

ANALYSIS OF KINEMATIC PARAMETERS BETWEEN SPANISH AND WORLD CLASS JAVELIN THROWERS

José Campos, Gabriel Brizuela, Víctor Ramón, Javier Gámez
Department of Sport and Physical Education. University of Valencia (Spain)

A Kinematic analysis was performed on 3D photogrametric technique to try to describe and to compare the differences between Spanish and World Class javelin throwers. Results showed significant differences between groups ($p < 0.05$) in 11 of 35 kinematic variables. The major differences occur in the final phases of the throw. These differences show that those throwers belonging to the world class group have a greater ability to use the power of the body to accelerate the javelin. Therefore it makes possible to know the technical lacks of Spanish throwers which could help to lead their individual coaching programs.

KEY WORDS: javelin throw, kinematics, technique, biomechanics, groups, t-test.

INTRODUCTION: It is important for sports coaches to know the differences between their athletes, technical execution, and that of those who are closer to the theoretical technical pattern. Most of biomechanical studies tend to describe the kinematic parameters of elite throwers (Mero, Komi, Korjus *et al*, 1994), (Morris, Bartlett, 1996), (Morris, Bartlett, Navarro, 2001). Nevertheless, a limited number of biomechanical studies in javelin throw are centered on the analysis of the differences between throwers of different skill level (Bartlett, *et al*, 1996). In the javelin throw, the most representative studies that have undertaken the analysis of the differences found between javelin throwers of different performance levels have been carried out by Menzel (1986, 1987); Whiting, Gregor, Halushka (1991); and Bartlett, Müller, Lindinger, Brunner, Morris (1996). The aim of this study was to compare the differences between the best Spanish javelin throwers and a group of world class javelin throwers, and the consequences that this brings about.

METHODS: The study was developed with a 3D photogrametric technique, based on two synchronized S-VHS video cameras recording at 50 fields per second. Statistics were applied to know the significant differences between groups by a *t-test*. Moreover, the *variation coefficient* in each of the variables was calculated to know the level of variability in the performance execution. Two groups were analyzed in the study. The first group contained the 8 best Spanish throwers recorded at the final of the Spanish National Athletic Championship in Valencia'01. The second group contained 7 elite world class throwers recorded at the final of World Athletic Championships in Sevilla'99. The main times that define the intervals represent the final phase in javelin throw and were the following:

- T2: arrival of the left foot at the ground (beginning for the two-legged support phase).
- T3: javelin release.

RESULTS AND DISCUSSION: Results showed significant differences between groups ($p < 0.05$) in 11 of 35 kinematic variables. Some of these findings coincide with previous studies (Bartlett *et al*, 1996). Basically, affiliation in height throwing level was largely attributable to great release speeds and large paths of acceleration. The percentage of variation of the variables showed different tendencies per group, except for horizontal shoulder axis rotation and hip velocity, both at release time. The major percentage of variation, in both groups, takes place at the time of releasing the javelin and more specifically concerning the action of the hips; In the world class group: hip axis rotation (27%), and hip velocity at release (25%); In the spanish group: hip velocity at release (25%).

The variables that show significant differences per group were the following: VJAV3: Velocity of the javelin at release (T3); VMAXEL: Peak elbow velocity.; VMAXSHO: Peak shoulder velocity.; ROTSHO3: Shoulder axis rotation at release (T3);; ROTHIP3: Hip axis rotation at release (T3); RKNEE3: Right knee angle at release (T3); ELB2: Elbow angle at the beginning of the final ; hase (T2); VZ: Vertical velocity component of the javelin at release (T3); VY;

Horizontal velocity component of the javelin at release (T3); $\Sigma V2_3$: rise in velocity from T2 and T3; ZHAND: Height of release (T3)

Table 1. Descriptive data for variable DISTANCE (m).

GROUP	Mean	St. Dev.	Min.	Máx.	N
World class (>80)	86.45	2.31	83.84	89.52	6
National (<75)	68.39	2.78	63.95	70.97	8

Table 2. Significant differences between groups (t-test)

Variable	Means	t-value	2 tail Sig (95%)
Vjav3 (m/s)	>80: 28.91 <75: 24.80	12.125	.000
Vmaxel (m/s)	>80: 14.83 <75: 12.71	3.306	.006
Vmaxshou (m/s)	>80: 9.48 <75: 8.00	5.858	.000
Rotsho3(°)	>80: 46.28 <75: 65.75	-3.344	.003
Rothip3 (°)	>80: 65.85 <75: 87.00	-2.660	.011
Rknee3 (°)	>80: 133.57 <75: 114.25	2.119	.050
Elb2 (°)	>80: 131.57 <75: 102.25	3.753	.002
Vz (m/s)	>80: 15.89 <75: 13.45	3.094	.009
Vy (m/s)	>80: 24.04 <75: 21.16	3.689	.003
$\Sigma V2_3$	>80: 20.08 <75: 15.37	8.431	.000
Zhand (m)	>80: 1.97 <75: 1.80	2.622	.021

