AN ANALYSIS OF THE JUMP TOUCHDOWN TO TAKEOFF CHARACTERISTICS OF THE MEN'S LONG JUMP

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INTRODUCTION

This study was concerned with the measurement of a selection of performance variables from finalists in the men's long jump of the UK National Championships held in Birmingham, England in July 1991.

The literature (eg. Hay and Nohara, 1990; Nixdorf and Bruggemann, 1990) suggests that the general technique of long, jumping involves (i) as high a speed of approach as is possible to control, (ii) a lowering of the body centre of gravity (CG) during the last few strides and (iii) the contact fool placed well in front of the CG at touchdown (TD) into the jump (D_{TD}). All of these have sound reasons for their importance, supported by data from the literature. Other characteristics noted in the long jump run up, TD and takeoff (TO) can be related to these.

The purpose of this study was to present data on national level male long jumpers, and to identify the essential characteristics of technique as related to the model of long jumping outlined above. It is also intended to extend the database on the TD to TO phase with particular reference to energy changes and work done during the ground contact phase.

METHOD

Six male long jumpers were filmed during their competitive performances of the Men's Long Jump final during the 1991 U.K. National athletics championships. All performances of all competitors were filmed at 100 Hz with one Locam camera placed perpendicular to the runway, about 7 m from the take off board, such that the foot contact during TD of the last stride was visible and about 1 m alter the take off board. This ensured that sufficient frames of film were available after TO into the jump to adequately calculate release parameters. Judges were asked to co-operate and agreed to place themselves so that they were not in the field of view of the camera. The trials analysed were the best two jumps for each athlete. In all 12 jumps were analysed. No data were available for the standard anthropometric measurements of body height and mass.

The film was analysed using an 11 segment biomechanical model defined by 18 points using standard segmental data. Data was smoothed using a Butter-worth Second Order filter with padded end points and a cut off frequency of 8 Hz. First and second derivatives were calculated by direct differentiation. Derived parameters such as kinetic energy (KE), potential energy (PE) and work done (WD) per kg were computed on tlie basis of a whole body model, using equations defined by Lees et al. (1992).

An error analysis suggested that tlie expected en-or in linear displacement measures was around 5%. Similarly tlie expected error in angular displacements was about 9%; displacement changes about 14%, linear velocities about 5%, and angular velocities about 17%.

RESULTS AND DISCUSSION

The trajectory of the CG during the touchdown last stride (TDLS), takeoff last stride (TOLS), TD and TO into the jump is shown in Figure 1. Also marked on this figure is the point of maximum knee flexion (MKF) during the compression phase. It can be seen from this that the trajectory is exceptionally flat over the flight phase of the last stride and shows no appreciable reduction at TD. It appears to rise immediately from TD through MKF to TO, with the majority of this increase occurring between MKF and TO

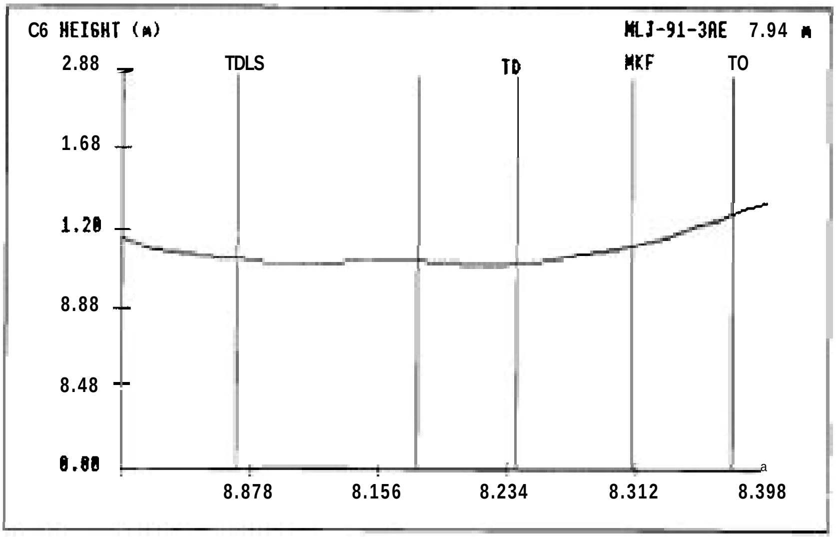

Figure 1 The path of the centre of gravity (CG) during the last stride and the takeoff into the jump.

