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BIOMECHANICAL ASSESSMENT OF HORIZONTAL JUMPS TRAINNING

Filipe Conceição[1,3], João Peralta[1], Susana Martins[1], Leandro Machado[1,3], Filipa Sousa[1,3], Pedro Gonçalves, Paulo Colaço[1], J.P. Vilas-Boas[1,3], José Augusto Santos[1] and João Carvalho[2]

Faculty of Sports, CIFI2D, University of Porto, Portugal[1]
Faculty of Engineering, University of Porto, Porto, Portugal[2]
Porto Biomechanics Laboratory, University of Porto, Portugal[3]

A setup for assessing the performance obtained in horizontal jumps has been described. One of the main challenges is to provide meaningful and timely information to elite athletes. This assessment program started in 2007 with some of the best jumpers and combines kinematic and dynamic information. Results obtained allowed to identify the weaknesses and the mechanisms that determine the performance as well as design remarks to provide support to the athletes. Values obtained are in agreement with those described in the literature for elite athletes. The purpose of this work was to develop a programme to assess the strategies adopted by horizontal jumpers during different jump phases to obtain a more effective and efficient performance.

KEY WORDS: Jumps, Approach Run, Take-off, Velocity, Forces.

INTRODUCTION: A programme concerning the biomechanical assessment of the state of preparation of track and field jumper's was started in 2007, in the Faculty of Sport - University of Porto. The reason was to bring the theoretical knowledge already developed (Conceição, 2005) to improve jumpers' motor skill and performance, i.e. bring the lab to the track with the minimal disruption of training and competition programs. After these years, a robust assessment program has been developed allowing us to work closely to our best track and field jumpers, drawing out the most important variables from the competitive performance to give technical feedback to coaches and athletes, to correct and/or improve jump skills.

Experimental research in horizontal track and field jumps has been developed since the 50's,highlighting the approach run (AR) as the most important phase for the performance, and the take-off as the most critical (Conceição, 2005). Kinematics has been a major research tool and other means were relegated to a secondary plane. During this period, a significant number of issues have been addressed and solved or clarified namely: (i) strategies used by jumpers to regulate and control the run-up (Hay, 1988); (ii) identification and characterization of the technique used by jumpers in the preparatory and take-off phases (Nixdorf & Brüggemann, 1983); (iii) the point where the maximum speed is reached (Hay & Miller, 1985); (iv) the step amplitude as an indicator of the performance (Popov, 1971); (v) angular momentum and technique (Herzog, 1985; Ramey, 1973); (vi) optimal landing position (Mendoza, 1989), etc..

Although knowledge has been growing up during recent years, little has been done concerning take-off in track and field jumps. Through force platforms, insights about the mechanics of vertical and horizontal jumps during take-off can be understood, although little can be found in the literature. The knowledge of the shape of the force-time curve, the impulse, and peak force applied during the take-off, together with kinematic information, will enable a more thorough evaluation of the jumper technique and efficiency. Another challenge for biomechanics is the releasing of timely and meaningful information to coaches and elite athletes. With the development of new technologies more accurate data can be gathered from different systems, and information delivered faster for athletes/coaches, and other approaches can be developed as well.

The purpose of this work was to develop a programme to assess the strategies adopted by horizontal jumpers during different jump phases to obtain a more efficient and effective performance.

METHODS: To collect data a set-up based on one Doppler velocimeter (DV), Radar Stalker Ats, two video cameras (one high speed Redlake MS 8000S), one force plate (Bertec), a pair of photocells and an A/D Biopac converter were used. All these systems were synchronized through a pair of photocells placed 1 m behind the take-off board. The main phases to be analyzed were the AR, the take-off and, when necessary, the flight and/or the landing.

The AR velocity data recoil was carried out by (i) a DV placed at the end of the pit sand, in the frontal plane of the athlete's displacement line, sampling at a frequency of 100Hz to assess the task of accuracy (Hay, 1988) and optimum speed; (ii) a 25 Hz PAL camera was placed parallel to the AR corridor for collecting information concerning the step amplitude and frequency throughout the AR; (iii) three pairs of photocells placed in the last part of the AR, that is 11-6m and 6-1m as described by Susanka, Jurdik, Koukal, Kratky & Velebil (1987).

