Relationship between the sequential movement, muscle co-contraction and kinematic variables of flying disc backhand throwing

In Sub Jeong[1], Woo Seong Heo[1], Gizem Ozkaya[1], Jin Hyun Kim[2], Ki Kwang Lee[1]

Kookmin University, Seoul, Korea[1]

Jeju International University, Jeju, Korea[2]

The aim of this study was to analyse sequential movement of segments and co-contraction index and its correlation with kinematic variables. Disc trajectory and velocity (DV) variables calculated according to the medio-lateral (DOM) and vertical (DOV) displacement. The time differences calculated according to maximum linear velocity of segments from proximal to distal and reported as shoulder & elbow (S-E), elbow & wrist (E-W), wrist & finger (W-F). Co-contraction index (CI) were calculated for flexor and extensor carpi radialis. DV and S-E, W-F, DOM showed correlation which may be caused by the sequential movement of S-E, W-F and the displacement of the disc. Also, there was a correlation between the CI, DOM and DOV. Therefore, decrease of time gap between the segment movements and higher CI may increase the DV effectively.

KEY WORDS: Flying disc throwing, sequential, correlation, Co-contraction Index

INTRODUCTION: Throwing performance reported to affected by the throwing velocity, height and angle of the disc (Hong, Lee, & Kim, 1998). Most of researches has been conducted for air condition around the disc which is visualized through wind tunnel tests (Kase & Ito, 2012; Koyanagi, Seo, Ohta, & Ohgi, 2012; Lukes, Hart, Potts, & Haake, 2014). However, there are few studies about of body movement during throwing (Sasakawa & Sakurai, 2013). Therefore, disc velocity (DV) and movement until disc release moment can be important factors in throwing sports. MUDR influences on trajectory of disc and DV is affected by this trajectory. Joints should be stabilize from start to end of the swing phase (SP) for proper flying disc throwing (Choi, Ha, Kim, & Kim, 2014). It has been reported that co-contraction of muscles reduces unnecessary movement during the learning activities and plays an important role to enhance the stability of the joints. (Di Nardo, Mengarelli, Maranesi, Burattini, & Fioretti, 2015). Optimal DV can be achieved by the segments sequential movements from proximal to distal (Elliott, Grove, Gibson, & Thurston, 1986). The purpose of this study was to investigate the sequential movement of segments and co-contraction index (CI) and its correlation with kinematics variables during flying disc backhand throws.

METHODS: This study has been approved by the Institutional Review Board of Kookmin University. Five male flying disc players (age: 31.2±11.01, height: 173.2±3.56cm, Body mass: 75.4±5.32kg, Career: 4.2±1.64years), from the Korea Flying Disc Federation, voluntarily took part in this study. All of the participants were experienced flying disc athletes with 3-6 year experience. All of the subjects were performed 10 min warm-up session to be able to perform at their competition level. 3D motion analysis was used to record kinematic data (Vicon MX, Oxford Metrics Inc., Oxford, UK) The Vicon's plug-in gait marker set (39 markers) were used and additional 5 markers attached on disc. Kinematic data sampling rate 200Hz. Muscle activity data were collected by a wireless EMG (Delsys Trigno wireless EMG, USA) and recorded at 2000Hz. Two electrodes were attached to the muscle belly according to the direction of the muscle fibers on the wrist flexor (flexor carpi radialis) and extensor (extensor carpi radialis) muscles. The subjects performed 10 throws with disc and instructed to throw as fast as possible in the laboratory. Laboratory dimensions were 11m x 5m and 4 m were given to participants for necessary cross-step before the disc release (Figure 1). Therefore, maximum throwing distance couldn't measure because of the laboratory dimensions. Events and phase were described in Figure 2.

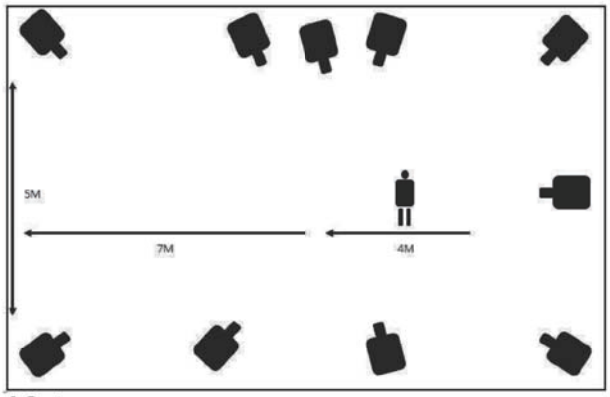

Figure 1 : Experimental Setup

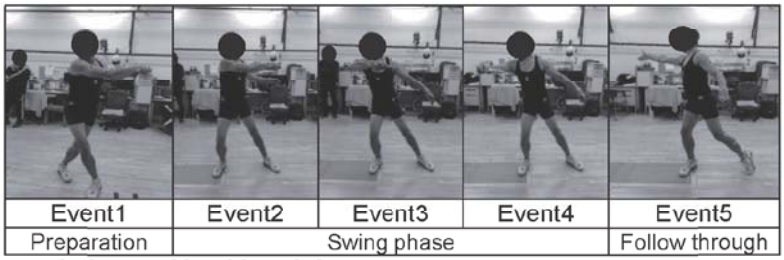

Figure 2 : Event and phase of backhand throws

Time difference of the segment movements calculated as the difference between the maximum linear velocity of the proximal joint and the distal joint linear velocity crossed at the first time for each joint (Figure 2). The time differences were shown at Figure 2 for each proximal to distal joint: a) shoulder-elbow b) elbow-wrist c) wrist-finger.

