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Biomechanics

BIOMECHANICAL ANALYSIS OF THE LAST STRIDES, THE TOUCHDOWN AND THE TAKEOFF OF TOP GREEK MALE AND FEMALE LONG JUMPERS*

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Abstract

The purpose of the present study was to compare the technique of top Greek male and female long jumpers and to examine their technique using as reference biomechanical characteristics of elite international jumpers. Two-dimensional kinematic data from top ten Greek male (25.4 ± 3.0 years) and top twelve Greek female (25.5 ± 4.3 years) long jumpers were video recorded while participating in the 2007 Greek National Championships finals. A qualitative assessment of the long jump technique was also conducted. Application of Principal Components Analysis did not reveal a solid "speed" or "vertical impulse" dependency of performance. However, the top three athletes were clearly identified as the "faster and stronger" jumpers ($p < 0.05$). The obtained values suggested that top Greek long jumpers were inferior compared to corresponding values reported for elite international athletes. However, the examined jumpers performed their jumps without any obvious technical mistakes. Track and field coaches of elite Greek athletes should modify training so that athletes can better utilize their velocity at take off during long-jumping.

Key words: Track and field, Direct Linear Transformation, Technique assessment, Principal Components Analysis, Gender

*An extended Summary Plus English version is freely available at www.hellenicjsport.com

Introduction

It has been reported that Greek long jumpers achieve lower jumping distances compared to the best European athletes (Deli et al., 2008). Furthermore, female Greek long jumpers also have lower performance than European jumpers, despite their consistent improvement the last decade. The purpose of the present study was: i) to examine the kinematic parameters of the technique of top Greek male and female long jumpers, ii) to compare these parameters between male and females jumpers, iii) to qualitative assess their technique, and iv) to compare and their technique using as reference the biomechanical characteristics of elite jumpers selected from the literature (Koyama, Muraki, Takamoto & Ae, 2008; Müller & Brüggemann, 1997; Nixdorf & Brüggemann, 1990).

Method

Ten Greek male (M; 25.4 ± 3.0 years) and twelve Greek female (F; 25.5 ± 4.3 years) long jumpers were recorded while participating in the 2007 Greek National Championships. A digital JVC GR-DVL-9600EG video camera (Victor Company, Japan), operating at a 100fps sampling frequency, was used to capture the last two strides, the touchdown and the takeoff of the participants. The runway and the take-off area were calibrated using a 2.5m × 2.5m frame with 16 control markers, positioned perpendicular to the camera's optical axis. All trials were recorded, but the best valid jump for each athlete was selected for further analysis. For the execution of a 2D-DLT kinematic analysis (Kollias, 1997), twenty-two anatomical points of the body were digitized in each field. A digital 6Hz cut-off frequency was selected for smoothing the data. Digitization, smoothing and analysis were conducted using the A.P.A.S.-XP software (Ariel Dynamics Inc., Trabuco Canyon, CA).

A qualitative assessment of the long jump technique was conducted utilizing the Model Technique Analysis Sheet proposed by Tidow (1989). An independent samples T-Test was run for the comparison of the kinematic parameters between M and F. Furthermore, a Principal Components Analysis with a Varimax rotation was executed in order to examine a possible tendency of "speed" or "vertical impulse" dependency upon the execution of the takeoff for the jump (Panoutsakopoulos et al., 2007). All statistical procedures were conducted using the SPSS 10.0 software (SPSS Inc., Chicago, IL). An alpha level of 0.05 was used.

Results

M were inferior (p<.05) compared to F concerning the parameters related to physical capability (horizontal and vertical Body Center of Mass-BCM takeoff velocity) and anthropometry (BCM height). M also had increased (p<.05) values in the parameters which define the projectile of the jump (Table 1).

Table 1: Average (x) and standard deviation (sd) of the kinematic variables analyzed.

