KINEMATIC ANALYSIS OF JAVELIN RELEASE CHARACTERISTICS - A CASE STUDY

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Abstract

Many studies have recently dealt with the javelin throw in elite competitions such as Olympic Games and international competitions. Owing to them it has become possible to compare throwing techniques of any athlete with those achieved by athletes who, according to official results, rank as the best in the world.

The purpose of this study was to compare javelin release characteristics performed by one Croatian athlete with those performed by the best male throwers in the 1992 Olympic Games in Barcelona.

The achieved results have shown significant differences in numerous parameters: javelin release angle, release velocities, knee and elbow angles, grip distance, as well as differences in timing of peak joint centers speed. Since those technical shortcomings significantly influence the distance of the throw, they should be corrected during the training process in order to increase the distance.

Keywords: *javelin throw, kinematic analysis, Olympic Games*

Zusammenfassung

KINEMATISCHE ANALYSE DER SPEERABWURFPHASE - DIE ANALYSE EINES FALLES

In letzter Zeit wurden viele Analysen des Speerabwurfes während der großen Wettbewerbe, wie z.B. die Olympischen Spiele, Weltmeisterschaften, usw., durchgeführt. Dank dieser Analysen ist es möglich die Wurftechniken von vielen Sportlern mit denjenigen zu vergleichen, die, gemäß der offiziellen Ergebnisse, zu den besten Sportlern auf der Welt zählen.

Das Ziel dieser Studie ist der Vergleich von Abwurfcharakteristiken bei einem kroatischen Sportler mit denjenigen Charakteriken, die den Abwurf bei den besten Speerwerfern im Finale der Olympischen Spiele in Barcelona (1992) gekennzeichnet haben.

Die Ergebnisse zeigen, daß es bedeutende Unterschiede in vielen Parametern gibt, wie z.B. im Abwurfwinkel, in der Abwurfschnelligkeit, im Knie- und Ellbogenwinkel, in der Griffdistanz, und in der Reihenfolge, in der die Spitzengelenkszentrenschnelligkeit erzielt wird. Da die diagnostizierten technischen Fehler die Wurfdistanz bedeutend beeinflussen, müssen sie während des Trainingsprozesses korrigiert werden.

Schlüsselwörter: *Speerwurf, kinematische Analyse, die Olympischen Spiele*

Introduction

A relatively large number of authors have analyzed various release conditions in javelin throw (e.g., Ariel et al. 1980; Teraudus 1975, 1978; 1985, Ikegami et al. 1981; Barlett 1983; Miller and Munro 1983; Hubard 1984, 1987, Gregor 1985, Komi and Mero 1985; Menzel 1986, Lawler 1993, Mero et al. 1994). Despite different approaches and methods of analysis, they all agree that the distance of the throw is generally determined by speed, angles and height of the javelin at the moment of release.

Some of these studies are done on top athletes, performing the javelin throw at important competitions like the Olympic Games and World Championships. Thanks to them it became possible to compare various athletes with those who are, according to the official results, ranked as the best in the world.

The purpose of this study is to compare javelin release characteristics performed by a single athlete, with those performed by the best male throwers at the Olympic Games in Barcelona (1992).

Methods

The subject of this study was a Croatian javelin throw champion, ranked between best 20 in the world. His basic anthropometric measures and analyzed throw length parameters are presented in Table 1.

Table 1.

Height	196 cm
Weight	115 kg
Age	29
Analyzed throw	75.5 m

The subject was videotaped during training in a preparation period of current year periodisation. The biomechanical analysis of his best throw was made with the purpose to discover the shortcomings in throwing technique, and consequently, according to collected results, to help make suggestions for possible changes in his training.

The performance has been recorded by two VHS video cameras operating at 60 frames per second, positioned in such a way as to provide a 3-D analysis. Among twelve successful attempts, the best throw (75.5 m) was subjected to further analysis. The collected video images were digitized using APAS (Ariel Performance Analysis System). The coordinates of 18 points, defining the 14-segmental model of human body, plus 3 points for describing the javelin, were manually processed for each frame of the movement. Transformation into 3D space was made by DLT (Direct Linear Transformation) method (Abdel-Aziz and Karara, 1971). The obtained 3-D coordinates of the digitized body and the javelin parts were then filtered using Cubic Spline smoothing method. The smoothed coordinates were used to calculate different kinematic parameters necessary for the comparison with the best javelin throwers from the Olympic Games in Barcelona 1992, described by Mero et al. (1994).

Results and discussion

Model for comparison

Mero et al. (1994) have analyzed throws of 11 javelin finalists at the 1992 Olympic Games in Barcelona. Their basic anthropometric and throw length parameters are described in Table 2.

Table 2.

PARAMETER	M	SD	Min	Max
Height	1.88	0.03	1.84	1.96
Mass	95.9	7.2	80	105
Age	26.0	3.2	22	.31
Analyzed Throw	80.47	4.21	75.5	88.18

Means (M) and standard deviations (SD) for numerous kinematic parameters describing the moment of javelin release have been calculated on the sample.

