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Sports Science Teaching of Athletics Based on Nonlinear Mathematical Equation

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Abstract

To study the teaching of sports science in athletics, this paper adopts the method of a nonlinear mathematical equation. According to the explosive power = force * speed and hill force speed equation, the best matching value between the load weight and the muscle contraction speed when the athlete reaches the maximum explosive power is obtained by the mathematical method, to achieve the objective of quantifying and scientifying the maximum explosive power training method according to the individual ability of the athlete. The results show that the training intensity is slightly lower than the optimal strength load (about 30%F0) and faster than the optimal movement speed. Jumping events adopt load weight higher than the optimal load to 50% F0 and load intensity slightly slower than the optimal speed combination for training; Conclusion: According to the characteristics of track and field events, this paper discusses the application of the research results in the training of athletes' explosive development in different track and field events, to achieve better training effect and improve students' athletic ability.

Keywords: Maximum burst power; Physical education teaching; Nonlinear mathematical equation**AMS 2010 codes:** 35F20

1 Introduction

Developing track and field teaching in physical education can enhance students' physique and their comprehensive ability. But it is found in practice that many students have prejudice to track and field events, which they think involves only running and jumping. Hence they feel it is boring and cannot actively participate in them. Given this situation, teachers should combine theoretical knowledge teaching, improve students' understanding of track and field [1]. For example, when teaching high jump, teachers can first teach relevant theoretical knowledge so that students can understand the development of high jump, stimulate students' interest in learning and

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kindle their interest in learning. With the help of a multimedia system, video of high jump can be played, and detailed explanation can be provided to guide students to learn and master high jump skills [2]. In addition, teachers can also guide students to appreciate the video of the competition so that students can feel the charm of the high jump and stimulate their enthusiasm for learning. Then, using effective training methods to train the students, the students should be made to experience and personally feel the fun of the high jump, to have a new understanding of the sport. The combination of theoretical teaching can enhance students' knowledge level and their understanding of track and field [3].

Explosive power is an important quality of athletic athletes who are mainly engaged in muscular activities. It is prominently embodied in the key movements such as the starting, marching and crossing attack hurdles of sprints and hurdles, the taking off of jumps and the last force of throwing. It plays an important role in track and field events. Explosive power is more important than maximum power in most dynamic sports. Therefore, the research of developing the means of explosive force training has become a topic of concern. Based on the equation of burst power = force speed and hill force speed, this paper tries to calculate the value of load weight and movement speed which should be adopted in the training of explosive force following the individual ability of athletes by using the mathematical method, to provide a reference for the scientific training of explosive force of athletes in different track and field events. Athletics is an ancient and traditional sport, and track and field sports are considered to be the identity of sports at the national level. In competitive sports they are described as 'the track and field of the world' because track and field is the basis of all sports [4]. Track and field sports of our country has levelled up with the continuous development of our country's economy, the comprehensive national strength has increased, also made great strides in development, and also has made no small achievement in international competitions, such as Wang Junxia who won gold medals in 5000 m in 1996 Atlanta Olympics and in 2004 Athens Olympics, Liu Xiang who won the gold medal in men's 110 m hurdles, etc. Although we have made good achievements, there is still a big gap left between the level of track and field in our country and foreign countries. How to bridge these gaps is an important question that China's track and field sports need to address at present [5].

In today's world of track and field sports, the United States occupies a very important position, and China, though they have obtained no small results, these results are not so eye-catching. By combing the number of track and field gold medals obtained by our country in the past, we can explain the level of track and field sports in our country [6]. From the 1984 2012 London Olympic Games, China has clinched only won 6 gold medals in track and field events in the Olympic Games. In the 1996 Atlanta Olympic Games, Wang Junxia won the gold medal for the 5000m event.

In the 2000 Sydney Olympic Games, Wang Liping won the gold medal in race walking. In the 2004 Athens Olympic Games, Liu Xiang won the gold medal in the men's 110m hurdles and Xing Huina won the gold medal in the women's 10,000m event. In the 2012 London Olympic Games, Chen Ding won the gold medal for men's 20km race walking.

