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ARM MOTIONS FOR DIFFERENT TARGET POSITIONS DURING TAEKWONDO ROUNDHOUSE KICKS

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The purpose of this study was to investigate arm motions for five different target positions during Taekwondo roundhouse kicks. Nine Taekwondo experts performed roundhouse kicks at a target. A 3D motion analysis was conducted. One-way repeated ANOVA was used to compare the arm motion among five conditions. This study reveals that a higher kick needs the increased vertical separation of the right and left arm (elbow and wrist) in release phase. For a longer kick at Body level, elbows should be more vertically apart and wrists should be more horizontally apart in the release phase. Both attackers and counter attackers in Taekwondo athletes can use the arm swing characteristics at different target heights and distances.

KEY WORDS: roundhouse kick, different target position, arm position.

INTRODUCTION: Within a type of Taekwondo roundhouse kick, targeting positions can vary. In sparring, the initial arm motion can be carefully observed to predict the coming kick motion by the opponent and utilized by the kicker for a better performance. Previous studies on Taekwondo roundhouse kick motions have analysed the kicking leg, pelvis, and trunk concentrating on parameters such as time, velocity, and angle of segment (Falco et al., 2009; Kim, Kwon, Yenuga, & Kwon, 2010). A countermovement of the trunk motion was studied as a preparation motion for the kick (Hwang, Lee, & Lim, 2004). As the arm swing of a sprinter is considered to improve performance, a Taekwondo kick also requires an arm swing for a fast and powerful kick. Such a swing will assist the initiation of trunk motion and eventually enhance the final kick. The arm swing along with the initiation motion will be determined by the target position as soon as an attack chance is recognized. This kind of information will improve the athletes' skill for predicting the incoming attack and the kick skill. Previous Taekwondo literature does not provide this information. Thus, the purpose of this study was to investigate the arm motion for five different target positions during Taekwondo roundhouse kicks.

METHODS: Nine Taekwondo experts with right leg preference participated in the roundhouse kick test. Their height, mass, age, and level were 174.2 ± 5.9 cm, 76.2 ± 8.3 kg, 27.0 ± 1.6 years, and 4.0 ± 1.3 dans, respectively. With the approval of experimental protocols, data collection was conducted in the Biomechanics laboratory, at Texas Woman's University. Five different conditions were given by using a double mitt kicking target: Short Face, Normal Face, Short Body, Normal Body, and Long Body. Equal distance was used from Normal distance condition, a comfortable targeting position regarding Long and Short distance. A total of 30 reflective markers were placed on the participant's body and on the target. Each trial was randomly selected. Motion data were collected at a frame rate of 240 Hz using a 10-camera Vicon MX-T10 system (Vicon, Centennial, CO, USA) for the three dimensional motion analysis and the coordinated of labelled trials in Nexus Software Suite were transferred to Kwon3d XP Motion Analysis Suite (Visol, Korea; Version 4.1) in C3D data format for subsequent processing. Raw coordinates were filtered through a fourth-order Butterworth zero phase-lag low-pass filter with a cut-off frequency of 8 Hz. From Figure 1, events were set as Start (initiation of motion), Toe-off (foot off the ground), MKF (maximum knee flexion), and Impact (foot contact to the target). Both arm motions were measured from Toe-off to MKF (release phase) and maximum values of Left-to-right elbow and Left-to-right wrist were obtained in horizontal and vertical direction. All the measured values were

individually normalized with the right and left upper arm length throughout the trunk (100.2 ± 5.9 cm) (% in EEJL).
One-way repeated ANOVA was used to compare the arm motion among five conditions. The comparison between two conditions that were not in common in terms of distance or height was dropped. The Huynh-Feldt adjustment was performed to correct for violation of sphericity. The post-hoc test was conducted using paired t-tests with Sidak adjustment. Alpha was set at 0.05 in all statistical analyses.

