A QUALITATIVE COMPARISON OF DISC MOVEMENT AND INTER JOINT COORDINATION OF UPPER LIMB IN FLYING DISC FOREHAND THROWING

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The aim of this study was to investigate the characteristics of players according to their experience levels during Flying disc forehand throwing. Two players were recruited for this study according to their experience level (skilled (SP) and unskilled (UP)). 3 dimensional motion analysis were performed to analyse the disc trajectory and inter-joint coordination patterns qualitatively. SP showed greater range of disc trajectory both on horizontal and sagittal plane according to their release point. Coordination patterns showed differences especially on shoulder and wrist joint angles. Disc trajectories and inter joint coordination results can be explained as a result of changes on upper body moments according to the experience level of players. Therefore, these characteristics increase the initial velocity of disc which can affect the disc.

KEY WORDS: Angle-angle diagram, Coordination patterns, Disc trajectory

INTRODUCTION: Disc golf is a flying disc game and the throwing distance of disc is an important factor which can affect the competition performance as well as during golf (Kim, 2013). According to the principle of parabolic, increase in the initial velocity was positively proportional with distance, if throwing height and angle are the same during release. Therefore, the initial velocity of disc is an important factor for performance even though the release parameters are different during every throws. It has been reported that the skilled players showed higher initial disc speeds, therefore higher throwing distances (Sasakawa, 2008; Hay, 1995; Choi, 2014). Forehand (FH) and backhand of the disc throwing are the most basic skills for Flying disc (Sasakawa, 2008). FH throwing is a movement but it is difficult to acquire the appropriate skills to perform. SP(skilled player)s have been showed more smooth movements and higher throwing distances than UP(unskilled player)s (Sasakawa, 2008; Winograd, 2012). Bernstein (1967) has proposed the concept of the coordination and the nature of movement has been changed according to the ability that can take advantage of the degree of freedom. Quantitative analysis of coordination pattern can be made through cross-correlation analysis and angle-angle diagrams (Kim, 2009). Both methods have been used by many researchers, however it has been affected by the linearity of the data and the interpretation of standardized R values (Kim & Lee, 2000). Angle-angle diagrams also have a disadvantage because the interpretation has been made according to the graphs rather than exact values. However, it is helpful to identify the differences easily (Winstein & Garfinkel, 1989). Therefore, the aim of this study was to explain the movement characteristics by angle-angle diagrams and its effects on disc initial velocity.

METHODS: This study has been approved by Institutional Review Board of Kookmin University. Subjects were volunteered two male Disc golf players who are registered on Flying Disc Federation. Subjects classified as skilled (178cm, 70kg, 5 years career) and unskilled (173cm, 75kg, 2 years career) according to their experience level and both subjects were right handed. Subjects performed 3 FH throwing before the actual experiments to perform at their maximum capacity as well as in competition. Subjects were instructed to throw as fast as possible with power grip and cross step. They performed 10 throws with a 30 sec rest period. Disc initial velocity was 27.3 ± 0.8 m/s and 20.2 ± 0.9 m/s for SP and UP, respectively. These results also supported by previous researches in case of increased disc velocity dependent

on skill level (Sasakawa, 2008; Winograd, 2012). Even though, throwing distance is an important factor for performance evaluation, it couldn't be reported because of the laboratory conditions. Only the fastest trials of subjects were showed on the graphs below to prevent the confusion and explain the results more understandable.
A motion capture system (Vicon MX-T40, UK) was used to collect three-dimensional position datas from reflective markers at a sampling rate of 200 Hz. Thirty-nine reflective makers (Plug-in gait) were attached on participants and five were attached on disc. Marker trajectories were filtered using a low-pass Butterworth filter with coutoff frequency of 5 Hz.

