THE TAKE-OFF ANGLE ANALYSIS IN CASE OF LONG JUMP TRIAL

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Abstract: *In the present paper it is presented a method used to find out one of the influence parameter that determinate the jump distance during the long jump trial. The performances obtained the athletes depends on some parameters as: the length of the run-up, the take off force and time, the mass center angle vs. horizontal direction, the mass centre balancing position during the flight through the air, and the correct landing position. The founded parameter was the mass center angle, of the athlete, vs. horizontal direction, at the end of take-off moment.*
Keywords: *biomechanics, long jump, jump trajectory, motion analysis, imagine processing*

1. INTRODUCTION

The long jump is one of the most important athletic trials known since the first Olympic games. Biomechanics is a special scientific domain useful in different special activities as: sports, special activities at the work place, physical disabilities, etc. The roots of biomechanics are situated in the ancient times but the basics of a scientific study were done beginning with the Middle Age. Leonardo da Vinci who analysed the muscle forces, the joints between bones and realised some very accurate drawings of the human parts made the first known studies. Another important study was done by Galileo Galilei who applied principles of mechanics to the bone structure doing a so-called "hydrostatic balance" to find the specific body weight. Isaac Newton defined the scientific basics of classical mechanics and implicitly of biomechanics. He posited the bodies motion axioms that express the connections between forces and their effects. Practically all the athletes' mechanical behaviour is based on Newton's laws. James Keill who calculated the number of muscle fibres in a muscle and defined the stress developed on each fibre did another important step in biomechanics. In the 19th century, Samuel Haughton developed biomechanics studies on different animals. P.F. Leshaft founded the sports biomechanics. He did the first course about the theory of human body motion for sports. The course contents data about the proportions of the human body parts, about motion and positions in different sport trials. Currently the studies are more accurate and are based on experimental data and the facilities offered by the simulation codes.
The long jump phases, in the order of their succession, are as follows: run-up, take-off, aerial and landing. Thus the performance of a long jumper directly depends on: his/her qualities as sprinter in the first phase, the developed force in legs in the take-off moment, flight and landing.
As it is known, for a great jump distance the athlete must have to the end of the run-up a high horizontal velocity with the take-off placed as close as is possible on the take-off board. After the moment of the take-off the athlete must generate a large vertical velocity combined with a loss minimizing of the horizontal velocity. Another important aspect of the athlete technique is represented by the flight phase when it is necessary to be developed a self-control of the forward rotation produced at the take-off moment. Description of all these phases can be found in different specific papers [1, 2, 3, 4, 5, 6].
In the run-up phase, at the end of the track, the athlete has to obtain a maximum horizontal velocity that is used in the take-off moment. The main target of the take-off is to maximize the flight distance of the athlete body (i.e. the centre of mass) based on both optimum take-off angle and optimum take-off velocity.
The take-off is considered an essential phase in the long jump test being in the same time the hardest one because during the execution of this phase it is recovered the entire system of forces, especially in the moment of getting vertical speed and keeping as much as possible horizontal speed, and these components require a pace short of achievement. From a biomechanical point of view, the way of take-off doing it is very difficult. This difficulty is given by the driving actions in the moment of the contact with the ground, switch to the phase of flight, resulting the ground run out of the athlete.
Considering a segmentation of this phase in terms of moments that succeed follows: the moment of beating leg placing on the threshold; the moment of shock taking up; the moment of active take-off.
A short contact time of the leg in the moment of the take-off and a high force developed in the moment of take-off to produce the push-off, are some of other factors that influence the quality of the long jump.

2. EXPERIMENTAL SET-UP

The aim of the study was to record four jumpers, and analyse their jumps, to determine some mathematical correlations. The four considered subjects were jumpers with high-level competition performances. Two of them were females and the other two were males. All the four athletes were members of the Romania National Athletic Team and having different jump techniques.
The motion was recorded by a high speed camera (AOS X - PRI) done with a resolution of 800x600 pixels at 500 frames/s, directly connected to Laptop (Fig.1).

