KINEMATIC RELEVANCE OF SHORT APPROACH JUMPS AS A TRAINING TOOL FOR COMPETITION LONG JUMPING

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Training for the long jump involves short approach jumps which are often assumed to replicate full approach jump take-offs. The aim of this study was to compare directly the kinematics of short and full approach jumps. One elite female long jumper completed seven 10 step approach jumps during one training session, and five full approach jumps in an international competition. Video from a fixed camera was digitised and kinematic variables for the final touchdown calculated. Approach run step kinematics were obtained from a panning camera. Statistically significant ($p < 0.05$) differences were identified in approach step characteristics and in horizontal velocity, but none were found in vertical velocity generated. Results indicate short approach jumps are a useful tool for generation of vertical velocity but do not directly replicate full approach jumps in approach or take off.

KEYWORDS: PERFORMANCE, ELITE, COMPARISON

INTRODUCTION: Key factors affecting long jump performance have been subject to a significant amount of research, applying deterministic (e.g. Hay, 1993a), modelling (e.g. Seyfarth et al., 2000) and experimental (e.g. Graham-Smith & Lees, 2005) approaches. Although not universally agreed, touch down (TD) and take-off (TO) velocities and TD knee angles have been found to relate to performance.

In long jump impact forces of 4-11.2 bodyweights have been reported (based on an 80 kg male; Hay, 1986) in the activity itself as well as high forces in many of the training methods used such as sprinting (4.6-5.5 bodyweights; Mero et al., 1992) and plyometrics (4.32-6.77 bodyweights; Donoghue et al., 2011). With this in mind, technique specific training is often modified to reduce training load and allow more repetitions. An example of such a modification is the adaptation from full approach jumps to short approach jumps. This adaptation is intended to reduce the risk of injury while still maintaining sufficient stimulus for technical improvements.

The aim of the study was to compare the kinematics of short and full approach jumps and investigate any differences between correlations of key variables with performance.

METHODS: One elite female long jumper completed seven 10 step approach jumps during one training session and five full approach (18 step) jumps in an international competition. Jumps were recorded with a fixed camera (240 Hz during competition; 150 Hz during training) with a field of view of the final two steps and approximately three metres beyond the board, as well as a panning camera (240 Hz). Video from the fixed camera was calibrated, and digitised using an 18 point body model. As jumps are not routinely measured in training, jump distance was calculated based on parabolic equations for both competition and training data for consistency and validity of comparison. Centre of mass (CoM) position and 13 kinematic variables for the final contact were calculated from digitised data; these included vertical and horizontal velocities of the CoM at TD and TO, horizontal velocity of the foot relative to CoM, knee angular range of motion, and TD and TO angles; TD angle was defined as the angle made between the ankle and the CoM relative to horizontal, while TO angle is the arctan of vertical velocity of the CoM divided by its horizontal velocity. Kinematics of step length (SL), flight time (FT), contact time (CT), and knee angle at TD were calculated from calibrated panning data. In order to assess individual component differences between short and full approach jumps, a series of Student's t-tests were conducted, while linear regressions were used to identify key variables relating to performance.

RESULTS: While not statistically significant, a larger parabolic flight distance of 0.25m in competition would be considered a large difference in international long jumping. The results demonstrated higher horizontal velocities in competition jumps (Table 1), as well as differences in all measured kinematics of the final three steps (Table 1); longer steps, contact times and flight times and a more extended knee during competition. Knee range of motion was found to be significantly small in take-off for the full vs. short approach jumps.

Table 1: Means and standard deviations of kinematic step characteristics for both training and competition data sets and significance value from comparative t-tests.

Variable	Unit	Competition		Training		P
		Mean	SD	Mean	SD	Value
Parabolic flight distance	m	6.53	0.31	6.26	0.32	0.178
Horizontal velocity at TD	$m \cdot s^{-1}$	9.07	0.23	8.56	0.20	0.015*
Horizontal velocity at TO	$m \cdot s^{-1}$	7.45	0.28	6.88	0.28	0.007*
Loss of horizontal velocity	$m \cdot s^{-1}$	1.62	0. 18	1.68	0.23	0.674
Vertical velocity at TD	$m \cdot s^{-1}$	-0.71	0.09	-0.63	0. 10	0.052
Vertical velocity at TO	$m \cdot s^{-1}$	2.82	0.28	2.84	0.27	0.893
Gain in vertical velocity	$m \cdot s^{-1}$	3.53	0.27	3.44	0.30	0.639
CoM height change in final step	m	0.25	0.02	0.26	0.03	0.323
Relative horizontal velocity of the foot	$m \cdot s^{-1}$	-6.01	0.50	-6.35	0.23	0.639
TO angle	°	20.73	2.30	22.46	2.33	0.233
TD angle	°	58.35	1.90	59. 10	1.75	0.522
Minimum knee angle	°	132.70	5.08	128.43	4.59	0.159
Knee Range of motion	°	36.02	5.02	40.90	2. 14	0.042*
Time to minimum knee angle	s	0.06	0.01	0.06	0.01	0.868
TO height	m	1. 16	0.03	1. 18	0.02	0.576
TO distance	m	0.30	0.03	0.34	0.03	0.470
SL ratio (2nd:1st)	%	1.04	0.04	0.99	0.04	0.113
SL final	m	2. 17	0. 10	2.00	0.07	0.006*
SL 2nd last	m	2.25	0.05	1.98	0.09	0.003*
SL 3rd last	m	2. 12	0.04	1.89	0.04	<0.001*
CT final	s	0. 16	0.00	0. 14	0.01	0.023*
CT 2nd last	s	0. 14	0.01	0. 14	0.01	0.565
CT 3rd last	s	0. 13	0.00	0. 12	0.01	0.015*
FT final	s	0. 12	0.01	0.08	0.01	0.003*
FT 2nd last	s	0. 16	0.00	0. 11	0.01	0.015*
FT 3rd last	s	0. 15	0.01	0. 12	0.00	0.015*
Knee angle at TD final	°	166.65	1.09	155.02	2.43	<0.001*
Knee angle TD 2nd last	°	149.50	2.58	141.75	2.54	0.001*
Knee angle TD 3rd last	°	145.63	3.06	133.82	4.69	0.001*