From the above data, we can see that the overall development level of track and field in China is still low, and there is a big gap between the sports level of some powerful countries in track and field in the world. Although it is currently in the leading position among Asian countries, these advantages are not very big and may be surpassed by other countries at any time.

2 Research methods

2.1 Research overview of burst power

2.1.1 Bursting power = force $\times$ speed

At present, there is still no consensus on the definition of the concept of explosive force, but what is expressed is basically the same, and it refers to the ability of muscles whose tension has begun to increase to overcome resistance as quickly as possible. It is the ability to exert as much power as possible in as little time as possible,

an organic combination of power and speed. The idea is that explosive force is the product of speed and force,

Explosive force = force times velocity,

The $P = F \times V$,

Is the burst power.

2.1.2 Hill's force velocity equation

In 1938, Hill, a famous British physiologist, took the sartorius muscle of a frog in isolation for experiments. By measuring the heat production and mechanical work done in the process of muscle contraction, based on the first law of thermodynamics, he derived the FV relationship with extensive significance, which is the famous Hill characteristic equation in muscle mechanics:

$$(a + F)(V + b) = b(F_0 + a)$$

Among them, F_0 is the maximum tension produced under muscle contracture;

F is the tension generated when one end is relaxed,

$F < F_0$,

2.2 The best matching value between the load weight of the maximum burst power and the operating speed

2.2.1 Overview of maximum burst power training method

Previous studies have shown that small and medium load strength training can not effectively mobilise fast muscle fiber with low excitability to participate in contraction, and large load strength training is not beneficial to the establishment of fast or super-fast motion stereotyping. Therefore, the maximum burst power training method came into being [9, 10]. The maximum burst power training method is an effective way to develop the explosive force, which combines the appropriate load weight and the appropriate movement speed in the training to reach the maximum burst power output limit load of the human body, which is indispensable for the development of rapid strength. At present, the results of studies on the optimal weight load for the development speed force are quite different and therefore inconclusive. Selecting the load weight suitable for the individual ability of the athletes and adopting the corresponding fastest speed to strengthen the training can effectively improve the burst power. The physiological mechanism is that the maximum burst power of the human body is constantly stimulated and strengthened through the body adaptation mechanism so that the body can produce biological adaptation and balance to the maximum burst power load of the human body at this stage so that the rapid strengthening of the human body can be improved.

2.2.2 Theoretical basis for the optimal matching value between the load weight of the maximum burst power and the operating speed

Burst power = force $\times$ speed

Emphasise that the muscle releases the maximum power under the optimal coordination of the force and speed used, and take this as the criterion to evaluate the burst power. The output of burst power is affected by the speed of muscle contraction, muscle force and muscle movement

It is the most scientific and efficient way to develop burst power through the direct correlative factors affecting burst power: muscle tension and contraction rate. From the formula

$$P = F * V$$

It can be seen that to improve the burst power, we have three corresponding training approaches:

1. Keep the action speed unchanged and increase the load weight;
2. Keep the load weight unchanged and speed up the action;
3. the load weight and the speed of action increased at the same time.

2.2.3 Mathematical determination of the optimal matching value of load weight and action speed of the maximum burst power

In this paper, the relation between the load weight and the speed of action which can reach the maximum burst power is calculated by the method of derivation. The analytical method is as follows: According to the Hill force velocity equation $(A + F)(V + B) = B(F_0 + A)$, the relationship between load weight F and contraction speed V is deduced

$$(a + F)(V + b) = b(F_0 + a)$$

$$V = b(F_0 + a)/(F + a) - b$$

So we have P is equal to F times V , and we put V in

$$P = F[b(F_0 + a)/(F + a) - b]$$

You take the derivative with respect to P , and you find the extreme of P

$$\begin{aligned} P'(F) &= [(-bF_0bF^2)/(F + a)]; \\ &= (-bF^2 - 2abF + abF_0)/(F + a)^2 \end{aligned}$$

