167 - TEMPORAL ORGANIZATION OF ARM MOVEMENTS IN ACCURATE THROWS

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INTRODUCTION

Open kinematic loop movements are usually featured by a proximal-to-distal sequence of limb segments, so that a distal segment is moved only after the adjacent proximal segment has reached its highest velocity (PUTNAN, 1991; ANDERSON & SIDAWAY, 1994). Such a sequence allows one to optimize production of fast movements of the most distal segment, making it appropriate for high performance on ballistic actions (PUTNAN, 1993; OKAZAKI et al., 2006). Due to its mechanical efficiency, a proximal-to-distal movement organization might be potentially useful for movements requiring accuracy also. The rationale for this proposition is that by using such a temporal organization an individual would minimize the demands of force production in the most distal segment, favoring this way the production of accurate movements. As previous results have shown that movement velocity and movement variability are inversely related (SCHMIDT et al., 1978, 1979; TEIXEIRA, 1999, 2000), a proximal-to-distal movement organization might be the sequence of joints motion naturally selected by expert performers at tasks requiring accurate movements. This issue was investigated in expert basketball players in the situation of free throw shooting.

METHODOLOGY

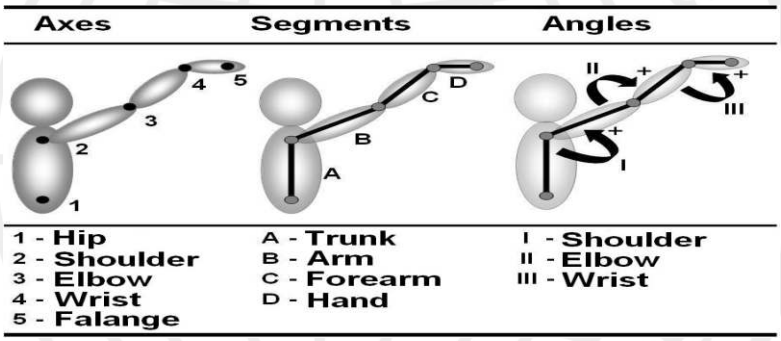
Sample

Non-professional right-handed players (n = 15) from university first men's basketball team volunteered to participate in this study, after signing an informed consent form. Their average age was 24.1 years (SD = 6.1), with average time of systematic basketball training of 10.6 years (SD = 4.8).

Experimental Procedures

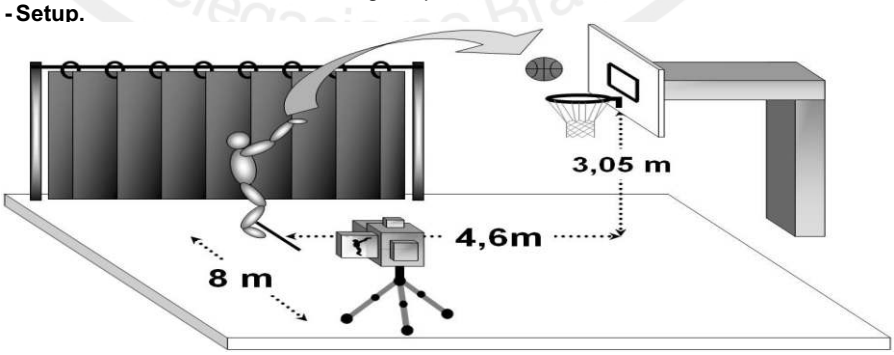
These participants performed the jump shooting from the free throw position to a regular game basket (3.05 m high and 4.6 m far from the throwing position), performing the action with their right arm. In order to analyze arm extension movements in the main propulsive phase of the action, reflective markers were affixed on the following points: (1) iliac crest; (2) shoulder joint centre (approximately 5 cm bellow the acromium); (3) humeral lateral epicondile; (4) stiloid process of the ulnae; and (5) joint axis of the fifth phalange (figure 1).

Figure 1 - Biomechanical Model.



Movements were recorded through a Panasonic camera (Palmcorder - VHS), positioned 8 m far from the participants on their right hand side, perpendicularly to the main plane of the movement (figure 2). Participants performed 10 trials, from which 3 successful trials were assorted for analysis. Images were analyzed through Geeware Motion Analysis System (Beta version) and manually digitized. The kinematic landmark considered in the analysis was peak angular acceleration, for movements at the shoulder, the elbow and the wrist. Peak angular acceleration was used as the reference for the moment of the most important participation of each joint in the action. Data were smoothed by using a recursive fourth order Butterworth filter with a cutoff frequency of 10 Hz, and then normalized as a function of total movement time through a spline function.

Figure 2 - Setup.



