A NEW BIOMECHANICAL ASPECT FOR ASSESSING MECHANICAL PARAMETERS IN THE LONG JUMP

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INTRODUCTION: We have considered long jump movements in three main phases: run-up, take-off and flight phases. In each phase we considered the mechanical parameters and tried to estimate their magnitudes by simply measuring time and distance. Most of studies in the long jump have been concerned with the take-off phase (J.G.Hay, 1984), because the magnitude of the jumped distance would be mostly determined during that phase.
In our research, in order to make a comparison between Iranian jumpers and world champions, in the absence of a Motion Analyzer, we made a biomechanical model with which we were able to assess mechanical parameters such as: final run-up velocity, initial take-off velocity and angle, initial velocity components, time of the last touch down and the force applied by the jumpers and also their height of flight. This assessment can be feasible just by measuring run-up time **t**r, flight time tf, flight distance, **R**,and the total run-up and flight time, **t**t.

METHOD: The jumper's run-up time *t*r and flight time *t*f, separately and also total time *t*f as a whole, were measured with a precision of 10^{-2} sec. There was a significant difference between *t*f and the sum of (*tr* +*t*f). With *t*r, the jumper's velocity arriving at take-off can easily be obtained, and also by knowing *t*f, and the distance jumped, we are able not only to achieve the initial velocity of the jump, but also the angle of the jump and the maximum height of CG during jumping. We also found a significant difference between the velocity which the jumper gains at the end of his run-up and the velocity with which the jumper jumps. In fact the jumper loses his maximum velocity at the end of the run-up, *Vf*r, in order to change his velocity direction to a direction for jumping at an angle of Θ.This would necessitate muscle force applied by the jumper.

Mathematical Model
1. Run-up velocity *Vf*r: in order to achieve this velocity, it is necessary to know the run-up distance and run-up time, and using the kinematic relationship such as

$$X=1/2\, at^{+2} \qquad (1)$$

we get the acceleration with which *Vf*r can be obtained.

2. Flight velocity *Vof*: knowing the time of flight, *tf*, and the distance jumped, we can use the kinematic relationship to get the angle Θ and the velocity as below:

$$R=(V_{of}\ Cos\Theta)t_f \qquad (2)$$

$$0=V_{of}\ Sin\Theta - gt_f/2 \qquad (3)$$

$$\Theta = \tan^{-1}(gt_f^2/2R) \qquad (4)$$

Once the Θ is known the velocity at which the jump is made can easily be found.

RESULTS: ll ten subjects were males, five belonging to the Iranian Track team and five other top competitors. We have shown their mechanical parameters values in two tables, one of which shows the theoretical values, while the other shows the values obtained by filming (Panasonic M3000). The *Tý*r,*T*f and *T*t were measured by a timer especially designed (Shahbazi et al., 1996) with 10 as precision.

Table 1. Theoretical mechanical parameters means SD

Mech. Param.	*V*fr (m/s)	*V*of (m/s)	Θ (Deg.)	*V*ox (m/s)	*V*oy (m/s)
National team	10.22 ± 1.52	9.1 ± 1.2	23.2 ± 1.5	8.38 ± 1.1	3.58 ± 0.25
Top competitors	9.2 ± 1.1	8.05 ± 1.5	21.3 ± 1.7	7.5 ± 1.2	2.97 ± 0.27

Table 2. Measured mechanical parameters means ±SD

Mech. Param.	*Vfr* (m/s)	*Vo*f (m/s)	(Deg.)	*tr* (Sec.)	*t*f (Sec.)	*t*t (Sec.)	*t* (Sec.)	*F* *N*
National team	10.35± 1.32	9.25± 1.15	24.1± 1.45	3.5± 0.15	0.81± 0.02	4.05± 0.04	0.28± 0.04	293± 15
Top Compet.	9.3 ± 1.1	8.15 ± 1.3	21.55± 1.6	3.9 ± 0.1	0.75 ± 0.33	4.25 ± 0.10	0.35 ± 0.03	262.8± 12

Force and Torque Calculation

As we can see in Table 1, there is a difference between the velocities at touch down and there is also a difference in time, e.g.

$$t_t - (t_r + t_f) = \Delta t \qquad (5)$$

Referring to the impact formula in mechanics, we can get the muscle force as follows

$$F_m = M\ \Delta V/\ \Delta t \qquad (6)$$

knowing each subject's mass we can deduce the force and also with anthropometric measures we can estimate the torque applied to the joints by simple moment relationship.

Ground Reaction Force

At touch down the jumpers receive a ground reaction force which can be easily calculated as follows. We know that at touch down the vertical component of velocity reaches zero. Therefore we can, by using the kinematic formula, have

$$F\mathrm{R} = M \, \Delta \, V o \mathrm{y} \, / \, \Delta \, t \qquad (7)$$

The results we have obtained are 960 ±25 N for the National Team and 565 ± 15 N for the top competitors.

CONCLUSIONS: Our approach in estimating the mechanical parameters in long jump is very simple and does not require expensive equipment, and besides we can estimate the forces of muscles and the reaction forces without using a force platform. The angle and the initial velocity of jumpers can also be achieved with the aid of the mechanical formulae.

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