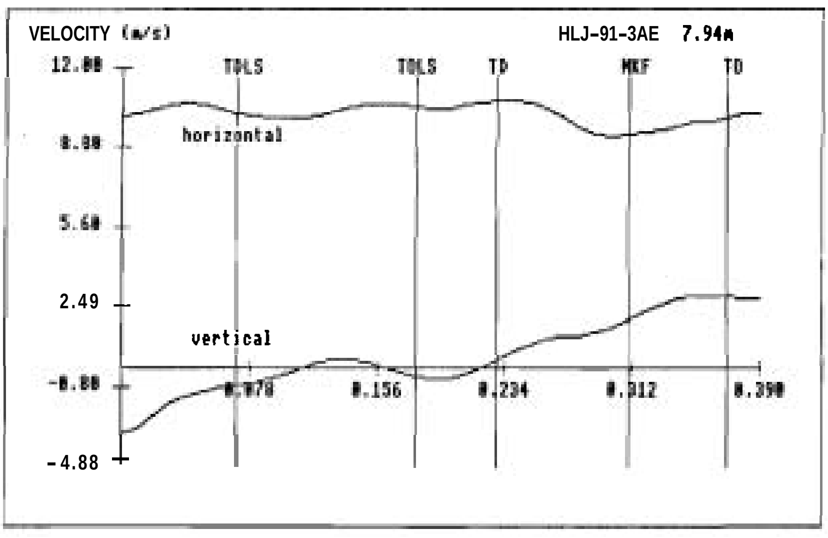

Figure 2 The horizontal and vertical velocities of the CG during the last stride and the takeoff into the jump

The corresponding velocity components with the same events marked are given in Figure 2 The point of TD was the first frame where the foot was in contact with the ground and the point of TO was the first frame after the foot has left the ground It is clear that there is a reduction in horizontal velocity as a result of contact with the ground, most of which occurs before MKF. From MKF to TO there is an increase in both vertical and horizontal velocities. Table 1 presents selected data on each of the TD, MKF and TO points

VARIABLE	TD mean	TD SD	MKF mean	MKF SD	TO mean	TO SD
vector velocity($m.s^{-1}$)	9.83	0.61	9.05	0.46	9.90	0.43
vertical velocity($m.s^{-1}$)	0.11	0.19	2.11	0.22	2.96	0.50
horizontal velocity($m.s^{-1}$)	9.83	0.60	8.82	0.46	9.44	0.49
CG height (m)	1.06	0.04	1.12	0.04	1.31	0.04
Knee Flexion angle(degs)	165.20	7.50	141.10	9.70	-	-
D_{TD} (m)	0.51	0.06	0.00	0.08	-0.50	0.06
A_{TD} (degs)	28.60	3.20	-		-25.70	4.40
KE ($J.kg^{-1}$)	48.50	6.00	41.00	4.20	51.80	5.30

	mean	SD
average vel. over LS ($m.s^{-1}$)	10.03	0.50
projection angle at TO (degs)	17.30	3.60
time of contact (s)	0.13	0.01
MAX(-ve)KF velocity ($rads.s^{-1}$)	-11.80	2.20
MAX(+ve)KF velocity ($rads.s^{-1}$)	9.00	1.10
change in $PE_{(TD-MKF)}$ ($J.kg^{-1}$)	0.63	0.20
$WD_{(TD-MKF)}$ ($J.kg^{-1}$)	-6.80	4.20
change in $PE_{(MKF-TO)}$ ($J.kg^{-1}$)	1.56	0.30
$WD_{(MKF-TO)}$ ($J.kg^{-1}$)	10.80	5.60

Table I. descriptive data for TD, MKF and TO, and other variables (N=12). KF=knee flexion

The model of long jumping referred to in the introduction leads to the expectation of relationships between certain variables on the basis of a causal model. The relationships expected are between the speed of approach. take off parameters and distances jumped. These are tabulated in Table 2.

