THE BIOMECHANICAL CHARACTERISTICS OF THE TAKE-OFF TECHNIQUE IN THE LONG JUMP

Hongfeng Xu
Sports Department of Fujian Teachers' University, Peolple's Republic of China

The purpose of this study was to examine the biomechanical characteristics of the take-off technique in the long jump of elite athletes. Problems experienced in the take off phase ultimately determine whether or not the outcome will be successful. Through documents, observation and statistical analysis, the performance of 21 elite athletes during the take off phase in the long jump event was compared with that of international long jump record holders. In order to determine the main characteristics of the take-off technique, biomechanical analysis was used. An objective evaluation of skills required for successful completion of the routine will be valuable for both athletes and coaches, seeking improvement in the execution of the long jump event.

KEY WORDS: long jump, take-off, horizontal velocity transform rate

INTRODUCTION: In 1968, the male long jump world record of 8.90m was established. From that date, many experts, scholars, coaches and experienced long jump athletes have devoted a great deal of research to improvement in the movement structure of long jump technique. As a result, much progress has been made. In 1991, the previous record was broken when 8.95m was achieved in the World Track and Field Championship (Tokyo). Another excellent achievement in this event was 8.91m, (super-wind-speed). In 1993, the record was set again, this time, even higher at 8.98m (super-wind-speed). Seldom has anyone ever attained such an achievement. This paper raises questions regarding the success of international athletes and the disparity between their performance and that of the subjects in the study. Therefore, the purpose of this study was to analyze the biomechanical characteristics of the take-off technique of 21 long jump elites. The data obtained from the study will lead to improved technical expertise and a greater measure of success in competition.

METHODS: The data on 26 performances was collected from different documents and then calculated using the statistical method. 21 experienced athletes were divided into two groups according to their achievements. For example, the average score of group A was 8.57m and for group B was 7.95m. The index of the scores was identified as follows: achievement (S), last 6-1m velocity of run-up (V_{6-1}), bounce velocity (V), horizontal bounce velocity (Vx), vertical bounce velocity (Vy), bounce angleθ, transform rate of the horizontal velocity (V_{6-1}-Vy / V_{6-1})×100%, lose of the horizontal velocity (V_{6-1}-Vx / V_{6-1})×100%, and the ratio between horizontal velocity and vertical velocity (Vx / Vy). These indexes were then analyzed with a statistical method.

RESULTS AND DISCUSSION: The take-off technique is one of the key skills to be mastered for a successful performance in the long jump event. Success in the take-off is reflected in the take-off technique. The take-off effect is determined by various factors. The overall level of expertise depends on the respective factors and their coordination. These 9 indexes affect the end result either directly or indirectly. They reflect the changes in the movement parameter, and their limiting affect on performance.

Velocity of Run-Up (last 6-1m -V_{6-1}). An obvious difference is seen between the V_{6-1} of group A and group B. The V_{6-1} of group A ranged from10.40 to 11.40m/s, and the average value was 10.74m/s. The V_{6-1} of group B ranged from10.12 to 10.78m/s, and the average value was 10.38m/s. The absolute value and average value of group B were lower than that of group A.

Table 1 The Analysis of the Technique Parameter of Long Jump Elite Athletes

Elite	Score (m)	Last 6-1m V of run-up (m/s)	Take-off V (m/s)	HV of take-off (m/s)	VV of take-off (m/s)	Take-off AV (%)	Lose-rate of HV (%)	Transform rate of HV (%)	HV vertical
Group A									
x	8.57	10.74	9.60	8.888	3.57	21.7	17.21	33.28	2.51
s	0.251	0.3239	0.2917	0.3176	0.3100	1.9890	2.2175	3.2715	0.2313
Group B									
x	7.95	10.30	9.45	8.89	3.18	19.7	14.33	30.62	2.81
s	0.1169	0.2235	0.2677	0.3411	0.2295	1.6989	3.3049	2.3443	0.2719

*, wind speed 2.9m/s. V, velocity. AV, angle velocity, HV, horizontal velocity, VV, vertical velocity

The run-up speed is one of the most important factors affecting the successful outcome of the long jump. Regardless of what kind of run-up and rhythm are used, the purpose is to reach top speed in the last few meters prior to take off. V_{6-1} is the epitome of the run-up velocity. It reflects the quality of the sprint component of the long jump performance. The overall development of skills in the long jump depends on the degree of improvement in the sprint capability of the athlete. Those competitors, whose run up velocity is sufficiently fast can concentrate on improvement of specifics in the take off technique, while others should improve their sprint technique, on the expectation of an improvement in the run-up velocity.