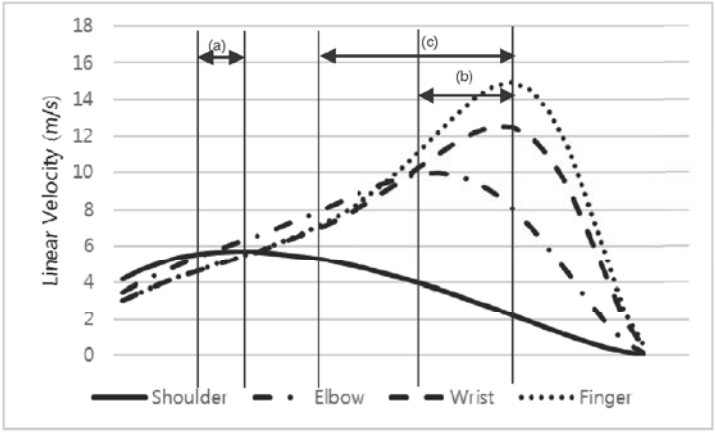

Figure 3 : Example of time gap

Disc trajectory and velocity (DV) variables calculated according to the medio-lateral (DOM) and vertical (DOV) displacement of centre marker of the disc. SPSS Version 23.0 were used for statistical analysis and Pearson's product moment correlation coefficient used to explain the relationship between variables.

RESULTS: Results of the mean and the standard deviation of each variable can be found in Table 1. Table 1 is obtained by analysing each sequential time difference moved to segment (S-E, E-W, W-F) and correlation of maximum velocity of the disc in the swing section during the movement of the backhand flying disc. Table1 analysed the correlation associated with the x-axis variation in disk (DOV) and the variation in the z-axis (DOV) and the Co-contraction index of the lower arm (of the FCR and ECR) in the swing section. As a result, in the Table1, the maximum velocity of the disk, SE (p = .001, r = - .708), WF (p = .007, r = - .377) and DOV (p = 0.026, r = - 315) was revealed a correlation. Table 1 also, Co-contraction index of DOV (p = .003, r =. - 406) and DOV (p = .001, r = -. 629) in the swing section was showed a significant difference in (p <.01).

Table 1
Mean (±SD) of kinematic variables and correlations between variables

	S-E (Frame)	E-W (Frame)	W-F (Frame)	CI (%)	DOM (m)	DOV (m)	DV (m/s)
M ± SD	7.9 ± 4.3	3.3 ± 3.7	9.1 ± 3.7	36.3 ± 11.7	2.1 ± 0.9	1.2 ± 0.5	24.0± 2.7
DV	-.708**	.195	-.377**	.279	-.315*	-.265	1
CI	-.548**	-.060	-.089	1	-.406 **	-.629**	.279
N	50	50	50	50	50	50	50

Note. ** p<.01, * p<.05

DISCUSION: DV showed a negative correlation with S-E, W-F and DOM. Therefore, decreasing of the time gap between the segments and also the medio-lateral displacement of the disc may be helpful to increase the DV. Choi et al. (2014) described the appropriate movement for disc throwing should be achieved to stabilize the joint and move in a straight line which is consisted with our result. Also, Elliott et al. (1986) results were consisted with our results which has been reported that the distal segments have higher linear velocity than the proximal segments. Decrease of the time gap between the maximal linear velocities and the sequential timing of segments increase the ball velocity during baseball pitching (Elliott et al., 1986) (Figure 2). An example of one subject has been showed at Figure 3. Furthermore, DOM should be decreased to increase the DV according to the results. CI also has a negative correlation with DOM and DOV which can be interpreted as the stability of the forearm decreased because of the higher displacement of DOM and DOV. Co-contraction maintains joints stability, extends function of ligaments and distributes rotation of joints and resistance of pressure to joints surface (Di Nardo et al., 2015). Fujii (2007) suggested that forearm only moved on flexion because of co-contraction of wrist flexor-extensors. Therefore, increased CI can provide straight displacement of the disc and positive effect on DV to throw the disc further.

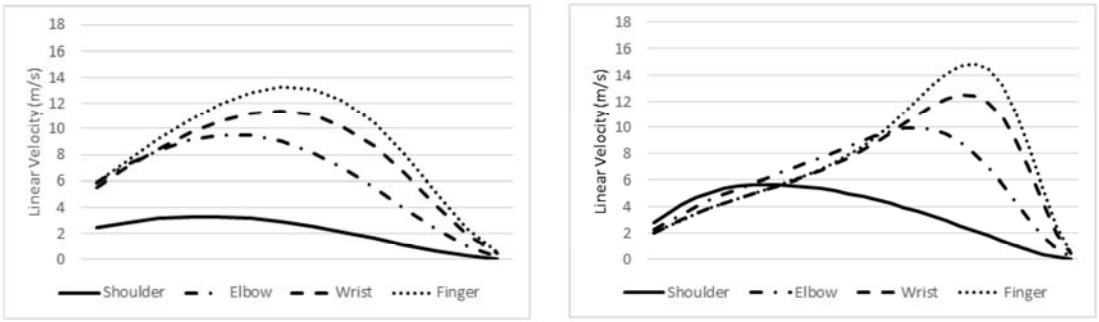

Figure 4: Difference graph of sequential movement of same subject (left:bad, right:good)

CONCLUSION: This study results showed that decreased DOM, DOV should be decreased to maximize the DV. Also, DV can be increased by the higher CI and decreasing the sequential timing between the segments. Athletes should be trained to optimize these variables for better flying disc backhand throwing performance.

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