* indicates p value below 0.05.

When looking at correlations, the only variable found to correlate significantly with parabolic flight (jump) distance was the horizontal velocity at touchdown in the short approach condition. The R^2 values show a much higher proportion of the variability is due to changes in horizontal velocity at touchdown in the short approach (91.4%) when compared with the full approach (35.6%).

Table 2: Bivariate correlation data. Shading indicates competition data while white is training data.

		Jump Distance (m)	Horizontal Velocity TD ($m{\cdot}s^{-1}$)	TD Angle (°)	Knee Angle TD (°)	Vertical velocity gain ($m{\cdot}s^{-1}$)	TO Angle (°)
Jump distance (m)	R-value		0.356	-0.63	-0.399	0.643	0.334
	P-value		0.556	0.920	0.506	0.242	0.583
Horizontal Velocity TD ($m{\cdot}s^{-1}$)	R-value	0.914*		0.507	0.663	-0.103	-0.414
	P-value	0.004*		0.383	0.222	0.869	0.488
TD Angle (°)	R-value	-0.421	-0.316		0.272	-0.759	-0.958*
	P-value	0.347	0.491		0.657	0.137	0.010*
Knee Angle at TD (°)	R-value	0.376	0.473	0.043		-0.407	-0.399
	P-value	0.406	0.284	0.927		0.497	0.505
Vertical velocity gain ($m{\cdot}s^{-1}$)	R-value	0.643	0.471	-0.805*	0.436		0.872
	P-value	0.119	0.286	0.029*	0.328		0.054
TO Angle (°)	R-value	0.348	0.125	-0.427	0.361	0.911*	
	P-value	0.445	0.790	0.339	0.426	0.004*	

*** indicates p value below 0.05.**

DISCUSSION: The current study demonstrates a number of differences in approach characteristics between competition and training data (table 1), with the last three steps when approaching the board all longer in competition by a statistically significant margin, as well as being longer in duration of contact and flight times.

Knee angle at TD was significantly larger in competition jumps compared with training jumps (table 1) but was not statistically significantly correlated with any of the other identified key variables (table 3). In opposition to previous research (e.g. Lees et al., 1993; Graham-Smith & Lees, 2005), this indicates that it does not co-vary with changes in velocity, TD, or TO angle. A straighter knee angle at TD means the knee extensor muscles do not have to work as hard to maintain extension due to a more advantageous moment arm; the effectiveness of which decreases as the knee flexes. The maintenance of a straighter knee during TO, exhibited to a significantly greater extent in the full-approach jumps via a smaller range of motion (table 2), could be expected to facilitate performance via an increase in TO height. This does not appear to be the case the current study as the TO height is not greater in full approach jumps (1.16 m compared to 1.18 m), indicating TO height is generated via different mechanics in the short approach jumps.

Vertical velocity gain was found to correlate significantly with both TD and TO angles for short approach jumps (table 2), with a lower TD angle and larger TO angle increasing vertical velocity. Moving through a larger arc could increase velocity by increasing contact time and therefore impulse but this cannot be assessed using the current data. The differences in knee and CoM angle indicate differences in vertical velocity generation strategy. Additional research looking at joint moments could be beneficial to improve understanding of this apparent different between short and full approach jumps.

Previous research has investigated a large range of approach velocities and has reported a significant, positive linear effect of approach velocity on jump performance (e.g. Hay, 1993b; Bridgett & Linthorne, 2006). The strong linear relationship documented in this study by the training (short approach) data supports this; however there was no apparent relationship between the full approach TO velocity and distance jumped and if taken at face value, this could be interpreted as this athlete being more reliant on differences in technique than velocity during competition. However, a similar scenario in high jumping was discussed by Yeadon and Challis (1994) with the authors concluding that the small range in approach velocities in competition made it impossible to draw conclusions on relationships. Despite this limitation, and the use of only one athlete, these findings do give us some insight into the difference in strategies adopted in short and full approach jumps by an elite athlete.

CONCLUSION: Short approach jumps inherently decrease the number of contacts and therefore the impact on the athlete, but the differences highlighted should be considered by coaches. Although the small number of trials makes it difficult to reach definitive conclusions, the results indicate that different kinematic approach run and jump strategies are adopted for short and full approach jumps by this athlete. While short approach jumps are a useful training tool in developing vertical velocity, they cannot be said to replicate competition jumps exactly.

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