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Research Article

Takeoff Technical Analysis in Long Jump Based on the Dynamics Statistical Model

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Abstract: In the professional and technical teaching, is jumping is the most key link in long jump techniques. From the mechanics' angle, takeoff jumping can be divided into steps-treading and jumping. The task of jumping is to acquire an appropriate takeoff angle of body gravity and more reasonable initial swinging velocity under rapid run-up conditions, through reasonable takeoff movements to change human body movement direction. Therefore, whether athlete's takeoff technique is good or bad, is one of the important symbols of his sport level. Therefore, the fundamental factor to improve the performance of long jump is to master the full set of takeoff technology. From the point of statistical computing science and through the dynamics analysis, this study established a dynamic statistical model and discussed the influence factors of stepping and jumping stage, which provides a theoretical basis for athletes training.

Keywords: Dynamics, motion parameters, statistical model, software packages, takeoff technique

INTRODUCTION

Long jump is a sport which can make the body jump over horizontal distance using reasonable posture and movement, through the rapid run-up and positive takeoff. For a long time, people conduct a positive study on the project and have accumulated more research results. With the development of technology and continuous improvement of training methods, the research on long jump technique and theory becomes much further as well. Xin-Bo and Xiang-Ning found that Adrian (1994): Whether or not the landing angle and pedal angle are appropriate, it reflects the athlete's pedal technique quality. We can determine the appropriate landing angle according to the individual characteristics of athletes; Sector angle transformation time should be before the projection point of center of gravity. When you take off, the hip joint angle is 165 b~170°, the knee joint angle is 175~178°, the angle between calf and ground is about 65° or so; With the improvement of the performance of long jump, the initiative of takeoff leg tapping plate also rises accordingly, the landing angle goes up to 65~70°, the angle between two legs reduces to 38~32 degrees and the upper body angle is 90~107°, all of which are helpful to enhance the enthusiasm of tapping plate. Xia Ling suggests that the Chinese men's takeoff angle is 68.7° through GM (1, N) model (Linthorne, 2001). Bi-Yu and Xiao-Wu found that: the landing plate angle of Chinese long jump athletes is 59.7° (Matthew and Challis, 2004). It points out that the smaller landing angle can make the horizontal velocity loss increase and at the same time increase the impact load when the takeoff leg is landing on the plate. All of them are not conducive to unleash and make use of the leg strength and slows down the speed of muscle superfine long work (Jin-Zhou and Si-Zhe, 2007). Wen-Yi and Mian-fang from Shanghai Sports Institute once used statistical regression method to optimize analysis and numerical calculation and concluded that there is a best takeoff angle in long jump, which is not fixed. The best takeoff angle that contemporary levels could reach is 24°. Robert j. Markey's study found that: the ideal takeoff angle should be in 20~25° (Alvarez *et al.*, 1998). Zhang Bi-Yu and others in the study divided jumping movements into front support stage and rear support stage. Chen Min-Cheng and others introduced the brake pedal stretch stage and power pedal stretch stage on the basis of the original movements and structure. The angle between brake pedal stretch time and the vertical support surface is called the pedal takeoff angle. The angle size on the one hand reflects the athletes' grasp to the takeoff time; on the other hand, it also reflects the athletes' leg strength. Gang and Gui-Min in the study took the moment of swinging leg down buffer to start stretch in the last approach step as takeoff action start time; the flag is divided into closely linked four parts: swinging leg rear pedal, body soar, takeoff leg buffer and takeoff leg pedal stretch (Xiao-Ming, 1999). This classification method more prominently embodied the close coupling of the approach and take-off movement, fully reflecting the importance of positive buffering action to improve body weight jumping vertical speed (Liu, 2005). The above stage awareness and study of the long jump takeoff stage, not only conforms to the close conjunction technical characteristics of the

Table 1: The research object situation

Name	Date of birth	Height (m)	Weight (kg)	Sign up score (m)
A	90.04	1.75	67	6.33
B	94.08	1.77	63	6.12
C	91.01	1.78	64	6.37
D	88.10	1.71	61	5.90
E	89.01	1.70	57	6.18
F	80.12	1.76	56	5.92

long jump approach and takeoff, but also reflects the requirements of the development of long jump technique (Jun-Xia and Sheng-Jie, 2009).

To sum up, many experts and scholars had different levels of study on the long jump in the past, but research based on the dynamics model is blank. With the progress of science and technology, in sports scientific research region the use of some advanced instruments and equipment and research means are unceasingly rich, the long jump project research is more in-depth and meticulous, research indicator and data of the long jump technique will also be more accurate, thus it gradually reveals the essential characteristics and form a more correct theory. From the point of statistical computing science and through the dynamics analysis, this study established a dynamic statistical model and discussed the influence factors of stepping and jumping stage, which provides a theoretical basis for athletes training.