Variables with a Coefficient of Variation greater than 15%	
World Class Group	Spanish Goup
Hip axis rotation T3 (27%)	Hip velocity T3 (25%)
Hip velocity T3 (25%)	Attitude angle T2 (18%)
Elbow velocity T2 (19%)	Elbow angle T2 (18%)
Shoulder velocity T3 (17%)	Shoulder axis rot. T3 (18%)
Shoulder axis rot. T3 (16%)	Hip axis rotation T2 (16%)
Elbow velocity T2 (15%)	Attitude angle T3 (16%)
Attitude angle T2 (15%)	

Release speed depends on the quality of the transmission of the body's kinetic energy to the arm, and from this to the javelin. The results show that throwers of an international level (>80m) are capable of throwing the javelin at a greater speed. Differences were found not only in the release speed of the javelin (Vjav3), but also in the increase of the speed of the javelin from T2 to T3 ($V2_3$), and in the horizontal (Vy) and vertical (Vz) components of the release speed. The release speed averages for each group, registered as 28.9 and 24.8 m/s, establish differences of more than 4 m/s, that is to say more than 14Km/h. These results corroborate the findings that appear in the literature, in which release speed has been recognised as one of the factors that most clearly separate throwers of different performance levels (Whiting *et al*, 1991), (Bartlett *et al*, 1996). Another speed variable that gives a high degree of correlation with the release speed is the maximum speed of the elbow (Menzel, 1987). The results obtained show that the maximum speed achieved by the elbow establishes significant differences between groups. The throwers of the international group reach an average speed in the elbow of the throwing arm of 14.83 m/s, while those of the Spanish group reached an average speed of 12.71 m/s. Therefore it continues to be shown that the differences between throwers affect mainly the speed variables, and especially the segments close to the implement that acts in the last 60ms. In relation to the position variables, differences were found between the groups for the variables related to the position of the lines of the hips and of the shoulders. Bartlett *et al* (1996) studied the orientation of the projection of the lines of the hips and of the shoulders on the horizontal plane, verifying that

the best throwers had a greater angular path, and that the line of the hips was found to be further forward than the line of the shoulders with respect to the vertical axis at the moment of release (T3). The results obtained corroborate these findings. The throwers of international level place the line of the hips on average 19° more turned than do the throwers of the national group at the instant of release. In the case of the line of the shoulders, the athletes of the international group are also capable of turning the shoulders an average of 19° more at the instant of release; this helps to produce a greater impulsion path. Another of the variables in which differences were found between groups is the height of release. The data reveal that the throwers of international level throw from a higher position than those of national level, having registered average values of 1.97m and 1.90m respectively for each group ($p: 0.021$). It should be born in mind that the release height is conditioned by the size of the thrower, therefore it would have been advisable to apply some corrective function to regularise the results. Nevertheless, it is also true that the release height is conditioned not only by the size of the thrower, but by the actions performed throughout the final phase, among which the actions of the right and left leg, the hips, the shoulders and the elbow should be considered. Since the level of statistical significance for the differences is relatively high ($p: 0.028$), it could be accepted that the fact that the throwers from the international group throw from a higher position is due to the technical execution more than to the differences of an anthropometrical character that separate the throwers. In fact, two of the variables in which differences were found between the groups, and which can help to assume a higher final position are, on the one hand, the angle of elbow flexion, and on the other, the angle of knee flexion for the right leg, both at the instant of release. The data show that the throwers of international level keep his elbow more extended than those of national level (131° and 102° respectively), and the right knee more extended (133° and 114° respectively).

CONCLUSIONS: In the first place, it must be pointed out that the results and values obtained are in accordance to those specifically in the literature to analyse kinematic parameters in javelin throwers of different levels of performance, which allows us to validate the methodology used. The major differences between groups occur in the final phases of the throw. These differences show that those throwers belonging to the world class group have a greater ability to use the power of the body to accelerate the javelin. Therefore, the technical lack of Spanish throwers is revealed. This gives us interesting information to be applied to individual coaching programs. More specifically, the results reveal that the throwers of higher performance levels (world class) are different from the throwers of lower performance (national) in the following questions: *they throw the javelin at greater speed; the maximum speed of the elbow and the shoulders reach higher values; they achieve greater rotation of the lines of the hips and of the shoulders at the instant of release (T3); they throw with a greater extension of the elbow at the instant of release; and, they throw from a higher position; they manage to increase to a greater degree the speed of the javelin between T2 and T3.* All in all, the principle contribution of this study is to verify that *the maximum speed of the markers that represent the speed of the articulation points of the elbow, shoulder, and of the javelin* are the indicators of greatest importance when it comes to establishing the differences that separate the throwers of one group from the other. On the other hand, it should be emphasised that no significant differences were found between groups in parameters considered as fundamental when explaining the general theoretical model, as it is the case of the flexion angle of the knee of the front leg, or the angle of attack. All in all, it is proposed to advance the study of the differences between throwers of different performance levels using wider samples of throwers for each performance group, with the object to make possible the application of more powerful statistical techniques of classification.

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