The data concerning the take-off were collected through: (i) a high frequency video camera sampling at 1000Hz and placed in line with the take-off board in the sagittal plane of the jumper's line of displacement to assess the kinematics actions and (ii) a Bertec force platform sampling at 1000Hz to collect the ground reaction forces (GRF) data.

The AR was assessed by performing a re-sampling and reparametrization of the data. Next step was to determine where the visual control occurred using cross-correlation and display mean curves for each subject with its reproducibility. For the GRF initially the global and local maximum and minimum in each component of GRF, their time of occurrence, impulses and contact time were determined based on Tiupa, Aleshinsky, Primakov & Pereverzev. (1982). Finally data were resampled over new time vector between [0; 1000] and scaled to their maximum value to obtain GRF profiles for each jumper during the take-off.

A total of 25 athletes participated in this program. Although in this paper more emphasis will be done on the data of an elite female long jumper, 1,81m height, 71kg mass, with best performance of 7.12 m, free from injury, who participated in three different assessment sessions.

RESULTS AND DISCUSSION: The way in which jumpers build-up their velocity during the AR seems to be of great interest since the velocity is the main parameter for the performance. Therefore the first approach has been to analyze the velocity curves concerning their shape and the point were the athlete changes his/her strategy in order to perform the take-off accurately. Figure 1 shows velocity curves from two elite Portuguese jumpers. As it can be seen they present different curve shapes concerning the behaviour of the velocity throughout the AR. In both cases the maximum velocity developed was around 10 m/s and it was achieved in the penultimate step, which is in agreement with results described in the literature (Hay, Miller, & Canterna, 1986).

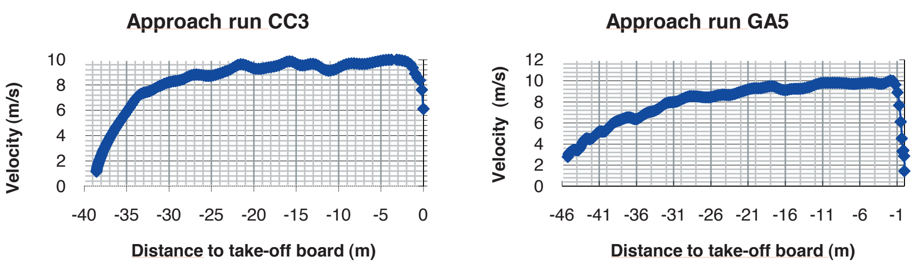

Figure 1: Velocity curves from the athlete selected, collected by using the velocimeter Doppler in two different assessment sessions.

Concerning the visual control point we found that it occurred between 10 and 15 m before the take-off board which are approximately 5-7 steps. Figure 2 represents the auto-correlation of a velocity curve, in order to determine the visual control point (Martins, 2007), of a female elite athlete during the AR.

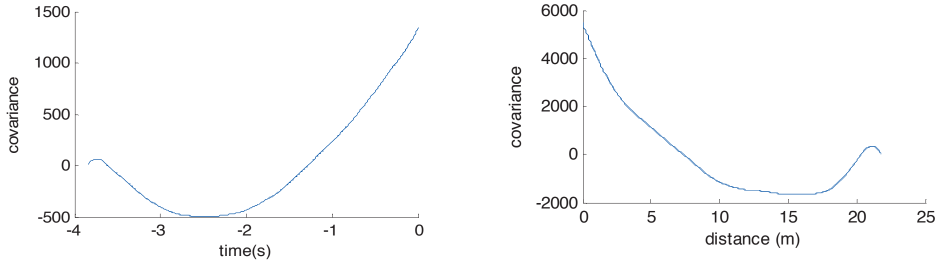

Figure 2: Auto correlation curves as function of time and distance from an athlete.

As a measure of consistency of the athletes when performing the AR, the reproducibility of velocity curves was determined. With regard to training, the relevance of this parameter lies in the fact that it allows to determine, throughout the whole approach run, the point in which athletes and coaches should pay more attention to improve it for better performance. Results referring to the reproducibility can be seen in Figure 3.