The comparison of parameters (some of them are presented in Table 1) gathered on the subject of this analysis with those calculated in Olympic finalists is presented in Table 3.

Figure 1

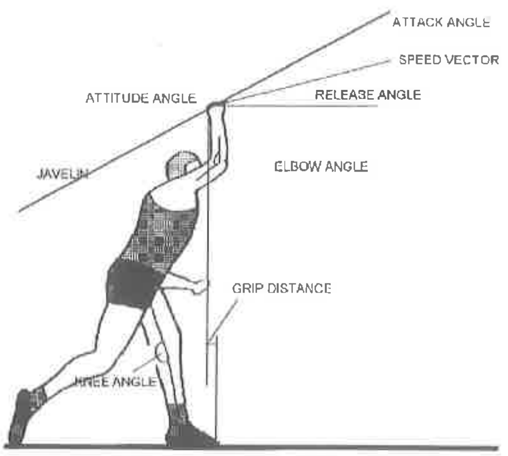


Table 3.

Parameter	M	SD	HR
Release angle	32	3	27**
Attitude angle	31	6	28
Attack angle	-1	6	2
Horizontal speed (m/s^{-1})	23.9	0.9	20.9**
Vertical speed (m/s^{-1})	14.9	1.5	13.7*
Resultant speed (m/s^{-1})	28.3	0.9	25.3**
Time: first contact - double support (ms)	221	22	217
Time: double support - release (ms)	135	12	133
Elbow angle at the beginning	124	14	93**
Elbow angle minimum	80	12	78
Elbow angle at release	123	16	140**
Knee angle at the beginning	178	4	175*
Knee angle minimum	165	7	146**
Knee angle at release	168	8	150**
Grip height at release (cm)	181	0.04	186**
Grip distance at release (cm)	34	0.16	58**
Resultant speed of CG during release (m/s^{-1})	3.1	1.0	317
Vertical speed of CG during release (m/s^{-1})	1.0	0.5	0.14**
Peak hip center speed in final contact (m/s^{-1})	7.7	1.0	4.81**
Peak shoulder center speed in final contact (m/s^{-1})	9.1	0.5	7.37**
Peak elbow center speed in final contact (m/s^{-1})	15.4	1.3	11.0**
Peak wrist center speed in final contact (m/s^{-1})	20.9	1.4	17.9**
Peak hand center speed in final contact (m/s^{-1})	23.5	1.7	20.9**
Time: peak hip speed (ms)	16	12	83**
Time: peak shoulder speed (ms)	56	25	33**
Time: peak elbow speed (ms)	83	21	66**
Time: peak wrist speed (ms)	121	19	133
Time: peak hand speed (ms)	127	20	133

* = $p<0.05$; ** = $p<0.01$

Results and discussion

The main difference between the throw performed by the subject and the throws performed by Barcelona 1992 Olympic Games finalists is in the length of the throw, 75.50 m versus 80.47 m. (Tables 1 and 2). Since the distance of the throw is basically determined by speed, angles and grip height at release, those parameters will be discussed in further analysis.

Release speed

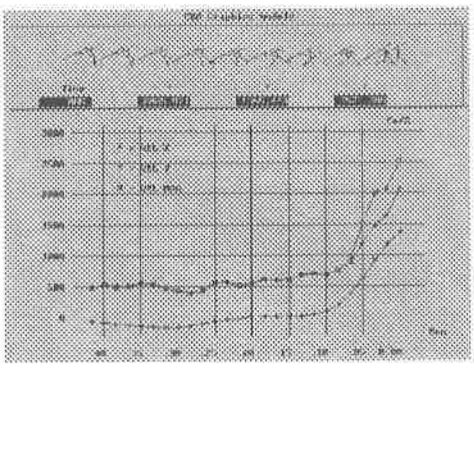
There is no doubt that release velocity has the greatest influence on length of the javelin throw. In other words, release velocity should always be maximized while the values of other factors should be optimal.

In case of this analysis there are great differences in horizontal and vertical speed of javelin at release, as well as in their resultant vector. They were all significantly (p) lower then those measured in Olympic finalists (Table 3). The horizontal speed of the analyzed throw was 20.9 m/s^{-1} compared to 23.9 m/s^{-1}, vertical 13.7 m/s^{-1} compared to 14.9 m/s^{-1}, and resultant speed was 25.3 m/s^{-1} compared to 28.3 m/s^{-1}.