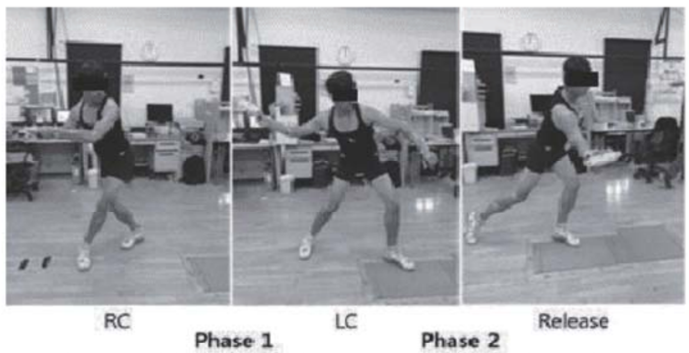

Figure 1: Event and Phase of Forhand throwing

Initial velocity defined as the velocity of the centre marker of the disc at the time of release.
Throwing movement was divided into three event such as RC (Right foot contact), LC (Left foot contact), release (the changing moment of distance between disc and hands). Datas were normalized to 100% for every throws from RC to Release. Disc trajectory diagrams were analyzed according to graphs properties. Horizontal plane graphs were explained according to the range of length (anterior-posterior distance), width (medio-lateral distance), height (vertical distance). Coordination patterns were explained by angle-angle diagrams (Winstein & Garfinkel, 1989) of thorax, shoulder, elbow and wrist joint flexion/extension angle. .

RESULTS & DISCUSSION:

1. Disc movement

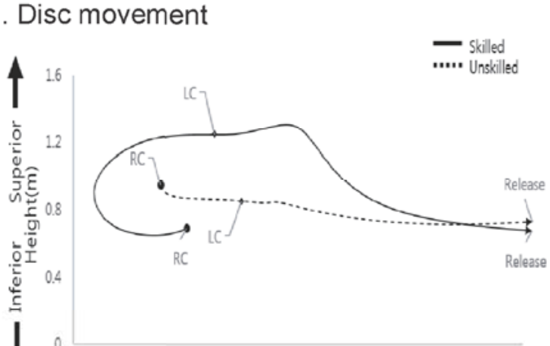

Figure 2: Disc trajectory at sagittal plane

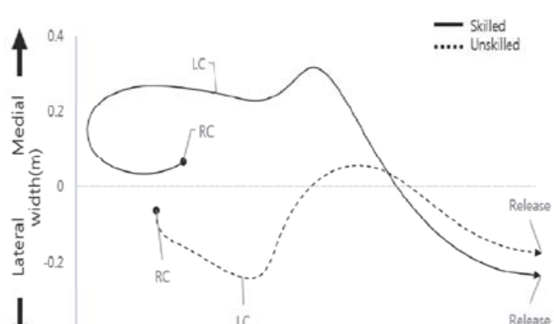

Figure 3: Disc trajectory at horizontal plane

Height of the disc movement was 0.5 m for SP and 0.2 m for UP (Figure 1). Height of the disc movement decreased after the LC for UP, while the SP showed a wave pattern after LC therefore cause an increase on the length. It has been suggested that the increasing the releasing time gives more impulse to baseball ball during pitching (Chun, 2012). Therefore, it can be interpreted that the increased disc intial velocity of SP can be a result of the increased flight distance of disc.

There was differences especially for disc width movement (Figure 2). UP showed a negative slope from RC to LC. However, SP showed more smooth peaks for disc width movement than UP. Choi (2014) suggested the smooth movement of the center of gravity has effect on throwing during Flying disc throwing. Center of mass results didn't reported in this study, however the step length difference of SP (0.33m) and UP (0.05m) can be a indication of center of gravity movement when the disc width graph observed. Center of mass movement can be increased proportionally with the step length. Therefore, higher step length of SP can be interpreted as higher range of center of mass movement which can produce higher moments to throwing the disc further (Ramsey, 2014).

