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Excellent Long Jump Athletes in the World Mechanical Model of Influencing Factors

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Abstract: Based on mechanics model for reference, ideal for the worlds excellent long jump athletes and the kinematics parameters were analyzed and find the long jump athletes to perform the optimal mechanical factors, thus providing support to the long jump teaching and train related theory, provide the basis for the development and training of long jump technique. Studies have shown that improve the utilization rate of speed when the takeoff is the guarantee of takeoff effect and the key to obtain ideal result; Increasing use of run-up speed, increasing vertical speed, increase leaps Angle is the important way of long jump athletes get good grades; Athletes used effective methods with specific training, in order to improve the level of long jump movement finally to achieve.

Key words: Mechanical model, long jump, the influence factors

INTRODUCTION

Jump of the ancient games began from 780 BC, at the time as a project in five games. The men's long jump record first created by the British F.G. Gucci in (1864), the result is 5.80 meters. By Iceland's rail until 1875 to 7.04 m for the first time 7 m mark. Since the 90 s, the emptied to Europe for the center of the long jump technology extensively studied while ignoring the run-up speed of research, therefore, the long jump technique, there is no substantial increase. Now with the development of sports technology, the theory of the long jump technology from biomechanics and anatomy, psychology has carried on the system, extensive research, makes the long-jump result continuously improved (Cui, 2013). The world record set on the World Athletics Championships held in Tokyo in 1991 by the American athlete, Powell is held till the present (Zhang, 2013).

Takeoff is complex and the key link in the long jump technique, is the turning point of athletes from horizontal motion to mass ejection movement and is an important factor to decide the performance. Jump athlete should try to swing quickly, shorten the takeoff time, increasing the vertical speed, improve the utilization of run-up speed and choose the right Angle (Wang and Yang, 2013). For the kinematics of take-off technology research, most experts at home and abroad from the body before the spin angular velocity, the trunk, swing technology, step length, link and joint Angle and velocity analysis (Yang, 2013). The jump performance is associated with what factors, jump the complete technology consists of run, jump and fall to the ground suspension of four parts. Dynamic model of this paper is mainly on the world elite male long jump athletes performance and jump related parameters is analyzed with mechanics and aims to find the men's long jump athletes in the long jump from takeoff to fall to the ground in the process of mechanical characteristics, in order to in the future for athletes to provide theoretical basis for targeted training, to improve the level of the long-jump athletes has important guiding significance.

RESEARCH OBJECTS, METHODS AND RELEVANT TECHNICAL MEANS

Take the performance and relevant take-off parameters of the world elite male long jumpers as the research objects.

Consult the athletic long jump competition data, long jump influencing factors analysis, sports biomechanics, computer programming and other monographs in related aspects and relevant literature (Tan, 2013); understand the current influencing factors of long jump performance and empirical status quo and research methods from which the technical difficulties and keys of relevant researches can be found. Make statistics and analysis of the performance data in the material. Make analysis of the long jump performance and relevant data by applying the biomechanical principles and formulas, compile the data by the functions and formulas in Excel 2003 and make calculation and measurement of each parameter constituting the long jump performance (Gu, 2013).

RESULT AND ANALYSIS

Analysis of the long jump process: Athletes in the long jump, no matter adopt what kind of air movement, formed by the body's centre of gravity after takeoff trajectory is the basic won't change, is oblique movement. Body velocity of suspension for Vo, leaps Angle as the alpha, the origin of O for five points, the x axis of the OC for horizontal takeoff, when the body is due to run until point O A certain Angle of takeoff, assuming that the centre of gravity in point B, if not considering gravity (in the whole process of the analysis of the long jump to ignore the role of the air resistance), the athletes' body center of gravity should be made in the direction of the OB uniform motion in A straight line but due to the effect of gravity, athlete's center of gravity of body is actually diagonal movement, assuming as both feet touch the ground when the body's centre of gravity at point A, in the process of the human body center of gravity as A curve movement. From point A to start immediately after landing on knees, pelvis forward, two arms, the body moves quickly through point, center of gravity move quickly down to about two feet with site C, the whole process is shown in Fig. 1.

Long Jump degree is far from the take-off point to the landing point of the horizontal distance. I will jump process is divided into three stages, the long jump performance (L = OC) is the following three parts:

- **L1:** (the first phase jump, trajectory from O to B) line OE, is the focus of the projection point to jump the line horizontal distance. Legs jump when must have certain Angle with the ground (less than 90 degrees Celsius). L1 is by the player's height and Angle two joint decision parameters
- **L2:** (the second stage, the suspension movement that line from B to A) ED, is the body's center of gravity in the process of jumping the horizontal distance of flight
- **L3:** (the third stage, landing trajectory from A to C) line DC, center of gravity from the jump down to the horizontal location of horizontal distance.

The jump distance L should be expressed as:

$$L = L1 + L2 + L3$$

ESTABLISHMENT OF THE MATHEMATICAL MODEL

Assumptions: Athlete on the force points of the center of gravity and the body's center of gravity of the human body 1/2 the height of the cross section.