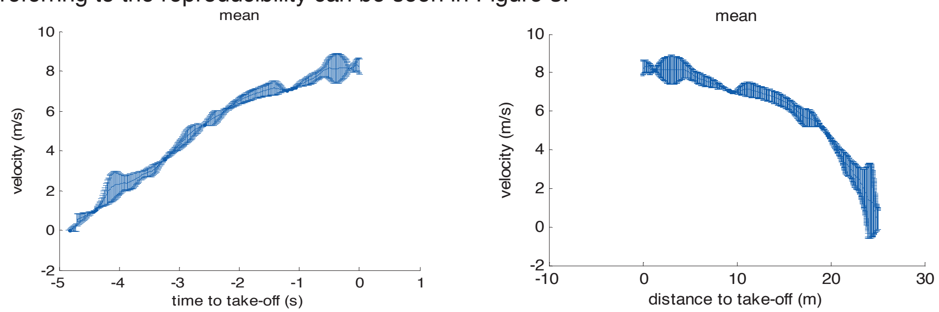

Figure 3: Approach run reproducibility curves with the time and distance to the take-off board.

The athlete's performance at the end of the AR was also analyzed taking into account the velocity behaviour during this part of the AR, i.e., between 11-6m and 6-1m before the take-off board, both in two different assessment sessions for a female elite athlete. Mean velocity differences of 0.3 and 0.28m/s were found, which means that this athlete should improve its AR, since the literature argue for a value of 0.15m/s (Zotko, 1991).

Although speed is the main parameter for the result in jumps, usually, the most critical phase seems to be the take-off, since it is there where many strong and fast athletes fail. The take-off is where the athlete changes the path of displacement in an extremely short time. For this reason, to obtain success in these disciplines, energy transformations, as well as the segmental and muscle contribution, requires a great athlete's technical, coordinative and conditional capacity. Table 1 shows the values obtained by a female long jumper during the take-off. These results allow verifying, in the vertical component of GRF, a short time interval between the first two intervals (t1 and t2) and a large applied force, resulting in an increased momentum during the take-off. The interval t2 and t3 shows that the athlete’s capacity to apply force may be improved. This interval corresponds to the active peak and it is possible to distinguish active and more or less dynamic subjects in this phase. Results suggest that this female jumper apparently, expresses some disconnection in the interval between t2 and t3, although she regains the control of the actions at the middle of the active phase of the vertical component of the GRF, located between t3 and t4. Supporting times for the different phases (eccentric, concentric phase and total) ranged from 87 to 106 ms, from 12 to 30 ms and 111 to 122 ms, respectively. Although some important results have been obtained, efforts should continue to improve this assessment program.

Table 1
Time interval values (t1, t2, t3, t4 and t5), forces (F1, F2 and F3) and impulses (S1, S2, S3, S4, S5) of the vertical and anterior posterior component of GRF of an elite athlete.

Vertical component of GRF								anterior-posterior component of GRF						
Trial	E 1	E 2	E 3	E 4	E 5	$\overline{X}$	SD	E 1	E 2	E 3	E 4	E 5	$\overline{X}$	SD
Dist.	5.9	6.38	6.4	6.42	6.7	6.36	0.3	5.9	6.38	6.4	6.42	6.7	6.36	0.3
t1	15	17	15	16	14	15.4	1.1	14	18	13	16	15	15.2	1.8
t2	26	25	17	19	25	22.4	3.9	92	87	82	71	75	81.4	8.1
t3	12	14	14	12	15	13.4	1.3	7	11	7	19	24	13.6	7.2
t4	53	49	49	40	36	45.4	6.7	5	6	9	10	6	7.2	2.0
t5	12	17	16	29	30	20.8	7.7							
F1	9046	8627	8245	7591	8799	8462	535	-4356	-4436	-3450	-3746	-4545	-4107	453.2
F2	3306	2992	3308	3087	3456	3230	176	295	342	331	301	333	320.4	19.8
F3	4040	3953	4094	3927	4057	4014	67.0							
S1	50	42	55	45	35	45.4	7.2	-20	-25	-18	-21	-21	-21	2.4
S2	125	122	87	96	133	112.6	18.8	-93	-98	-86	-88	-98	-92.6	5.2
S3	43	48	51	43	54	47.8	4.6	1	2	1	1	4	1.8	1.2
S4	138	146	147	136	116	136.6	11.8	1	1	2	1	1	1.2	0.4
S5	5	15	13	39	32	20.8	13.3							
A	64	76	75	88	81	76.8	8.3	-72	-71	-73	-71	-71	-71.6	0.8
M	6	16	14	42	35	22.6	14.3	381	386	360	340	361	365.6	17.4

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