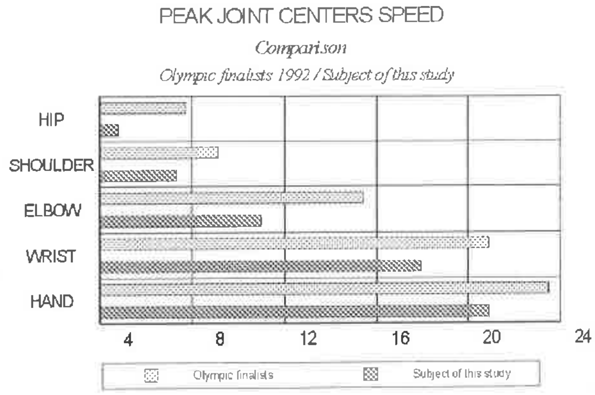
Since high release speed values are determined by great accelerations and velocities of the body kinetic chain in an attempt to find possible shortcomings in throwing technique, further analysis is necessary in order to check those parameters. In javelin throw, the body kinetic chain operates from bottom to the top, from feet to the hand. By bracing the lower parts of the body, great energy accumulated by approach is transferred to the upper parts of the body, causing them to accelerate. After that, by bracing the upper parts of the body the energy is transferred to the lower arm, hand and the javelin, which causes further increase of velocity. The whole system can be checked through peak CG and joint centers speeds in final contact. In our case there were no significant differences in the approach CG speed between our subject and Olympic finalists. Even the timing of the first contact to double support and the double support to release showed no difference (Table 3). But the peak joint centers speed in final contact were different (Table 3, Graph 2). All the speed values of the analyzed throw were significantly lower.

Obviously the kinetic chain of our subject was not efficient enough. The reason for that could be searched for in the timing of the peak joint centers speed. Namely, following the logic of the kinetic chain functioning, it could be expected that those speeds will reach the peak in the following order: hip, shoulder, elbow, wrist, hand. Such orderly progression in peak speeds from proximal to distal segments is necessary for delivering the kinetic energy from larger body segments to the javelin. This order has been actually achieved by the Olympic finalists. The peak hip speed was produced 16 ms after the double support had been established, shoulder after 56 ms, elbow after 83 ms, wrist after 121 ms and peak hand speed after 127 ms. That order changed significantly in the throw which is the subject of our study. The peak joint centers speed was reached in order that cannot provide an efficient energy transfer (Table 2, Graph 3.). The main problem was obviously in a very late achievement of peak hip speed, even later then shoulder and elbow. In other words, the bracing of the hip was too late, causing pour energy transfer, and thus affecting the release speed of the javelin.

Graph 1.



Graph 2.



Another reason for low release velocities could be found in significant difference in grip distance at release (Figure 1, Table 2). In the case of our subject that distance was much longer (58 cm) than it should be compared to the model from the Olympic Games (34 cm). It means that our subject has not used the whole possible path for energy transfer.

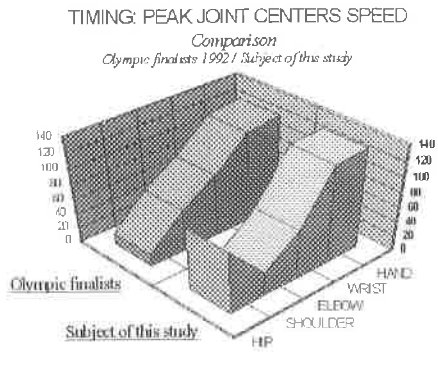
Release angles

As mentioned previously, release angles also greatly influence the length of the javelin throw. In the case of our subject the attack and attitude angles (Figure 1) were not significantly different. However, the release angle of our subject (27) was much smaller then the same angle in the Olympic finalists (Table 3).

The reason for this could be searched for in the comparison of angle characteristics in, for this event, two crucial joints, knee and elbow (Figure 1).

At the beginning of the final support phase the angle of the subject's knee was very similar to the model. But afterwards, the minimum knee angle was mach smaller (146 compared to 165). At the end of this phase, at the moment of release, the knee angle was still significantly

Graph 3.



smaller then in Olympic Games finalists (150 compared to 168). Obviously, the analyzed subject went "too much down" during the final support phase, enabling himself to reach the correct body position in the release. That error also caused the low vertical CG speed in release.

The angle changes in our subject's elbow joint were also different fom the ones in Olympic finalists. At the beginning of the final support phase the angle was significantly smaller (93 compared to124). The minimum was almost the same, but at the end of this phase, the angle was significantly bigger (140 compared to 123). Such angle caused a hand movement which was more of the "pushing" then of the "throwing" type. Although it was an obvious technical mistake, in the case of our subject, due to small knee angle at release, it was necessary to achieve a better release angle.

Grip height at release

The grip height at release is the third significant factor influencing the length of the javelin throw. Since the subject of our study is much taller (196 cm) than the average finalist from the Olympic Games (188), significant difference in grip height was expected (186cm compared to 181 cm). That difference could have been even bigger if our subject had used a proper knee flexion/extension technique.

Conclusion

The comparison of the javelin throw performed by the subject of this study with the model based on data collected on 11 finalists at the Olympic Games (Barcelona, 1992) showed significant differences in numerous parameters. Basically, the discovered technical shortcomings could be explained in five points:

- Low knee minimum and knee release angle in final support phase.
- Changes in elbow angle which suggest a more "pushing" then "throwing" type of movement.
- Low release angle.
- Long grip distance at release ("early" type of release)
- Exemption of orderly progression in peak speeds from proximal to distal segments.

Since those technical errors significantly influence the length of the throw, they must be corrected during the training process, in an attempt to achieve a longer length of the throw.

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