COORDINATION OF BASKETBALL SHOOTING MOVEMENT OF DIFFERENT SKILL LEVEL PLAYERS

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Shooting baskets requires a multi-segment coordination. How basketball players control the multiple joints in order to perform accurate and stable shots is an important issue in basketball training. The purpose of this study was to investigate the characteristics of the movements during basketball shooting for players of different skill level and at different distances from the basket. The goal is to gain a better understanding of the shooting movement. Three basketball players of different skill levels participated in the study. Starting from the penalty line, each participant had to perform 6 shots at 20 cm increments at a distance of up to 200 cm behind the 3-point line. Sixteen active LEDs were placed on the joints of the participants to examine the kinematic characteristics of the shooting movements. The results show that the lower limbs are responsible for the shooting distance whereas the movements of the upper limbs are related to fine tuning of the shooting movements. The results also support the hypothesis of freezing and freeing degrees of freedom at different skill levels in multiple degrees of freedom tasks. A temporal characteristic of the basketball shooting movement is also identified for all shooting distances.

KEY WORDS: coordination, degrees of freedom, basketball, shooting

INTRODUCTION: One important question of human motor coordination and control is how to differentiate a good vs. poor coordination. Bernstein (1967) suggested that novices freeze segments to constrain themselves in order to control their body easily when performing a multi-segment movement, but skilled performers can free their degrees of freedom as they wish. For example, for a skilled marksperson, a slight deviation of the shoulder movement will be compensated with an appropriate wrist movement in order to maintain an accurate aiming performance while the unskilled ones tend to freeze all the arm joints therefore a small deviation of the shoulder movement will be amplified at the wrist (Arutyunyan, Gurfinkel, & Mirsky, 1969).
Basketball shooting is a very important skill in winning basketball games. However, even in high level games, the shooting average of a skilled shooter is rarely approaching 80 percent. Although there are many factors influencing the shooting average, the shooting movement may be the most important and most fundamental factor affecting the shooting results. Basketball shooting movement involves a multi-segment control, the shooter needs to arrange the several segments of the body spatially and temporally in order to achieve an accurate shot. The purpose of this study was to investigate the characteristics of the shooting movements of different skill level players at different shooting distances in order to better understand the shooting movement.

METHOD:

Data Collection: A Phasespace motion capture system was used to collect 3-D data. Sixteen active LEDs were attached to the metatarsophalangeal (little finger), wrist, elbow, shoulder, hip, knee, ankle and metatarsophalangeal (outside of shoe) of both right and left sides of the participants. Twelve cameras were used for data collection. After sufficient time to warm up, the participants shot the baskets form in 21 systematically chosen positions. These positions start at the penalty line, and increase at increments of 20 cm from there. Total distance of participants moving was 400 cm. For every position chosen 3 clean shots for every participant were required, then they went to the next position. Participants completed two directions (far to near and near to far) thus a total of 6 clean shots per position per participant were recorded.

Data Analysis: Among all the trials collected, only the 6 clean shots from each position were analysed, resulting in total of 378 shooting movements from the 3 participants. The angular velocities of the six joint angles (right ankle, right knee, right hip, right shoulder, right elbow, and the right wrist) were derived from the collected 3D data using mathematica 5.1. Regression analyses and the Pearson Product correlation analyses among the joint anlges were performed using Sigma Plot 8.0 and SPSS 11.5.

RESULTS: Using the 3-point line as the seperator, the 21 positions were divideded into two parts (first part included positions 1 to 11, second part included positions 12-21). The shooting averages from the 3 participants showed a superior performance for participant 1 who is currently a professional basketball player in Taiwan. All 3 participants had better shooting averages for the first part (from penalty line to 3-point line) than the second part (from the 3-point line to 2 meters behind the 3-point line, see Table 1).