Table 2 The Relationship among the Technique Parameter of Male Long Jump Elite

Parameter	Group member	Number	X	S	t	$t_{0,05}$
Achievement (S)	A	13	8.57	0.2501	8.1176*	
	B		7.95	0.1169		
Last 6-1m velocity of run-up ($V_{6-1)}$	A	13	10.74	0.3239	3.2772*	
	B		10.38	0.2235		
Take-off velocity (V)	A	13	9.599	0.2917	1.3311	
	B		9.453	0.2617		
Horizontal velocity of take-off (Vx)	A	13	8.888	0.3178	0.0178	
	B		8.890	0.3411		
Vertical velocity of take-off (Vy)	A	13	3.57	0.3100	3.6660*	
	B		3.18	0.2295		
Take-off angle (θ)	A	13	21.65	1.9890	2.7037*	2.064
	B		19.68	1.6989		
Horizontal velocity lose-rate [(V_{6-1}-Vx/ V_{6-1})×100%]	A	13	17.21	2.2175	2.5330*	
	B		14.33	3.3048		
Vertical velocity transform rate [(V_{6-1}-Vy/ V_{6-1})×100%]	A	13	33.28	3.2715	2.3830*	
	B		30.62	2.3443		
Ratio of horizontal velocity and vertical velocity (Vx/Vy)	A	13	2.51	0.2313	3.0533*	
	B		2.81	0.2719		

*significant difference

Bounce velocity (V) and horizontal bounce velocity (Vx). Bounce velocity and horizontal bounce velocity have certain effects on the successful outcome of the long jump. According to the statistics, there was no obvious difference overall between V and Vx of group A and group B, especially for Vx. The V of group A ranged from 9.91 to 10.20m/s with the average value of 9.60m/s, and the value of Vx ranged from 8.50 to 9.27m/s with the average value of 8.88m/s. The V of group B ranged from 9.23 to 10.07m/s with the average value of 9.45m/s, and the value of Vx ranged from 8.50 to 9.64 with the average value of 8.89m/s. After the indexes were compared with the achievements, it was discovered that V and Vx objectively can not reflect the difference of take-off technique and take-off effect, and therefore can not reflect the characteristics of take-off technique of the elite athletes. There is an obvious difference on the V_{6-1} of group A and group B. However, their overall V and Vx shows no obvious difference. This phenomenon illustrates the profile of the different take-off technique characteristics of the two groups.

Vertical bounce velocity (Vy), bounce angle, θ (transform rate of the horizontal velocity (V_{6-1}—Vy / V_{6-1})×100%). Vertical bounce velocity and bounce angle is another important factor that affects the quality of the performance. Usually there is property relationship between vertical bounce velocity and bounce angle. With development of the level of expertise, the affect of Vy will be less important, as the higher the level, the closer is the relationship. Group A and group B have obvious differences on Vy and θ. Vy of group A ranging from 2.53 to 4.26m/s with the average value of 3.57m/s, and the value of θ ranging from 18.7°to 24.9°with the average value of 21.7°. Vy of group B ranging from 2.87 to 3.60m/s with the average value of 3.18m/s, and the value of θ ranging from 16.7°to 22.8°with the average value of 19.7°. With the development in the level of proficiency, in order to transform the horizontal velocity, prolong the bounce time and improve the bounce distance, athletes not only perform a faster run-up, but also pay more attention to improvement of their take – off technique. According to other related research, without any other condition change, performance improves with an increase in bounce angle even prior to reaching 26°. There is an improvement of 10-15cm with an average bounce angle increase of 2°. Conversely, there is an obvious decrease in performance when the bounce angle exceeds 26°.

