shown in Fig. 2, in the throwing movement, we know that the shot weight is 5 kg. How much force do we need to use to make the shot obtain an acceleration of 15 m/s^2. At this time, we need to use Newton's second law F = ma to solve the unknown quantity, where m = 5 kg and a = 15 m/s^2 are known. Substitute the formula F = 15 * 5 to get that we need a force of 75N to make the 5 kg shot have an acceleration of 15 m/s^2.

3.3 Application of Newton's Third Law in Track and Field

Newton's second law mentioned above refers to the resultant force used in the starting of 100m Sprint and the resultant force in throwing events respectively, and these two resultant forces include the force and reaction force in the third law. In the 100 m dash, when the athlete starts, the force of stepping on the starter pedal is the force applied to the pedal, and the force given to the athlete by the pedal is the reaction force [7]. The same is true in throwing. Athletes exert a force on the ground when pedaling and turning, and also receive the reaction force transmitted from the ground. When the reaction force reaches the maximum, and there is an appropriate throwing angle to form a resultant

force, we can achieve good throwing results, which is the relationship between force and reaction. More generally speaking, if we do not bend our legs and exert a downward force on the ground when we jump in situ and touch the height, we will find that we can't jump up or can only leave the ground a little distance, When we squat down actively during the vertical jump, we will receive a reaction force from the ground. At this time, we will find that we jump dozens of times higher than the original, which is the application of Newton's third law. In sports competition and training, we can also improve the performance of athletes through sports mechanics and Newton's third law.

4 Conclusion

The previous article has introduced the relationship between Newton's three laws and sports, but how to better apply Newton's laws to sports needs to consider some other factors. For example, in throwing sports, athletes want to throw objects far away, which is inseparable from two elements. One is the initial speed of the projectile, that is the force given by the athlete to the projectile, and the other is the appropriate throwing angle. These two elements will form a perfect parabola to achieve excellent competitive results. If the throwing speed is very fast, but the throwing angle is very low, it will form a downward parabola, and the projectile will hit the ground heavily, which cannot achieve good results. If the throwing angle is too high, it will form an upward parabola, the projectile will obtain more upward force, and reducing the force in the horizontal direction cannot achieve good results. In order to make the athletes' competitive performance better, through the calculation of Newton's law, it can be concluded that under the action of the same force, when the object forms an angle of 45° with the horizontal plane, it is the farthest to throw. Under the condition of the same throwing speed, the best throwing angle of throwing events is 45°, at which the athletes' best performance can be obtained. In the starting link of track and field 100m Sprint, athletes should use the starter to run up. In the starting link, faster acceleration can be obtained, and the angle of the front and rear pedals of the starter also uses Newton's law to calculate the best angle of the front and rear pedals. The front pedal is generally 40–45°, and the rear pedal is generally 70–80°. The starting pedal at this angle can exert the maximum force and get the maximum reaction force. If the angle is too low, it will not have the effect. If the angle is too high, it is easy to cause sports injury due to unstable center of gravity.

With the development of science, coaches and athletes pay more and more attention to the relationship between sports biomechanics and sports. In competition and training, they use sports cameras to shoot movements, and use sports biomechanics software to analyze, so as to obtain the best force point and angle of technical movements. Correcting the errors in athletes' technical movements and creating a training method more in line with this sport are the application of Newton's law to sports.

Authors' Contributions. Li Kehan, Male, Han nationality, PuYang City, Henan Province. Master candidate. Sports Science of education, University Putra Malaysia, Selangor Malaysia. Research interests: sports human science, track and field.

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