Throughout the course of the campaign ignoring air resistance, that is, in the flight phase, only by the force of gravity.

The initial speed of the run-up as the initial velocity of the body vacated.

Second (flight phase) and third phases (focus from A to C is the final stage) were the center of gravity for Projectile Motion. In fact, the focus of the third stage is a straight line. In order to facilitate the calculation for above assumption.

Variables and parameters: Vo vacated the initial velocity of the body; α is the angle of takeoff when vacated; H for the athlete's height; Vx is the horizontal velocity; remember the time off at time 0, Yo this time the vertical displacement of the center of gravity.

Phase I: as shown in Fig. 2:

The horizontal distance L1 of this stage is determined by the athlete height and the take-off angle:

$$L1 = H/2 \times COS\alpha$$

Second stage and the second stage: As the assumption (4) suggests that the gravity center is in projectile motion, in accordance with the parallelogram law of mechanics of motion, the motion of human body can be decomposed into two sub-motions in orthogonal directions (the horizontal direction X and the vertical direction Y) which are mutually independent.

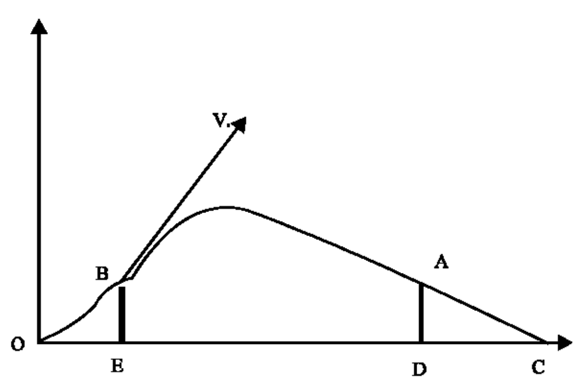

Fig. 1: Human body motion truck

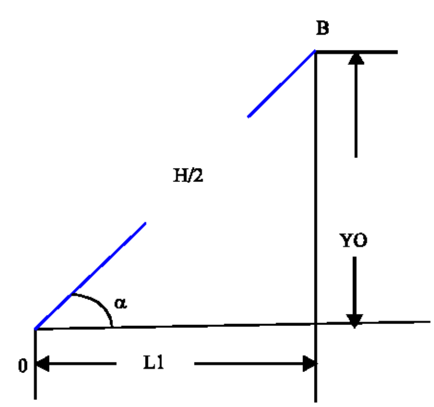

Fig. 2: Jump mechanical analysis

On the horizontal direction: The uniform rectilinear motion:

$$Vx = Vo\times\cos\alpha \tag{1}$$

$$L2+L3 = Vo\times\cos\alpha\times t \tag{2}$$

On the vertical direction: Vertical parabolic motion with the initial speed being $Vo\times\sin\alpha$:

$$Y = Yo+Vo\times\sin\alpha\times t-1/2\times g\times t\hat{}2 \tag{3}$$

(Yo is the height of gravity center when taking off: $Yo = H/2\times\sin\alpha$.)

When Y = 0, the athlete can complete the whole long jump process, then equation (3) can be solved:

$$t = (Vo\times\sin\alpha/g)\times (1+\sqrt{(1+2\times g\times Yo/Vo^2\times\sin a^2)}) \tag{4}$$

Substituting equation (2) with equation (4) gets:

$$L2 + L3 = Vo^2\times\cos\alpha\times(\sin\alpha/g) * (1+\sqrt{(1+2\times g\times Yo/Vo^2\times\sin a^2)})$$

From $L = L_1+L_2+L_3$ can get:

$$L = H/2\times\cos\alpha + Vo^2\times\cos\alpha *(\sin\alpha/g) * (1+\sqrt{(1+2\times g\times Yo/Vo^2\times\sin a^2)}) \tag{5}$$

Table 1 of the technical parameters of long jump of world-class athletes: shown in Table 1.

The performance got by substituting the model with relevant data of the following four athletes by using equation 5: Show in Table 2.

Ideal model result and actual result, model result from actual result on the high side, this is because in the long jump just after the third stage of the foot touches the ground legs contraction, center of gravity down to fall place for linear motion and the result of the influence of air resistance. L3 is the third phase of distance from the player's height and fall to the ground with the ground into the Angle of the decision, not according to the model assumptions for oblique movement, as in the model at the beginning of the third phase center of gravity is still with the level of speed for a long distance, thus caused the L3 slants big, make the big jump performance.

