A PROCEDURE FOR DETERMINING THE ACCELERATION PHASE IN JAVELIN THROWING

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INTRODUCTION

The throwing phase begins with the last left foot contact (for right throwers) and finishs with the delivery of the javelin, therefore, this phase corresponds to the last double feet contact. According to the majority of the authors, this period is divided in two parts. During the first one, the thrower turns the hips and shoulders consecutively through the longitudinal axis of the trunk. while, the javelin should remain to the rear so that the right shoulder, the upper arm and the elbow move upward-forward. At last of this part, an "arched position" must be reached (Koltai, 1985). In according to Koltai (1985), during this first part a muscular activity helps to strech the muscles located around the right shoulder, chest and the abdominal area. This eccentrical contraction will provide a firm base for the action of those muscles concerned with the acceleration phase. In according to Ikegami (1981), the kinetic energy of the thrower's body obtained during the approach run may be stored as an elastic energy in the earlier part and then released to accelerate the javelin in the later part.

The acceleration phase starts with the "arched position" and finishs with the javelin release. The energy is restored beginning by the trunk and following by the upper arm, under arm and javelin. During this period, the javelin gains the greatest amount of velocity; Miller (1983) measured that 50% of the release velocity is achied during the final 0.04-0.05 s prior to release.

Although, it seems that "arched position" is one of the most important factor in the javelin throwing, it has not been found in the literature information about the "arched position" in javelin throwing which can be used for estimating this position with accuracy. However, in other throwing skills, like in overarm pitches baseball, the throwing phase is stated in the beginning of the upper arm internal rotation.

Therefore, the objective of this work is to develop an upper limb model for calculating the instant in which the "arched position" is occurred. This instant will be considered like the moment in which the maximum external rotation of the upper arm is produced. The theorical model must be compatible with photogrammetric experimental techniques.

METHODOLOGY

Theorical model. It's based in an upper limb mechanical model composed by the next items (Figure 1):

i) Upper arm. It's a rigid solid defined by two points: shoulder and elbow joints.

ii) Under arm. It's a bar defined between the elbow and wrist joints.

iii) Elbow joint. It's joint with one degree of freedom.

The mechanical model is completed with the algorithm for calculating the "arched position" instant. The steps are the next:

i) A local reference system fixed with the upper arm is determined so that the XZ plane is defined for the shoulder, elbow and wrist joints when they are not aligned. Thus:

$$j = ((r_7-r_8) \times (r_9-r_8))/^3(r_7-r_8) \times (r_9-r_8)^3$$

$$k = (r_7-r_8)/^3 r_7-r_8{}^3$$

$$i = j \times k$$

ii) The z component of the angular velocity is obtained through the next expression:
$W_Z = -(dj/dt)$_k
iii) The "arched position" time is calculated like the instant in which the $W_Z = 0$, that is, the moment when the upper arm changes the rotation direction passing from external ($W_Z < 0$) to internal ($W_Z > 0$) rotation.

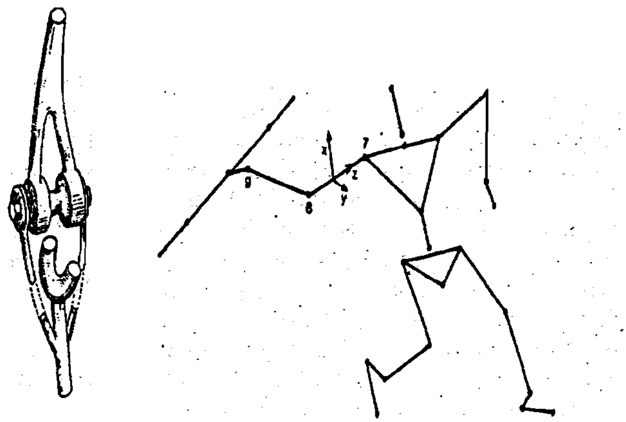

Figure 1. Mechanical model of the arm.

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Experimental technique. The experimental technique was the photogrammetry. The subjects were the two best spanish throwers. A total of 36 throws were analyzed. The distance range was 58-68.9 for subject A and 59-66 for subject B. Two cine-camaras were used at a frame of 200 H_Z. The three-dimensional co-ordinates of the 26 points which defined the body model were obtained using DLT algorithm. After computation of the thrower's center of mass coordinates, the data were smoothed and the velocities calculated using quintic splines (based on Woltring, 1986).

An computer program was develop for obtainning the variables. This program took the interpolated and smoothed co-ordinates (x,y,z) of the markers like data input and calculated the z component of angular velocity using the preceding model. After, the instant in which $W_Z = 0$ was estimated. The output was composed for the z component of angular velocity time functions graphs and some temporal parameters such as the acceleration phase time.

RESULTS AND DISCUSSION.

Figures 2 shows the angular velocity time function of a throw. A same pattern of upper arm internal-external rotation has been found for all the analyzed throws. This pattern shows that during the first part, the upper arm moves to external rotation while in the next moves to internal. Therefore, the existence of an instant which can be considered like the acceleration phase beginnning has been proved.

The average acceleration phase time for subject A was 0.06 s (SD = 0.004, n= 16) that is 45.4% (SD= 3.7, n=16) of throwing phase time. The subject B performs 0.065 (SD= 0.001, n= 20) and 41.2% (SD= 2.8, n=20) respectively.

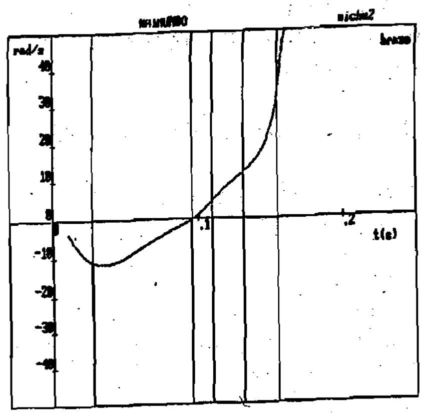

Figure 2. z component of angular velocity of the upper arm function time (Subject A).

CONCLUSIONS.

1. An experimental procedure has been developed which allows to calculate the acceleration phase time.

2. In objective criterion for determining the "arched position" is provided.

3. An upper arm model for determining the angular velocity about the longitudinal axis is presented.

REFERENCES.

Bartlett, R.M. y Best, R.J. (1988) The biomechanics of javeling throwing: a review. J. Sports Sci. **6(1),** 1-38.

Best, R.J., Bartlett, R.M. y Morris, C.J. (1993) A **three-dimensional** analysis of javelin throwing technique at the 1991 world student games. J. Sports Sci. **11(4),** 315-328.

Feltner, M.E. y **Dapena,** J. (1989) Three-dimensional interactions in a **two-segment** kinetic chain part I: general model. Int. J. Sport **Biomech. 5(4),** 403-419.

Ikegami, Y., **Miura,** M., **Matsui,** H. y **Hashimoto,** I. (1981) **Biomechanical** analysis of the javelin throw. En Biomechanics VII-B, **(Editado por Morecki,** A. y Fidelus, K.), University **Park** Press, Baltimore, 271-276.

Koltai, J. (1985) Javelin. En Athletes in action: the official IAAF book on track and field techniques, **(Editado por** Payne, H.), **s.n.,** London, 263-293.

Miller, **D.I.** (1980) Body segment contributions to sport skills performance: two **constrasting** approaches. Res. Q. **Exerc.** Sport. **51(1),** 219-233.