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INTRAINDIVUAL VARIABILITY OF THE MOVEMENT PATTERNS IN EXPERT HANDBALL THROWERS

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The aim of this study was to compare players' intra-individual variability in the throwing movement pattern in support, throwing to the four corners of the goal, and in the presence of the goalkeeper in handball. Four players from the Spanish first division participated as subjects, plus seven goalkeepers. The start of the goalkeepers' movements was recorded from a force platform with a frequency of 500 Hz, while the throw was videotaped by two video cameras synchronized at the same frequency with the force platform. The variability in the movement pattern faked the goalkeepers. The kinetic chain is proximal-distal (P-D) a temporal sequence orientated to reduce the stress in the joint of the shoulder. The inertia of the trunk reduced the time of execution and determined the instant of throwing depending on the goalkeeper´s movements.

KEY WORDS: Kinetic chain, proximal-to-distal sequence, handball throw

INTRODUCTION: Even for the javelin throw, where the only aim is to achieve the maximum distance, elite throwers demonstrate higher intra-individual variability than less experienced young throwers (Barlett et al., 1996). These changes in the movement pattern of highly skilled javelin throwers have been considered as a functional variability that allows them to adapt to environmental changes, or are related to injury prevention (Bartlett et al., 2007). Thus, it seems clear that this functional variability becomes particularly relevant when the throw is made in tasks that are influenced by the action of an opponent, such as tennis, baseball, badminton, handball etc. where it may be a compensation mechanism or very effective strategy for achieving the objectives of the throw or hit (Dicks et al., 2008). Therefore, in these one-on-one situations, the interaction between the thrower and the opponent must have a significant influence on the variability of movement patterns used by the thrower.

Schorer et al., (2007) have considered the existence of a set of patterns in handball throw, determined by the direction of release and where the thrower can use two types of strategies to mislead the goalkeeper: 1) use different movement patterns to throw in a specific direction and 2) use the same movement pattern to throw in different directions. However, this option requires the movement pattern to be modified at some point to aim the ball in the desired direction.

This research establishes a strategy closer to reality, linking possible changes in the throwing pattern to the goalkeeper's movements, and expecting the variability of movement patterns used for each throw direction to increase as a result of the uncertainty provided by the goalkeeper's presence.

In the light of the above, this paper has the objective of the detection of the intraindividual variability in the movement pattern the thrower uses for ten-meters throws aimed at the four corners of the goal.

METHODS: The participants, four specialists' throwers (24±1 years, 1.86±0.05 m and 86.36±6.13 kg) and seven goalkeepers, were team-handball players, belonged to first division teams in the Spanish League. The study was approved by the institution´s ethics

committee and carried out under its ethical guidelines, all participants signed informed consent.
Accepting the suggestions made by Button et al., (2006) and Bartlett, et al. (2007), about the best methodology for analysing the variability and structure of movement patterns, we decided to use an intra-subject rather than an inter-subject design. Each player made 35 throws to the four corners of the goal in blocks of 5 to the different goalkeepers, with the objective of avoid tiredness. Finally 27 throws were chosen for analysis eliminating the throws that went out of the goal. In all cases the thrower's dominant side was his right side and the directions of the throws were: a) the top right hand corner of the goal (RH), b) the bottom right hand corner of the goal (RL), c) the top left hand corner of the goal (LH) and d) the bottom left hand corner of the goal (LL).
The four field players were instructed to throw after a run 10 m from the goal, in a zone previously delimited by a reference system of 2.32 x 1.58 x 2 m, with the sole of the front foot firmly on the ground, seeking to obtain maximum velocity when releasing the ball and adjusting the throw to the corners of the goal. Despite the restrictions of the experimental situation, we tried to reproduce the real situation. Thus, the throwers were told that they could make their usual moves before throwing, as well as changing direction during the throw if they considered it opportune. Throws were considered valid where the thrower threw the ball at the goal, including the posts and the ground delimiting it.
We used a force platform (Dinascan /IBV Valencia, Spain) 0.8 x 0.8 m, assembled to a wood platform, situated in line with the centre of the goal and one metre in front of the shooting zone. The throws were filmed using two high-speed digital video cameras, Redlake MotionScope PCI 1000S (San Diego, CA), at a frequency of 500 Hz, situated on the thrower's dominant side at 25 m from the geometric centre of the shooting zone and 30 m apart. This same frequency was used to record the reaction force coming from the force platform. To synchronize the two cameras and the force platform, an electronic signal was used to activate the start (Figure 1).

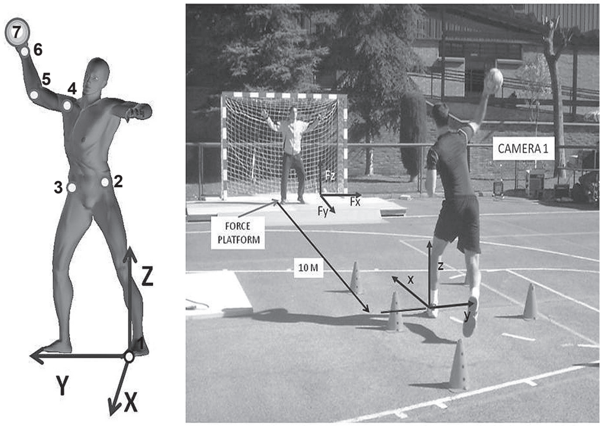

Figure 1: Representation of the experimental set-up used to collect data and the seven points digitized.