Discussion on the factors influencing the long jump performance: It can be known that the distance L of long jump is related to the run-up speed, the height and the take-off angle. The analysis was made successively:

- The performance will be different due to different gravity center heights of different athlete heights in spite of the same initial speed and the same take-off angle. The assumption (1) suggests that L1 will be larger as the gravity center height is bigger because of the height and long leg of athletes. It can be known from the expression L that L increases as H increases

It can be seen from Table 3 that: Athletes of different heights will make different long jump performance in the same initial speed and the same take-off angle; the larger the height is, the larger will be the long jump performance. The main factors determining the performance of long

Table 1: Relevant technical parameters of world elite athletes

Athlete name	Performance	The run-up speed of the last 10 m (m sec^{-1})	Initial speed of take off (m sec^{-1})	Horizontal speed (m sec^{-1})	Vertical speed (m sec^{-1})	Take-off angle (°)
Huang Geng	8.38	10.7	9.85	9.25	3.39	20.1
Beamon	8.9	10.7	9.6	8.76	3.96	24.2
Lewis	8.91	11.25	9.71	9.11	3.37	20.3
Powell	8.95	10.87	10.2	9.27	4.2	24.6

Table 2: Model data

Athlete name	Model performance (m)	Actual performance (m)	Error (m)
Huang Geng	8.75	8.38	0.37
Beamon	9.12	8.9	0.22
Lewis	9.13	8.91	0.22
Powell	9.21	8.95	0.26

Table 3: Measurement data Unit: meter (the initial speed is 9.5 m sec^{-1})

Take-off angle	Height: 1.57	Height: 1.67	Height:1.76	Height:1.94
16(degree)	6.74	6.94	7.12	7.46
19(degree)	7.43	7.62	8.00	8.11

Table 4: 100 meters, the run-up speed and the long jump performance

Athlete name	100-meter performance (s)	Run-up speed (m sec^{-1})	Long jump performance (m)
Lewis	9.91	11.25	8.91
Beamon	10.3	10.7	8.90
Powell	9.95	10.86	8.95

Table 5: Relationship between the long jump performance and the take-off angle of Chen Zunrong

Performance (m)	Take-off angle (°)
7.94	18.9
8.01	19.9
8.17	22.8
8.26	23.66

jump is the initial speed of take off which in turn is determined by the run-up speed. Therefore, people focus their attention on developing the run-up speed so as to achieve higher take-off speed and longer jumping length. However, the higher run-up speed increase the difficulty of effective take off and relatively large take-off angle which are right the key to the success of long jumpers. It can be concluded form the mechanics that:

$$L2 = Vo\^{}2\times\sin2\alpha/g$$

L2 is determined by the initial speed Vo and the take-off angle α. It is ideal to increase Vo and á simultaneously in theoretical sense yet it is impossible in practical situation. Because the two variables influence each other mutually, the length of jumping is affected not only by the initial speed of take off but also by the take-off angle and the initial speed is determined by the run-up speed.

It can be seen that the larger the run-up speed is, the better will be the long jump performance. Vo is determined by the run-up speed and to increase the absolute speed ability is the basis for the run-up speed of long jump. Compared with the 100m performance of Beamon, Powell and Lewis, the differentials reach 0.62, 0.37 and 0.96 sec, respectively which directly caused that the run up velocity of the last 10 m of Huang Geng lower than others thus hindering the improvement of his long jump performance.

It can be known from:

$$L2 = Vo\^{}2\times\sin2\alpha/g$$

L2 that the best projection angle is 45° under the circumstance that the projecting velocity will not change whereas it is impossible to adopt the angle of 45° in practice. With regard to the perspective of biomechanics, the root cause lies in that human body can not take off at any angle and keep the height of jump unaltered. It is because energy loss is inevitable as the momentum of human body changes sharply in the quick take-off process that the larger the take-off angle is, the more energy will be lost and the lower will be the take-off speed.

The Angle alpha within a certain range, the performance is as leaps increase with the increase of the Angle of alpha. By above knowable Chen Zunrong under the condition of other condition is constant leaps greater perspective about the jump performance is good. But, in fact, alpha is too big or too small. Too large, the loss is big, how horizontal velocity jump jump far; Is too small it is difficult to obtain the necessary height and suspension time, effect, also cannot achieve the ideal far degrees. Generally at about 20 degrees. By above knowable Chen Zunrong leaps Angle about below 25 degrees, under the condition of other condition is constant, in certain Angle range, teng Angle is bigger, the better the jump performance.

CONCLUSION

Of long jump athletes attempt to be born in different stages of the related parameters of kinematics analysis, think that each time the technology distribution is the key to guarantee good results.

The approach speed is an important component of the long jump, is an important factor decided to jump far degrees. Athlete should try to improve the run-up speed.

Improve the ability of fast jump, perfect take-off technology, on the premise of developing absolute speed, should improve the utilization rate of approach speed and so you can more fully prepared to jump, increase the ratio of vertical speed in speed at first, to create better results. The limit of the utilization rate of approach speed in long jump of 100%, however, to complete the takeoff action, players cannot achieve the absolute of it when the run-up speed. Because the run-up of the ultimate goal is to make maximize before takeoff controllable speed, this speed showed that the size of the utilization rate of speed. Visible, improve the utilization rate of approach speed is training and teaching problem that cannot be ignored. Speed has become the core element of the long jump technique. So must give top priority to exert its maximum speed training. To create better conditions for improve run-up speed. In the long jump training, should pay attention to run-up speed and accuracy of practice, should put most of the time on the improvement of approach and take-off technology development. At the same time should be emphasized in the training of long jump run-up ability, run-up speed, accuracy and take-off technology and special jumping ability coordinated development of many factors, such as training.

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