RESULTS

Temporal movement organization is presented, showing average relative time of peak acceleration regarding movement time of arm extension and standard deviation in parenthesis, for each inter-joint coordination pattern observed. A single case was found of synchronous activation, with the shoulder flexion (M = 0.71, SD = 3.21), wrist flexion (M = 0.71, SD = 7.55), and elbow extension (M = 0.71, SD = 4.51) reaching peak acceleration at the same time. Four participants showed a different pattern, with the elbow leading the sequence (M = 0.57, SD = 13.90), followed by the shoulder (M = 0.78, SD = 5.46) and finishing with the wrist action (M = 0.82, SD = 4.84). The predominant sequence of joints motion, observed in 10 participants, was elbow extension first (M = 0.55, SD = 14.67), wrist flexion second (M = 0.76, SD = 8.35), and shoulder flexion third (M = 0.88, SD = 5.95). None of the participants moved their joints in a proximal-to-distal sequence.

DISCUSSION

The results revealed a temporal organization in the free throw shooting different from the proximal-to-distal sequence frequently found in throwing for distance. Considering the observed modes of inter-joint coordination, it is apparent that in precision throwing arm joints play different roles. In order to perform accurate movements, two global components must be controlled in an integrated way, e.g., launching force and ball's release angle. In the observed predominant pattern, for example, the main movement phase of the launching component was found to be initiated earlier by the action of the elbow followed by the action of the wrist, which correspond to joints able to apply force on the ball in the direction of the spatial target. The release angle, determined by the shoulder position, seems to have been specified later in the movement execution, with peak acceleration taking place only at 88% in average of the extension phase of the movement. These results suggest that the launching component preceded the positioning component in movement temporal organization of most participants. A corollary of this observation is that the propulsive force seems to be specified in anticipation to the future arm position determining the ball's release angle when accuracy is the main requirement in the action. This interpretation is consistent with previous findings by Elliott (1992), since for this task the proximal-to-distal pattern of inter-joint coordination was observed for longer but not for shorter distances. Thus, the elbow-wrist-shoulder sequence seems to be the predominant mode of coordination in expert throwers in situations requiring more accurate movements like in free throw shooting.

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TEMPORAL ORGANIZATION OF ARM MOVEMENTS IN ACCURATE THROWS

ABSTRACT

Temporal organization of arm movements was assessed in expert basketball players while performing an accurate throw (free throw). Kinematic analysis indicated that the predominant sequence of peak acceleration was the elbow extension first, followed by wrist flexion, and shoulder flexion last, at relative times of 0.55, 0.76, and 0.88, respectively. These results suggest that in proficient throwing performance organization propulsive forces are specified in anticipation to the future arm position determining the ball's release angle. KEY -WORDS: Temporal organization, accurate throws, basketball shoot.

TIR DE BASKET-BALL ET TAILLE DE JOUEURS

RESUMÉ

Organisation temporelle des mouvements du bras a été évaluée au cours d'experts joueurs de basket-ball, en exécutant fidèlement jeter (lancer). Cinématique analyse a indiqué que la principale séquence d'accélération maximale a été l'extension du coude en premier, suivi par le poignet en flexion, la flexion et à l'épaule dernier, par rapport au temps de 0,55, 0,76 et 0,88, respectivement. Ces résultats suggèrent que, dans la maîtrise des performances de lancer l'organisation des forces de propulsion sont spécifiées en prévision de l'avenir de déterminer la position du bras le ballon angle de la libération.

MOTS CLES : Organisation temporelle, Accurete jeter, tir de basket-ball.

EL TIRO DEL BALONCESTO Y ALTURA DE LOS JUGADORES

RESUMEN

La organización temporal de los movimientos del brazo fue analizada en los jugadores del baloncesto expertos mientras que realizaba uno lanzamiento de precisión (tiro libre). El análisis cinemática indicó que la secuencia predominante de la aceleración máxima era la extensión del codo ocurriendo primero, seguido por la flexión del puño, y por último la flexión del hombro, con el tiempos relativos de 0.55, 0.76, y 0.88, respectivamente. Estos resultados sugieren que en la organización perita del lanzamiento las fuerzas propulsabas eran especificadas antes a la posición del brazo que determinara el ángulo del lanzamiento de la bola.

PALABRAS-CLAVES: Organización temporal, lanzamiento de precisión, lanzamiento del baloncesto.

ARREMESSO NO BASQUETEBOL E A ESTATURA DO JOGADOR

RESUMO

A organização temporal de movimentos do braço foi analisada em arremessadores de basquetebol experientes enquanto desempenharam arremessos de precisão (lance livre). A análise cinemática indicou que a seqüência predominante no pico de aceleração ocorre primeiro na extensão do cotovelo, seguida pela flexão do punho, e por último pela flexão do ombro, com tempos relativos de 0.55, 0.76 e 0.88, respectivamente. Estes resultados sugerem que a organização temporal das forças propulsivas no desempenho do arremesso são especificadas antes do posicionamento do braço para determinar o ângulo de arremesso.

PALAVRAS-CHAVE: Arremesso de Basquetebol, Estatura, Coordenação Motora.