Figure 1: Camera AOS X –PRI and recording data system

On each jumper body there were attached coloured markers, the points of attachments were established considering the main points of a mechanical equivalent model of the body and using the suggestions given by the trainers. The markers were placed on the bodies on the same side with the video camera.
The video camera was installed in the lateral direction, on a perpendicular direction on the jumpers at a distance of 5.20 meters from the jump path and was mainly focusing on the take-off point. In the same time the considered position offered the posibility to obtain images in the sagittal plane of the athlete during performing of the long jump
In Fig.2 it is presented the trajectory of the jumper highlight by a selected marker.

Figure 2: The trajectory of jumper mass

3. THE TAKE-OFF ANGLE ANALYSIS

Another important element that has to be taken into the consideration in long jump is the angle of the take-off. This angle can be calculated considering the two velocity vectors Vx and Vy.
In Table 1 there are presented the values of the take-off angle for the considered athlete.

Table 1: Jump length vs. take-off angle

No. Jump	Jump length [m]	Angle $\theta[\circ]$
1	5.27	16.15
2	5.36	22.03
3	5.39	23.18
4	6.59	22.03
5	6.43	19.69

Considering the above data, using the MATLAB code, can be found a function of correlation between the angle and the jump length (Fig. 3):

$$L(\theta) = -0.017\theta^3 + 1.057\theta^2 - 21.46\theta + 153.2 \quad (1)$$

The regression coefficient for the relation (5) is $R^2 = 0.9025$.

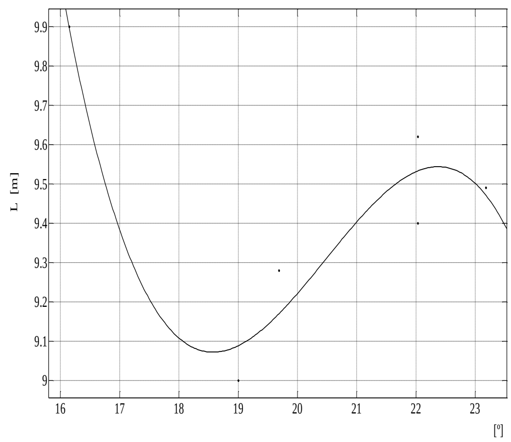

Figure 3: The curve interpolation for resultant angle vs. jump length

The realised simulations lead to a polynomial approximation.

3. CONCLUSION

The long jump consists of four phases that have their role in a good performance. One of these phases is the take-off. As was presented above there are done a lot of studies about this moment being analysed important parameter: the take-off angle of the mass centre reported to the horizontal direction. The main parameter that can increase the athlete performance are the take-off angle.

REFERENCES

[1] J. G. Hay, J. A. Miller, R. W. Canterna: The techniques of elite male long jumpers, Journal of Biomechanics, Vol. 19, (1986), pp. 855–66.

[2] J. G. Hay, H. Nohara: Techniques used by elite long jumpers in preparation for takeoff, Journal of Biomechanics, Vol. 23 (1990), pp. 229–39.

[3] J. G. Hay, T. J. Koh: Evaluating the approach in the horizontal jumps, International Journal of Sport Biomechanics, Vol. 4 (1988), pp. 372–92.
[4] A. Lees., N. Fowler, D. Derby: A biomechanical analysis of the last stride, touch-down and take-off characteristics of the women's long jump, Journal of Sports Sciences, Vol. 11 (1993), pp. 303–14.
[5] A. Lees, P. Graham-Smith, N. Fowler: A biomechanical analysis of the last stride, touchdown, and takeoff characteristics of the men's long jump, Journal of Applied Biomechanics, Vol. 10 (1994), pp. 61–78.
[6] A. Seyfarth, R. Blickhan, J. L. Van Leeuwen: Optimum take-off techniques and muscle design for long jump, The Journal of Experimental Biology, Vol. 203 (2000), pp. 741-750.