The descriptive data and the expected casual relationships between variables helps to reinforce the picture of long jumping technique. Despite the potentially large errors in variables a surprisingly clear picture emerges. The essential feature is the placement of the leg at TD well in front of the body and an ability to prevent it from undergoing too much flexion. A fast run up and lowered CG help to deter-mine tlie initial conditions. If the leg is placed well in front of the body tlie CG can ride up over the base and create a high proportion of vertical velocity. If the leg is kept stiff there will be a greater contribution to this mechanism at the expense of active muscle contraction during the MKF-TO phase. Stor-age of elastic energy would still be possible in this case as the leg must undergo a degree of flexion. In order to achieve this the angle of flexion of the leg at TD must not be large and the muscles of tlie leg must be strong enough to resist further flexion. The high forces in tlie muscles during this phase will allow the elastic structures to be stretched substantially more than would occur in running, and hence are likely to store more energy. If the leg flexes too much at TD beciruse of too great an initial flexion or insufficiently strong muscles, then the benefit of the CG riding over the base is reduced as possibly is the elastic storage of energy. In this situation, there would be greater possibility for a .supply of energy from concentric muscular contraction during the MKF-TO phase, but the contribution to vertical velocity of this would not compensate for the failure to gain vertical velocity from riding over the base.

variables correlation

		CG HEIGHT	@ TO	(TD-TO)
CG height @ TO	vs	D_{TD}	NS	NS
CG height (TD-TO)		A_{TD}	NS	NS
		min KF angle	NS	NS
		min KF vel	NS	NS
		horiz.vel @ TO	NS	-0.764**
			A_{TD}	D_{TD}
A_{TD}	vs	vert.vel(TD-TO)	NS	0.813**
D_{TD}		vert. vel @ TO	0.701*	0.843**
		horiz.vel(TD-TO)	-0.677*	NS
		proj.angle	NS	0.789**
		min KF vel	-0.810**	-0.755**
		KF angle(TD-MKF)	-0.875***	-0.789**
		eff. dist	0.795**	0.743*
min KF vel	vs	max KF vel	-0.778**	
		eff. dist	-0.880***	
KF angle (TD-MKF)	vs	eff. dist	-0.922***	
		horiz.vel @ TD	-0.751**	
		velocity	vertical	horizontall
vert.vel @ MKF		vert. vel @ TO	NS	NS
horiz.vel @ MKF	vs	vector vel @ TO	NS	NS
		proj. angle	NS	NS
		CG height @ TO	NS	NS
		distance	official	effective
official dist.	vs	vector vel @ TO	NS	NS
effective dist.		proj. angle	NS	NS
		CG height @ TO	NS	NS

Table 2. Correlations for causal model variables. (N=12). * $p<0.01$ ** $p<0.05$ *** $p<0.01$

CONCLUSIONS

The lack of certain expected relationships (eg. between CG height and touchdown variables, and take off variables and distances) and is a cause for concern in implementing the causal model. However this could be the result of experimental en-or, homogeneity of data samples or flaws in the causal model. Further investigation is warrented.

REFERENCES

-Hay, J. G. and Nohara, H. (1990). Techniques used by elite long jumpers in preparation for take off. Journal of Biomechanics, 23, 229-239.

-Lees,A., Derby, D., Fowler, N. (1992) An analysis of the jump touchdown to takeoff characteristics of the women's long jump. Journal of Sports Sciences, (in press).

-Nixdorf, E. and Bruggemann, G. P. (1990). Biomechanical Analysis of the Long Jump. Technical report to the IAF.

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