To $P'(F) = 0$, then

$$(-bF^2 - 2abF + abF_0)(F + a)^2 = 0$$

Because b does not equal 0, so

$$F^2 + 2aF - aF_0 = 0 \quad (F + a)^2 = aF_0 + a^2$$

Because F times b times b zero zero

$$F = a^2 + aF_0 - a$$

Because a , b , and F_0 are all greater than 0, then $P(F)$ is less than 0

$$F = a^2 + aF_0 - a$$

The maximum value of P is going to

$$F = a^2 + aF_0 - a$$

Plug in

$$V = b(F_0 + a)F + a - b$$

$$V = b(F_0 + a)a^2 + aF - b = bF_0 + aa - b$$

Substitute a and b to find the best match value of F and V and the maximum value of P .

The application of the maximum burst power training method is determined by the load weight and the motion speed. The value of F and V is introduced into the training, which can make the maximum burst power training method easy to be quantified, scientific and concrete. Furthermore, this relationship can also be used to estimate the athlete's maximum burst power by measuring F_0 (F_0 can be used as the athlete's maximum strength in training, instead of the maximum tension generated during muscle contracture

3 Research Results

3.1 Application of maximum burst power training method in track and field events

3.1.1 Determination of maximum burst power training method load

In training, the combination of the optimal load weight ($F = A_2 + AF_0 - A$) and the optimal movement speed ($V = BF_0 + AA - B$) can be adopted, which is slightly lower than the optimal load weight and the combination of faster than the optimal movement speed, or slightly slower than the optimal movement speed and large. One should practise with three load intensities for optimum load weight combination. The combination mode of specific load intensity should be selected according to the development level of athletes' physical quality and the characteristics of sports events and should be adjusted and controlled during training.

Maximum strength plays an important role in the development of burst power, so appropriate maximum strength training should be arranged at the right time to increase the number of muscle fibres that can be recruited by the nervous system. And with the timely arrangement of small load fast practice, while improving the nervous system concentration and exciting functional state, one can achieve the best effect of explosive force training.

The training practice has proved that it is not advisable to adopt the first two ways to develop the burst power, that is, to develop the power or speed by one side, and it is necessary to consider the development at the same time to get better results. Theoretically, according to the formula $P=FV$, that is, exercise with the maximum muscle strength and the fastest muscle contraction speed of the human body, the burst power P will reach the maximum. However, it is clear that the human body's ability is limited, and the curve can only move up within a certain range after long-term specialised training, as shown in Figure 1.

Fig. 1 Three ways to increase the maximum burst power

The F-V curve of the Hill force velocity equation reflects that muscle tension and muscle contraction speed jointly determine the size of explosive force, and there is a negative correlation between the two. The greater the muscle tension is, the slower the contraction speed will be, while the smaller the muscle tension is, the faster the contraction speed will be (as shown in Figure 1). The two cannot reach the maximum at the same time. Therefore, when the burst power P of the human body reaches the maximum, the force and speed do not reach the maximum simultaneously, but the optimal matching value of the two, that is, the maximum movement speed that the athlete can reach when overcoming the most appropriate load weight. This optimal matching point corresponds to the maximum burst power. To sum up, the key to the effective development of burst power training is to adopt the appropriate load weight and speed corresponding to the maximum burst power output for training. It should be noted that with the continuous improvement of athletes' training level, the load weight and speed adopted are in a dynamic balance. Therefore, the load weight and speed should be adjusted according to the principle of maximal explosive power according to the actual situation of the athletes. Make new demands, make it constantly raise, and reach a new balance.

3.1.2 Application in track and field events

The burst power is determined by two factors: force and speed. Feng Shuyong believes that in many events of track and field, some need explosive force based on speed, and some need explosive force based on strength. Tudorb divides the explosive force in motion into aperiodic explosive force and periodic explosive force. The following will be based on the characteristics of track and field events, combined with the above two classification methods to discuss the practical application of the maximum burst power training method.