The calculation process was conducted in three phases: a) the positions of the seven points were digitised from images from two high speed video cameras at a frequency of 125 Hz; b) the direct linear transformation method and c) quintic spline functions were applied to the spatial coordinates obtained in the previous phase to smooth and interpolate them at the same frequency at which they were filmed (500 Hz). To determine the instantaneous tangential velocity of the ball at the approximate time of its release (Vt (RELEASE)), which occurred between two consecutive images (a time interval of 0.002 s) the first time-derivative of the quintic spline functions was used.

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RESULTS: The mean velocity at the instant of release from the thrower's hand (Vt (RELEASE)) obtained in all the throws analyzed was 24.57±1.76 ms^{-1}. The time taken to make the throw varied between 183±16 ms for thrower 2 and 237±23 ms for thrower 3, the average of all throws being 206±30.3 ms.

The maximum speed of the elbow, shoulder, wrist and ball for each throw and direction were calculated for each thrower. Figure 2 is a typical graph of the thrower´s variability, it shows the speed graphs for participant 1, at the top of the figure the maximum speed for the joints an ball, and the moment in which the joints and ball reach the maximum velocity related to ball release (time = 0) is represented at the bottom of the figure.

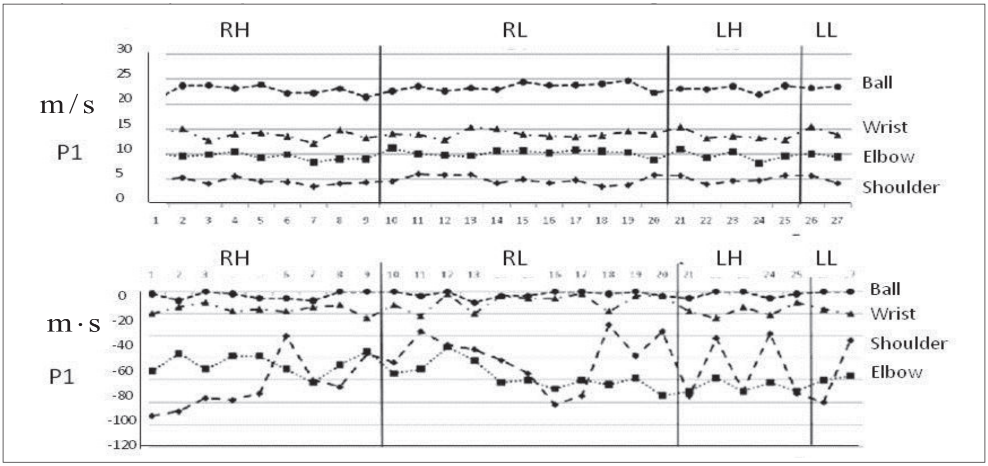

Figure 2: Typical graphs of the maximum velocity (top) of the joints and ball and moment related to ball release (t=0 (bottom)).

In all the cases there is revealed that the increase of the maximum tangential speed produces from more proximal joint to more distal (figure 2). The major increase takes place between the data of the wrist and the geometric center of the ball. It might associate this increase with the transfer of angular impulses typical of the kinetic sequential chains (Putnam, 1993), though, observing the times in which his maximum tangential speeds take place, they might be considered to be coincidental.

The time data corresponding to the shoulder possess a relatively high variability. In some throws, the shoulder reaches his maximum tangential speed nearer to the release that the elbow, breaking the model expected from the time sequence of the kinetic chain proximal-distal (P-D).

DISCUSSION AND CONCLUSIONS: The increase of the tangential velocity registered between the wrist and the geometric center of the ball is explained for the important contribution of the internal rotation of the shoulder (Van de Tillaar and Ettema, 2004; 2007; 2009). Considering the existence of a certain flexion of the elbow, when there takes place the internal rotation of the shoulder, the tangential speed of the wrist and of the geometric center of the ball, they would be related directly to the angular velocity and the distance to the axis of rotation. This information coincides with Van de Tillaar and Ettema (2004), which reveal that the flexion of the wrist contributes very little in the increase of the speed of the ball, and the function of the wrist is related with the precision of the throw.

Attending to the segmental contributions, typical of the kinetic sequential chains P-D in the throw, the angular accelerations of the trunk produce a certain angular impulse and the setback of the contiguous segments. At the same time, there is an external rotation of the shoulder and flexion of the elbow, with the consequent stretching of the implied musculature. Later, there would take place the internal rotation of the shoulder and the extension of the elbow, close to a certain transverse adducing of the shoulder. As a result of it, the forces of

reaction would produce in the shoulder a reduction of his tangential speed (Jöris, van Muijen, Schenau and Kemper, 1985).
The thrower does not need an excessive acceleration of the shoulder to initiate the kinetic chain P-D (from the shoulder to the ball). The time of execution is reduced and allows him/her to choose the beginning of the sequence of throw depending on his/her position and the movement of the goalkeeper. The thrower could begin the kinetic chain with a light rotation of the trunk and decide in which moment accelerate the shoulder, during this rotation, false accelerations or movements could make faking the goalkeeper. Besides the tactical commented advantages, the fact that the setback of the distal segments (specially the external rotation of the shoulder) takes place from a relatively small acceleration of the shoulder, it might be related to prevent injuries in the shoulder.
It is observed that not in all the throws there is a temporal anticipation of the maximum tangential speed of the shoulder with regard to the elbow (Figure 2), which indicate the existence of a intraindividual variability in the throwing pattern of movement. This variability is made of an adaptative capacity that the very expert players acquire with the intention of cheating the goalkeepers, to reduce the time of execution or to avoid injuries.

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