Research object of this study is the long jump athletes participated in a track and field Grand Prix. We take the last two approaching steps and take-off technique of the top six players and basic situation of athletes is Table 1.

THE RESEARCH METHOD

This study uses the mathematical statistics method and gets relevant motion parameters through experiment. We used the statistical software package and the relevant mathematical formulas to calculate and analysis the data. If ($p<0.01$), we think it has a very significant difference; If ($p<0.01$), we think it has a significant difference.

STATISTICAL ANALYSIS OF THE KINEMATICS IN THE TAKE-OFF TECHNIQUE

The take-off time analysis: Judging from Table 2, 3 and 4, correlation coefficient between T2 and performance is the highest ($R = 0.745$). The time ratio reflects the motor ability of the long jump athlete. In this study, the time ratio of T2 is the lowest; indicating that the athletes lower limb specific physical strength is under insufficient conditions. T1 is a reflection of the ability to convert the reaction force from the footboard to the body into take-off power. T3 shows how fast the swing leg of the long jump athlete could stop moving. In Table 4, the time ratio of T1 and T3 is equal. On the whole, there is still prodigious potential of the athletes' rapid take-off ability. The subsection time ratio of athlete B is the best, which is a main factor that she shows better performance. If athlete C can do a successful take-off and athlete A can improve in this link, they will achieve better results.

Table 2: The subsection time statistics during the 6 athletes' take-off stage

Name	Buffer time (T1)	Conversion time (T2)	Extension time (T3)	Take-off time (T4)
A	0.041	0.041	0.041	0.121
B	0.021	0.041	0.041	0.10
C	0.041	0.041	0.021	0.101
D	0.041	0.021	0.061	0.121
E	0.041	0.041	0.041	0.121
F	0.061	0.041	0.041	0.141
Average	0.041	0.037	0.041	0.1171

Ps: T1 is the buffer time when take-off; T2 is the conversion time when take-off; T3 is the extension time when take-off

Table 3: The statistical analysis of correlation coefficient between subsection time and performance

Phase	Buffer	Conversion	Extension	Whole take-off
r	-0.323	0.745	0.044	0.233
p	>0.05	<0.05	>0.05	>0.05

Table 4: The logo meter of each subsection time during take-off

Category	Buffer	Conversion	Extension
Ratio (%)	34.3%	31.7%	34.3%

Table 5: The motion parameter of athletes' take-off posture

Name	Landing angle	Angle of leg trust	Included angle	Sector angle
A	55.81	72.51	17.50	51.68
B	63.45	77.56	12.44	38.99
C	58.08	76.38	13.62	45.54
D	56.67	73.69	16.31	50.63
E	58.04	74.64	15.36	47.32
F	55.88	73.73	16.27	50.39
X	57.99	74.75	15.25	47.43
S	2.86	1.89	1.86	4.73

Statistic analysis of knee point angle, included angle between swing legs and sector angle at footboard moment: As can be seen from Table 5, the take-off angle of the 6 athletes ranges from 57.98±2.850, which don't match the Fleche mode (64-690). Some researchers have demonstrated that the landing angle of excellent athletes is about 63.140. The average landing angle of the 6 athletes is close to this number with a very significant difference about 5.15o ($T = -4.419$, $p<0.01$). Athlete B's landing angle is the largest (63.45°). The main reason of this result is that athlete B is able to take off in a short time and possesses favorable Stretch time index. Swing leg's landing angle and extension movement under certain run-up conditions determine the direction and time of take-off force. Foot extension when take-off (the angle is much too small) will increase the braking force and extend the action time. As a result, the upper part of the athlete body will lag behind and extension start too early. If the take-off angle is too big, he will jump too high, causing

Table 6: Conversion rate of athlete horizontal velocity and take-off angle jumping moment (m/s)

Name	horizontal velocity of pedal landing (m/s)	Unstuck speed of squat jumping (m/s)		The losses of velocity (m/s)
		Horizontal velocity	Vertical velocity	
A	9.38	8.04	2.88	1.36
B	9.97	7.33	2.76	2.63
C	10.62	9.13	3.27	1.47
D	10.13	9.04	3.23	1.10
E	9.48	7.82	2.89	1.66
F	8.43	7.51	2.75	0.94
Average	9.77	8.36	3.11	1.39
standard deviation	±0.66	±0.67	±0.21	±0.54

Table 7: The changing data of included angles between swinging legs during the 6 athletes' take-off stage

Name	Name	Landing (degree)	Maximum buffer (degree)	Liftoff (degree)
A	A	48.35	8.04	98.35
B	B	38.32	1.22	115.63
C	C	37.64	10.52	74.69
D	D	62.84	0.86	100.41
E	E	74.69	3.42	82.70
F	F	62.27	15.35	113.57