Table 1. Shooting averages (%)of each part for the 3 participants

				Participants				
	1			**2**			**3**	
1st	2nd	total	1st	2nd	total	1st	2nd	total
73.38	54.06	63.72	69.98	41.32	55.65	62.96	35.65	49.30

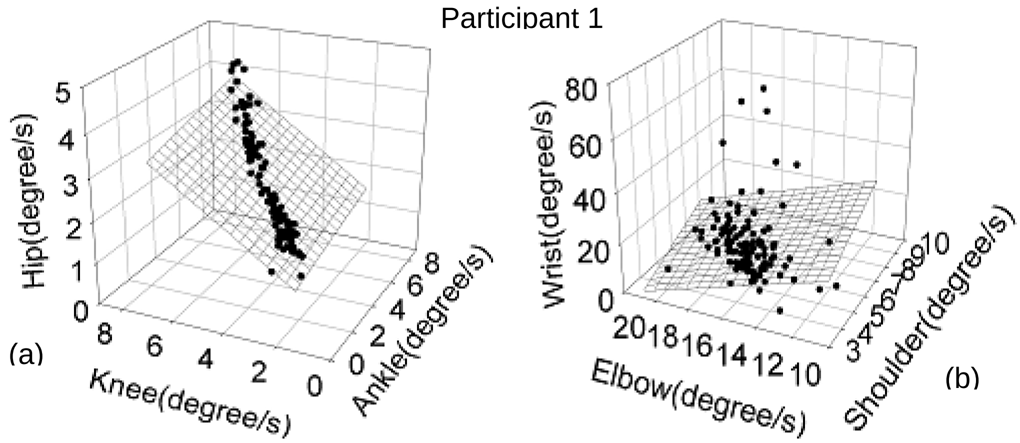

Figure 1: 3-D scatter plot and the linear model of the lower body joints (a) and upper body joints (b) for participant 1.

The maximal angular velocities of the six joints were divided into upper body (wrist, elbow and shoulder joints) and lower body (hip, knee and ankle joints). A 3-D linear model ($Z = a + bX + cY$) was used in the regression analysis for upper and lower body. The resulting goodness of fit (R^2) values from the 3-D fits were submitted for paired t-test, and the result shows a significant different structure between the upper (mean=. 07, sd=. 06) and the lower (mean=.66, sd=.18) bodies, t_5 =6.856, $p < .05$ (see Figure 1). Further investigating the structures of the upper body movements, the Pearson product-moment correlation of each pair of the maximal angular velocity of the upper joints from all 3 participants were derived. All 3 participants had significant correlation for the shoulder-elbow pairs, the professional player also showed slight tendency of elbow-wrist correlation for the first part (p=. 07). The other 2 participants had significant correlations for elbow-wrist, and shoulder-wrist pairs in the second part (see Table 2).

Table 2 Coefficient of correlation of peak angular velocities of upper trunk

	Participants					
	1		**2**		**3**	
	1st part	2nd part	1st part	2nd part	1st part	2nd part
Shoulder-Elbow	0.74**	0.67**	0.83**	0.85**	0.812**	0.72**
Elbow-Wrist	-0.23*	-0.19	-0.13	0.24*	0.01	0.42**
Shoulder-Wrist	-0.17	-0.12	-0.19	0.29**	0.03	0.33**

Note: * p<. 1; ** p<. 05.

The sequences of the maximal angular velocity of each joint were also analysed (Figure 2). The data show that the maximal angular velocity of the hip joint occurred first. Using the time when the hip maximal angular velocity occurred as the start point, the lags from the start point to the time when the maximal angular velocity of each joint occurred were compared using a mixed design 2-way (11 or 10 position X 6 joint) ANOVA. The results show that the duration of the entire movement decreased along the increment of shooting distance, and the lags for shoulder and elbow did not differ significantly for all positions except for the 2nd part for the professional player. The 2 non-professional players also show a tendency of synchronizing the maximal angular velocity of the hip and knee joints. The general order of the appearance of the maximal angular velocity follows the sequence of hip, knee, ankle, shoulder-elbow, and wrist (see figure 3).