The effective take-off technique demonstrated by international record holders is illustrated by factors such as reasonable take-off technique, which in turn develops the optimum vertical bounce velocity and bounce angle. The vertical bounce velocity and bounce angle of these world class athletes has an obvious advantage over others. Although run-up speed of the elite group member is only10.30m/s, the vertical bounce velocity and bounce angle was still very reasonable considering his take-off technique. Application of individual skills provided excellent opportunities for a successful outcome. The first rate run-up velocity of the world class athlete did not compensate for his shorter take-off technique and in addition, the vertical bounce velocity and bounce angle were below the average value. These observations emphasize the unique characteristics of the long jump event, indicated by limitations to vertical bounce velocity. There are question posed by the data that relate to specific technique required to obtain the optimum vertical bounce velocity? According to the statistics, the V_{6-1} / Vy of group A was 3.03□1 and for group B was 3.28□1, the Vx / Vy of group A was 2.51:1 and for group B was 2.81:1. The data from group A coincides with data on the performance of 15 trial jumps of 7 long jump elite athletes offered by the Russian coach. It indicates that elite athletes pay considerable attention to their take-off technique. In order to obtain a precise evaluation on the take-off course and the horizontal velocity to vertical velocity transform effect of run-up, the transform rate [(V_{6-1}—Vy / V_{6-1})×100%] of the horizontal velocity was presented as the index. From table 2 it has been established that the transform rate for group A was 33.28 and for group B was 30.36. The horizontal velocity transform rate of group A was obviously higher than that of group B. All the 5 indexes of $V_{6-1,}$ Vy, θ, (V_{6-1}—Vy / V_{6-1})×100% and (V_{6-1}—Vx / V_{6-1})×100% indicate that the take-off technique

characteristics of the elite athletes are improving the horizontal velocity transform rate and increasing the vertical velocity, on the basis of certain horizontal velocity at the take-off stage. **Loss rate of horizontal velocity [(V_{6-1}—Vx/V_{6-1})×100%].** For a successful outcome in the long jump event, horizontal velocity should be transformed into vertical velocity, therefore, the loss of horizontal velocity is inevitable. The question is whether or not the loss is profitable. The traditional perspective considers that a high rate of loss in horizontal velocity will decrease the vertical velocity, affecting a successful outcome, and that it is critical to decrease it. According to statistical analysis, the difference in the loss rate of horizontal velocity between the two groups was obvious. The loss rate of group A ranges from14.85 to 21.63%, with the average value of 17.21. The loss rate of group B ranges from 7.49 to 17.94%, with the average value of 13.25%. The loss rate of group A was obviously higher than those of group B, while the achievement of group A was higher than those of group B. Therefore, it is of no consequence to consider the loss rate of horizontal velocity as the only important factor in a successful outcome. From a systematic point of view, the take-off technique is one of the key components of the long jump. The take-off effect is an indication of the take-off technique. The coordination of the factors is important, and placing stress on a single factor will not necessarily produce the optimum result. Comparing the related indexes, it was found that the elite athletes in this study were concerned with the synthesis and compatibility of different factors. In order to transform the horizontal velocity into feasible vertical velocity, to prolong the bounce time, improve the take-off angle and bounce distance, long jump athletes are concerned with the horizontal velocity transformation rate of the take–off phase.

DISCUSSION: The run-up velocity is one of the most important factors affecting a successful outcome long jump event. The improvement of skill levels in the long jump depends on the improvement of individual sprint characteristics. Improving the horizontal velocity transformation rate, increasing the bounce angle and vertical velocity, based on specific horizontal velocity at the take-off stage, are all factors to be considered in the technique of long jump elite athletes. The horizontal velocity transformation rate of their take–off is key to the improvement of the over all performance and is the breakthrough point for greater levels of skill in the long jump event. $V_{6-1,}$ Vy, θ, (V_{6-1}—Vy / V_{6-1})×100% and (V_{6-1}—Vx / V_{6-1})×100% are the main index to evaluate the take-off effect.

REFERENCES:

Xu, M. (1991). Analysis to the factors of long jump［J］. *Sports Science and Technology of Shichuan*, **3**, 27-32.

Xu, T. (1994). Biomechanical Researches on Take-off of Long Jump(Review). *Journal of Beijing University of Physical Education,* **2**, 50-53.

Zheng, P.Y. (1989) An analysis on the development trend with related parameter［J］. *Sports Science and Technology of Hernang,* **1**, 87-93.

Hay, J., et al. (1987). Biomechanics of Elite Long Jumping by at James*. Track Techniauefall,* **101**, 3230-3231.

Vorobiev, A., Ter-Ovanessian, I., & Ariel,G. (1992). Two World's Best Long Jump: Comparative Biomechanical Analysis. *Journal of Track Quarterly*, **4**, 6-10.

Guskov, A., Vorobiev, A., & Ariel, G. (1992). Body Aerodynamics: Contribution to Long-Jump Performance. *Journal of Track Quarterly*, **4**, 11-13.