3.1.3 Application in the training of short-distance running and hurdle running

Short-distance running and hurdle running reflect the periodic explosive force, which requires the explosive force based on speed, and emphasises the combination of the improvement of the explosive force and the improvement of speed endurance. Therefore, when adopting the maximum burst power training method, athletes of such events can use the combination of load intensity slightly lower than the optimal force load (about 30%F0) and faster than the optimal movement speed for training, and under the condition of speed does not decrease, according to individual circumstances, repeat about 10 times, with a long interval. For the athletes who are too slow, explosive power should be developed by emphasising fast movement.

3.2 Matters needing attention in the application of maximum burst power training method

The improvement of technology and the enhancement of special explosive force are carried out simultaneously, and the means adopted in the training of explosive force must meet the requirements of special technology. Athletes have to conform to the special characteristics of explosives in the well, must have a reasonable and stable technology, will be to complete the action process, coordinate and smooth chain structure, should pay attention to the advantages of chain link in the improvement of technology and the weak link technology improvement, so that the athletes have physical performance.

4 Conclusion

When the explosive force is trained, the appropriate load weight should be selected according to the special characteristics and the development level of the athletes' physical quality to complete it as fast as possible, to develop the explosive force effectively. Specific to the track and field events for the sprint and hurdles: using slightly lower than the optimal force load (about 30% F0) and faster than the optimal speed of the combination of load intensity training; Jumping events: training with load weight higher than the optimal force load to 50% F0 and load intensity slightly slower than the combination of the optimal speed; Throwing events: a large load (about 50%-80%F0) higher than the optimal strength load is adopted for training, and the load intensity combined with the speed of action as fast as possible based on the premise of whole-body coordinated effort. The training means adopted must conform to the requirements of the special technique.

References

- [1] Lu Y, An S. Research on sports video detection technology motion 3D reconstruction based on hidden Markov model[J]. *Cluster Computing*, 2020, 23(3):1899-1909.
- [2] Wang S, Zhang F, Gong Q, et al. Research on PBL teaching of immunology based on network teaching platform[J]. *Procedia Computer Science*, 2021, 183(11):750-753.
- [3] Lazurenko S B, Solovyova T A, Terletskeya R N, et al. Problems of Health Protection of Students with Health Limitations in Educational Institutions of the Russian Federation[J]. *Integration of Education*, 2021, 25(1):127-143
- [4] Tong Y, Wu J, Zhang X. Research on Interdisciplinarity-Teaching of Digital Media Art Under Big Data[J]. *Journal of Physics: Conference Series*, 2021, 1883(1):012145 (6pp).
- [5] Liu L. 71.The Research of Highly Effective Wrestling Educational Model based on Optimized Theory Technology[J]. *Revista De La Facultad De Ingenieria*, 2017, 14(1):37-41.
- [6] Joly M, Rocha R, Sousa L, et al. The strategic importance of teaching Operations Research for achieving high perfor-

- mance in the petroleum refining business[J]. *Education for Chemical Engineers*, 2015, 10:1-19.
- [7] Jin H, Shin H J, Johnson M E, et al. Developing learning progression-based teacher knowledge measures[J]. *Journal of Research in Science Teaching*, 2015, 52(9):1269-1295.
- [8] Martin, Schwichow, Corinne, et al. What students learn from hands-on activities[J]. *Journal of Research in Science Teaching*, 2016, 53(7):980–1002.
- [9] Aidara S, Sagna Y. BSDEs driven by two mutually independent fractional Brownian motions with stochastic Lipschitz coefficients[J]. *Applied Mathematics and Nonlinear Sciences*, 2019, 4(1):151-162
- [10] Modanli M, A Akgül. On Solutions of Fractional order Telegraph Partial Differential Equation by Crank-Nicholson Finite Difference Method[J]. *Applied Mathematics and Nonlinear Sciences*, 2020, 5(1):163-170

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