Group		OFD (m)	2LS (m)	1LS (m)	Vx2L (m/sec)	Vx1L (m/sec)	rVfoot (m/sec)	TTB (m)	θknee (deg)	VxBOto (m/sec)	VyBOto (m/sec)	hBOto (m)	AngPr (°)
M (*n*=10)	x	7.51	2.41	2.10	9.70	9.86	-5.54	0.05	152	8.18	3.43	1.26	22.7
	sd	0.43	0.11	0.14	0.39	0.39	0.81	0.06	5.0	0.42	0.36	0.03	1.8
F (*n*=12)	x	6.11*	2.19*	2.05	8.56*	8.84*	-4.82*	0.07	146	7.48*	2.81*	1.17*	20.6*
	sd	0.27	0.13	0.14	0.62	0.41	0.70	0.06	6.0	0.31	0.19	0.04	1.2

** p<.05 compared to male jumpers.* ***OFD:*** *official distance,* ***2LS:*** *penultimate stride length,* ***1LS:*** *last stride length,* ***Vx2L:*** *horizontal BCM velocity for the penultimate stride,* ***Vx1L:*** *horizontal BCM velocity for the penultimate stride,* ***rVfoot:*** *horizontal foot velocity at touchdown with respect to BCM horizontal velocity,* ***TTB:*** *toe-to-boad distance,* ***θknee:*** *minimum knee angle of the push off leg,* ***VxBOto:*** *horizontal BCM takeoff velocity,* ***VyBOto:*** *horizontal BCM takeoff velocity,* ***hBOto :*** *BCM height at takeoff,* ***AngPr:*** *angle of projection.*

No gender effect (p>.05) was revealed for the qualitative assessment of the long jump technique (see Tidow, 1989), since 3.5±1.9 vs 3.6±1.4 mistakes in average were observed for each male and the female athlete, respectively. The results from the Principal Components Analysis did not reveal a solid "speed" or "vertical impulse" dependency for both groups (Figure 1). However, only the top three males and the top two females were spotted in the upper right section of the graph, which represent the "fast and strong" jumpers. Finally, both M and F were inferior when compared to elite international athletes, regarding the values of the analyzed kinematic parameters.

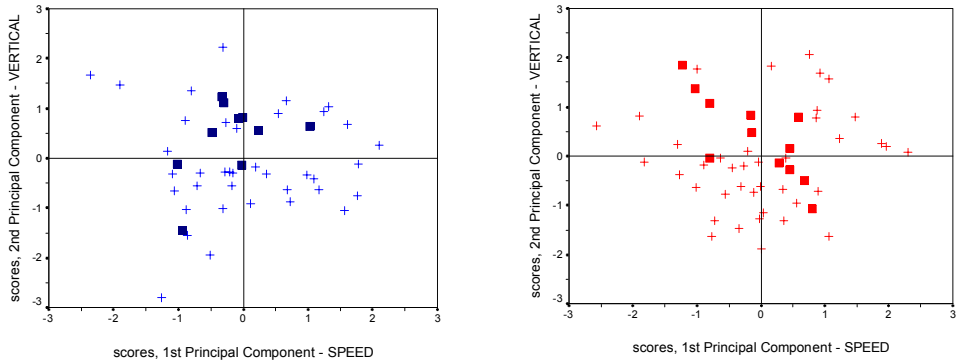

Figure 1. Factor scores of the long jump performance for M (■) and F (■) compared with scores from jumpers (+, +) cited in a database (Panoutsakopoulos et al., 2007).

Discussion

M performed the long jump exhibiting larger values than F for the kinematic parameters which relay to physical ability (i.e. speed) and body stature (BCM height at takeoff). A gender effect was not established for the kinematic parameters which interpret technique elements. The above mentioned was observed since both M and F utilized the "longer penultimate-shorter last stride" technique. This technique allowed the examined jumpers to achieve the goals of the approach run, i.e. to adjust their body position in the preparation for the takeoff and to facilitate optimum conditions for the jump (Hay & Nohara, 1990). Despite the good demonstration of the long jump technique, the Greek jumpers performed the long jump with less advantageous values of crucial biomechanical parameters, when compared to elite jumpers worldwide (Koyama et al., 2008; Müller & Brüggemann, 1997; Nixdorf & Brüggemann, 1990)

Conclusion

The examined jumpers executed the long jump without the presence of common noticed technical mistakes and should emphasize to: i) the execution of the last stride of the approach (swing of the limbs, direction of impulse), ii) the parameters related to "speed" dependency (males), and iii) the parameters related to "vertical impulse" dependency (females).

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