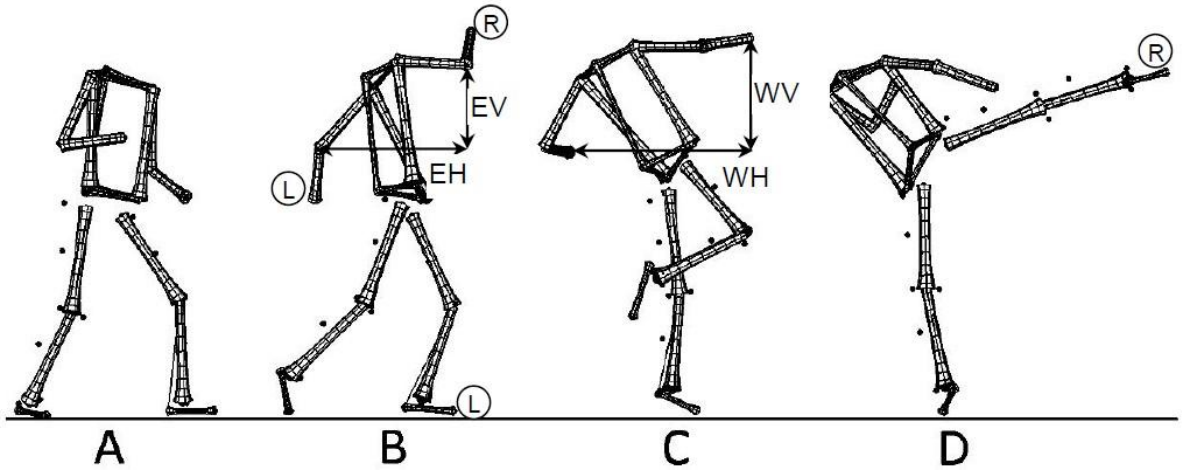

Figure 11 The roundhouse kick: Start (A), Toeoff(B), Maximum Knee Flexion (C), and Impact (D)

RESULTS: The normalized horizontal and vertical data of left-to-right elbow and wrist at maximum were represented in Table 1. Left-to-right elbow in vertical (EV) showed the significance regarding different height at each Short and Normal distance (**S** and **N**) and between Long Body and Short Body (E Left-to-right wrist W izontal (WY) indicated the significance differences at Body level between Normal and Long (**NL**), and Long and Short (**LS**). Left-to-right wrist in vertical (E showed the significance in height difference at Short distance. No significant target difference was found at Face level from elbow and wrist motions. Additionally, elbow motion did not show any significance in horizontal direction.

Table 1
Summary of Arm motion. (N=9; % in EEJL)

Variables	Height	Distance			
Max		*Short*	*Normal*	*Long*	Sig.(p<0.05)
Left-to-right elbow	*Face*	16.5 ± 9.2	19.9 ± 10.5		
in vertical (EV)	*Body*	1.0 ± 8.7**S**	4.7 ± 5.3**N**	10.0 ± 5.5	**LS**
Left-to-right wrist in	*Face*	47.2 ± 26.1	55.5 ± 23.7		
horizontal (WH)	*Body*	54.4 ± 22.0	50.3 ± 26.6	81.2 ± 12.2	**NL**, **LS**
Left-to-right wrist	*Face*	37.8 ± 21.2	38.2 ± 21.7		
in vertical (WV)	*Body*	22.5 ± 18.4**S**	26.4 ± 15.9	21.0 ± 9.0	

Data were presented in mean ± SD format; EEJL = Right-to-left elbow joint length throughout the trunk. ANOVA test comparisons: significant difference (p<0.05) between (**S**) Short Face and Short Body, (**N**) Normal Face and Normal Body, (**F**) Short Face and Normal Face, (**SN**) Short Body and Normal Body, (**NL**) Normal Body and Long Body, and (**LS**) Long Body and Short Body.

DISCUSSION: The purpose of this study was to investigate the arm motion, preparation to kick in the release phase (Toe-off to MKF) for the five different target positions. Among arm

swing motions in Taekwondo roundhouse kicks, a more elevated right elbow above left elbow is associated with higher target positions at both Short and Normal distances (**S** and **N**). Since all kickers are right dominated, the right foot is behind in the release phase while the right elbow is in front heading upwards as a swing motion. In order to perform a kick for Long than Short distance at Body level, relatively higher EV is required. The wrists at Body level should be more horizontally apart to perform a kick in Long compared to Short and Normal condition. WV showed the significant difference at Short (**S**) while not Normal (**N**). But, it still showed large mean difference (11.8 % in EEJL). Wrists also should be more apart vertically to increase kicking height. At Face level, a swing motion does not give any effect regarding the different distance. For the higher kick, right and left arms (elbow and wrist) should be more vertically apart. In order to kick longer at Body level, elbows should be more vertically apart and wrists should be more horizontally apart. Application of this information can be in two aspects;

(1) In order to increase performance level, such swing motions (upper arm and forearm) are informative to the athletes.

(2) Also, the athletes can use the information for the simulation training to predict the incoming motion in sparring.

CONCLUSION: This study reveals that the higher kick needs increased vertical right and left arm (elbow and wrist) separation in the release phase. In order to kick longer at Body level, elbows should be more vertically apart and wrists should be more horizontally apart. The arm swing characteristics in different target heights and distances are informative to both attackers and counter attackers in Taekwondo athletes.

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