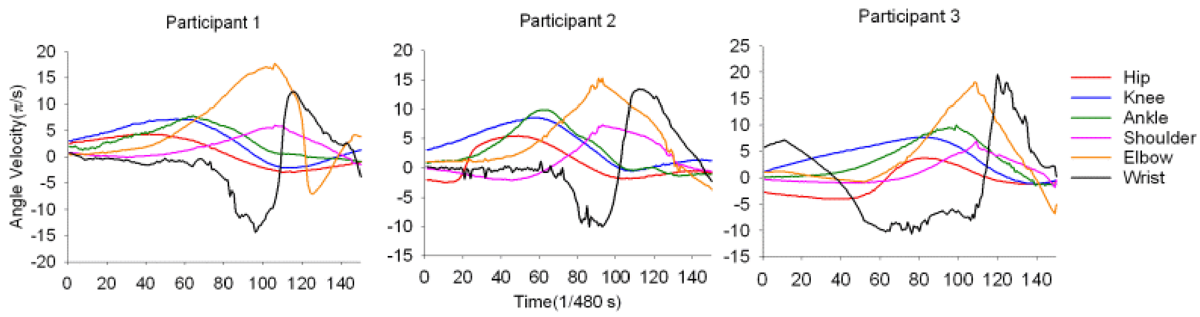

Figure 2: Sample time series of the segmental angular velocity curves from 3 participants.

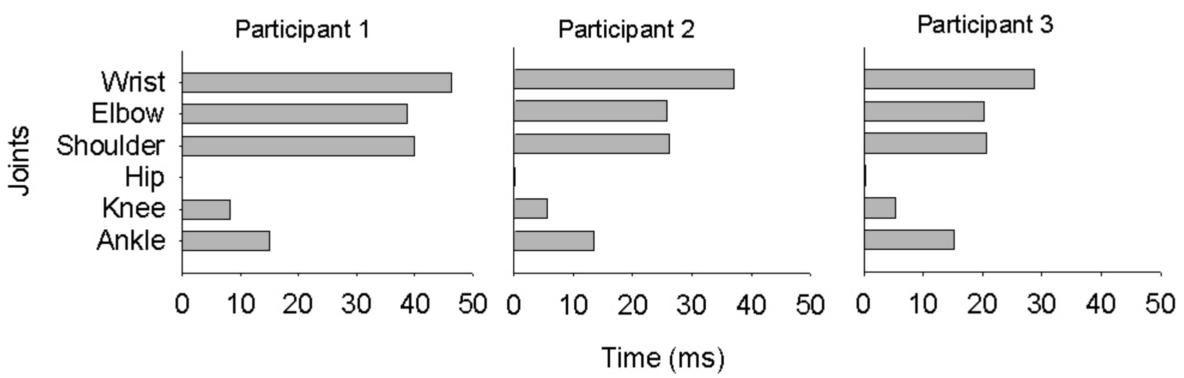

Figure 3: Individual participants' average time to peak angular velocity from the first occurrence of the segmental peak angular velocity of each trial for the 6 joints.

DISCUSSION: From the systematic manipulation of the shooting distance, we observe the tight linear relations among the movements of the hip, knee, and ankle to the shooting distance, whereas the movements from the upper extremity showed little variation with the shooting distance. This suggests that the leg movements are responsible for the shooting distance, and the arm movements are for aiming and fine tuning of the shooting movement. The high r^2 values of the 3-D linear regression on the peak angular velocity of the three lower joints reveal that the three joints' movements were constrained linearly by the shooting distance as the common factor. For the arm movements, the difference between the professional player and the other two participants resides with the relation between the wrist movement and that of the other two joints. The data suggest that for the non-professional players, when the shooting distance is longer than the three-point range, the three joints of the upper extremity tend to lock together whereas the professional player, who also had higher shooting average, seems to have more independent joint movements in the arms.
Regardless of the distance to the basket, the analyses of all the shooting movements reveal a temporal characteristic of the shooting coordination. In general, the peak velocities of the lower limbs occur first, but the sequence within the lower limbs is from top to bottom (hip to knee to ankle). For the upper limbs, the peak velocity of the shoulder and elbow tend to occur together, the peak velocity of the wrist comes last. This temporal sequence of the joint peak velocity may be used to characterize the basketball shooting coordination.

CONCLUSION: The multi-segment movement of basketball shooting can be divided into two parts: lower limbs are responsible for shooting distance and the upper limbs are for fine tuning of the movement to improve accuracy. Highly skilled basketball shooters have little correlation between arm joints indicating more flexibility in organizing the arm movements. Lastly, a temporal characteristic of the basketball shooting coordination is identified in a manner that the sequence of the segmental peak velocity occurs from hip, knee, ankle, shoulder-elbow, to wrist.

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