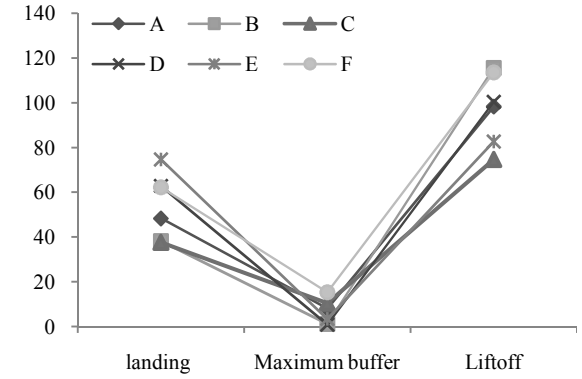

Fig. 1: The change of included angles between swinging legs during the 6 athletes' take-off stage

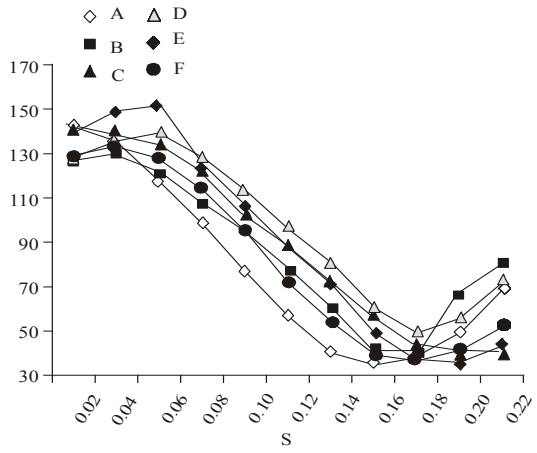

Fig. 2: Variation of knee angle between the swinging legs during the 6 athletes' take-off stage

the great losses of horizontal velocity. Takeoff leg is too close to the landing point (Namely landing angle is too big).

Taking athletes' take-off time into consideration, the average take-off time of the 6 athletes is 0.177s, which is not so different as the figure 0.08-0.14s suggested by Niger ($p<0.05$). Exceptional athlete's take-off time reaches to 0.10s, showing a faster take-off velocity.

Statistic analysis of horizontal velocity of pedal landing, unstuck speed and take-off angle of squat jumping: In the run-up and take-off process of the 6 athletes, the average maximum losses of velocity is 1.65±0.42 m/s, with athlete C's 2.88 m/s the highest, which might caused by the unsuccessful cooperation of fast run-up and take-off ability. Elite Chinese athletes and excellent athletes from abroad possess supporting ability and rapid extension ability. Research shows that Chinese athletes' vertical take-off velocity is favorable, while the horizontal velocity suffers huge losses. Therefore, there is further need to improve the training method and enhance the overall performance (Table 6).

Statistical analysis of the kinematics in the swinging leg: Judging from Fig. 1 and Table 7, the leg angle of athlete C is lower than the others under a reasonable changing scope. Athlete C shows good technology and consciousness to reduce the resistance loss of run-up and take-off stage, with swing leg's strong sense of freedom and reasonable usage of knee point to an active landing. Some shortcomings still exist in the jumping skills, such as the adverse effect of bad footboard technology.

If she had played more attention to take the chance to accelerate swinging after the swing legs' liftoff, the take-off effect might be better. Athlete C's included angle at footboard is the smallest, but the effect is unsatisfactory, the reason of which may be that the last step of run-up is too long. So as to reduce horizontal velocity loss and achieve the best result, the athletes should better boost the swing of swing legs. Long jump athletes should make full and rational use of swing leg and footboard knee point skill and intensify relative training to enhance their long jump skill level.

As can be seen in Fig. 2, for athlete E when reaching the footboard, the knee angle is 159.78° and the buffer time is 0.079s, the latter is highest among the 6 athletes. Decrease of knee-point angle contributes to jumping by reducing resistance. The increase of athlete vertical pressure leads the center of his gravity forward and reduces the takeoff time and the loss rate of velocity. As a result, the oversize of the knee point angle may have caused the wrong judgment of the distance between the body and the footboard. In practical teaching training, more attention should be played to the practice of amplitude of swing from the maximum buffer phrase to the liftoff phrase, in order to improve athletes' take-off effect.

CONCLUSION

The above analysis demonstrates that the knee point angle and angle between swinging legs when reaching the petal for excellent long jump athletes are good. However, the swing legs' weakness of swing consciousness for some athletes weakens their take-off effect. The general take-off time is reasonable, but the buffer time is a bit longer with an unreasonable overall arrangement of time, influencing the final take-off effect too. Previous researches have showed that there is no significant difference in the vertical velocity at the take-off moment between Chinese athletes and the world top athletes. However the take-off angle is very different, showing that it is still a main factor influencing Chinese athletes' performance. It is suggested that athletes should pay attention to the strengthening of knee points' eccentric and contraction ability as well as higher run-up velocity through training. Increase swing legs' swing especially under high speed motion state. Although the stick angle is of great importance to increase athletes' performance, this cannot be achieved by sacrifice of horizontal velocity.

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