2. Angle-angle diagram

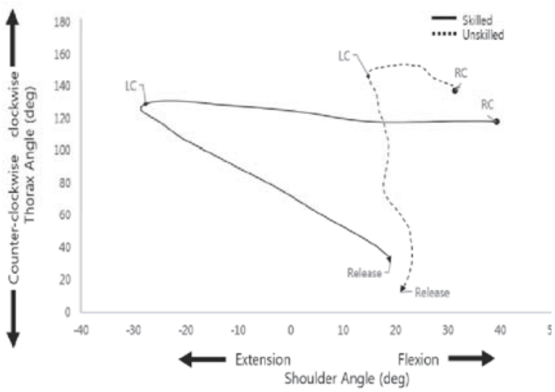

Figure 4: Shoulder & Throax angle diagram

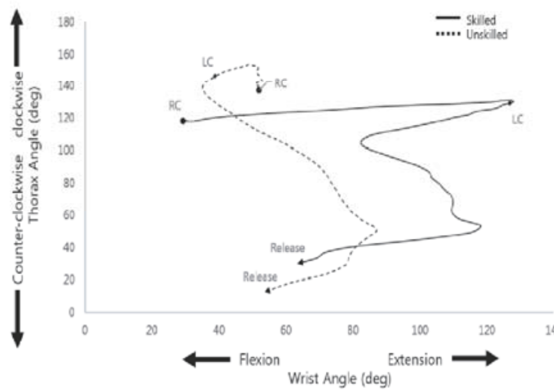

Figure 5: Wrist & Thorax angle diagram

Angle-angle diagram of shoulder-thorax showed that UP showed a mostly horizontal and vertical linear graph (Figure 3). While the SP showed higher range of motion for both trunk and shoulder. UP have a characteristic to depend on trunk movement while the shoulder almost finished its range of motion at the LC. It has been reported that higher range of motion of the arm can produce higher moments which can be a reason to SP developed this movement characteristics (Roach, 2013).

Angle-angle diagram of wrist–thorax also showed that UP relied more on thorax rotation while the SP showed higher wrist flexion range of motion (Figure 4). It is required lift forces needs for the disc to fly in the air and propulsion forces that maintains the rotation of the disc to throw further. Arm swing and snap of wrist can produce needed moment for higher propulsive forces which can explain the SP movement characteristics (Choi, 2014).

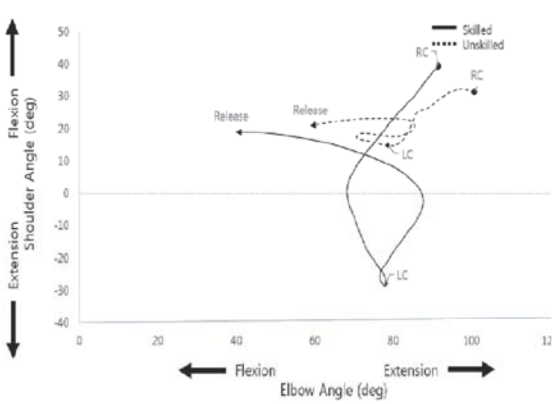

Figure 6: Elbow & Shoulder angle diagram

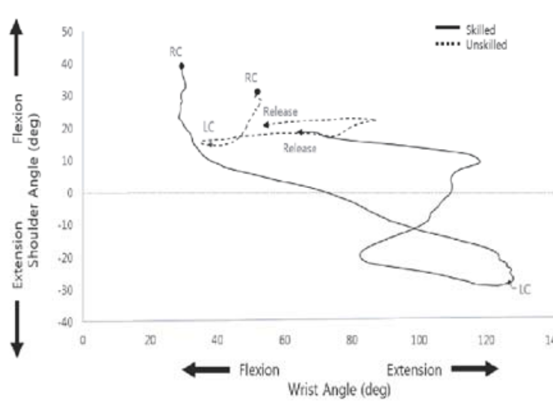

Figure 7: Wrist & Shoulder angle diagram

Shoulder-elbow and shoulder-wrist angle diagrams showed the same patterns (Figure 5, 6). However, SP showed higher range of motions than UP for every joints. According to the angle-angle diagram trajectory, SP has been able to use higher range of motions, reach his possible maximum and switch simultaneously, which is indicate better joint synchronization and intersegmental coordination at specific events (Winstein & Garfinkel, 1989).

CONCLUSION:
There were clear differences of techniques for FH Flying disc throwing according to the experience level. The importance of smooth centre of mass movement from one foot to another has been indirectly commented according to the step length which can be helpful to increase the initial velocity of the disc. Also, upper limb joint range of motion was higher for SP which can be interpreted as important factors rather than trunk rotation for better performance during FH Flying disc throwing. Furthermore, SP has been able to perform their maximum range of motion and showed better inter-joint coordination.

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