TECHNICAL FACTORS REQUIRED FOR PROPER BODY TRANSLATION IN THE DISCUS THROW

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The purpose of this study was to gain knowledge about technical requirement in male discus throwers, specific to their performance level, by comparing the parameters of body translation. The performances of 22 male discus throwers were analyzed. The subjects were divided into the following three groups based on the distance thrown: advanced, medium, and novice. From the results of this study, it can be concluded that the relevant technical requirement for novice is a dynamic shifting of the center of gravity to the left during the first double support phase. Furthermore, pushing into the ground vigorously before push-off the left foot to drive the body toward the throwing direction during the flight phase would enable novice group to create greater momentum and achieve a higher performance level.

KEY WORDS: athletics, three-dimensional analysis, double support phase, flight phase

INTRODUCTION: Complicated movements performed at high speed in a limited space make the discus throw technically very demanding (Hay & Yu, 1995). The event can generally be divided into five phases (Figure 1) (Yu et al., 2002). Generally, the discus throw relies on rotational movement, with most of the angular momentum being generated before the FP (Dapena, 1993) though shifting of the body weight. In addition to the rotational movement, some studies emphasize the linear movement involved in the discus throw. Yu et al. (2002) suggested that a discus thrower should drive his or her body (plus discus system) as vigorously as possible toward the throwing direction during SSP1. Accordingly, to create greater momentum, body translation is crucial for discus throwers. Furthermore, Tauchi et al. (2007) indicated that the most important phase of the discus throw varies depending on the performance level in discus throw; thus, the most important motion would also differ. However, few studies have dealt with body translation or with performance level differences in technical factors among male discus throwers. Therefore, the purpose of this study was to gain the knowledge about performance level specific required technical factors in male discus throwers, specific to their performance level by comparing parameters of body translation. From the results of this study, technical factors in relation to whole body propulsion required for novice throwers would become clear.

METHODS: The subjects of this study were 22 male discus throwers (with personal best throws ranging from 31.92 to 59.21 m). Sixteen of the throwers participated in the 2013 Japan Intercollegiate Championships in Athletics; the other six completed multiple throws specifically for this experiment. The subjects were divided into three groups on the basis of the distance thrown: advanced (51.55 m ± 3.25 m), medium (44.06 ± 1.47 m), and novice (34.23 m ± 1.91 m). Three high-speed cameras (CASIO, EX-F1, Tokyo, Japan) were used to record the throwing motion of each subject at 300 frames/s with a shutter speed of 1/1000 s or 1/2000 s. They were placed behind and on the side of the throwers. The throwing motion of each subject's best performance in the competition or experimental trial was chosen for analysis. Frame-DIASⅣ (DKH, Tokyo, Japan) was used to digitize and reconstruct the coordinate data from video images. The three-dimensional DLT method was applied to collect three-dimensional coordinate data of the endpoints of 15 body segments. The coordinate data were smoothed with a Butterworth digital filter. Cut-off frequencies ranging from 3 to 9 Hz were determined by using the residual analysis. To calculate the velocity of the center of gravity (CGV), the linear momentum and the path length of the center of gravity, the body segment inertia parameters proposed by Ae (1996) was used. One-way non-repeated ANOVA were performed to identify the differences among three groups in dependent measures. The significance level was set at $p<0.05$.

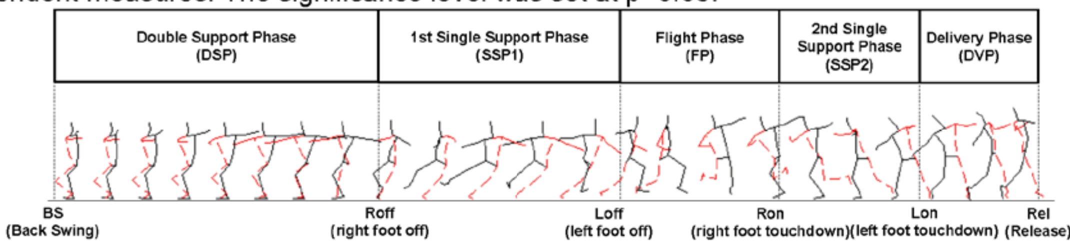

Figure 1: Definition of motion phases

RESULTS: Table 1 shows the mean and standard deviation of height, body mass, and distance thrown. There were no significant differences in height and body mass, but the advanced group threw significantly farther than the other two groups and the medium group threw significantly farther than the novice group.

Table 1
Comparison of parameters regarding physique and distance thrown among the three groups

	All (n = 22)	advanced (n = 8)	medium (n = 8)	novice (n = 6)	Multiple comparison
Height (m)	1.77 ± 0.05	1.79 ± 0.05	1.77 ± 0.04	1.77 ± 0.06	
Body mass (kg)	95.82 ± 11.13	100.75 ± 5.18	90.13 ± 12.11	96.83 ± 13.61	
Distance Thrown (m)	44.10 ± 7.36	51.55 ± 3.25	44.06 ± 1.47	34.23 ± 1.91	Ad > Med > Nov

Note: The differences in distance thrown were significant between all pairs of groups ($p < 0.05$)

Figure 2 shows the mean and standard deviation of CGV and linear momentum at each event for the three groups. With regard to CGV at push-off the right foot (Roff) and push-off the left foot (Loff), the advanced and medium groups were significantly higher than the novice group. They also had significantly greater linear momentum at Roff than the novice group. There was no significant difference in CGV or linear momentum between the advanced and medium groups.

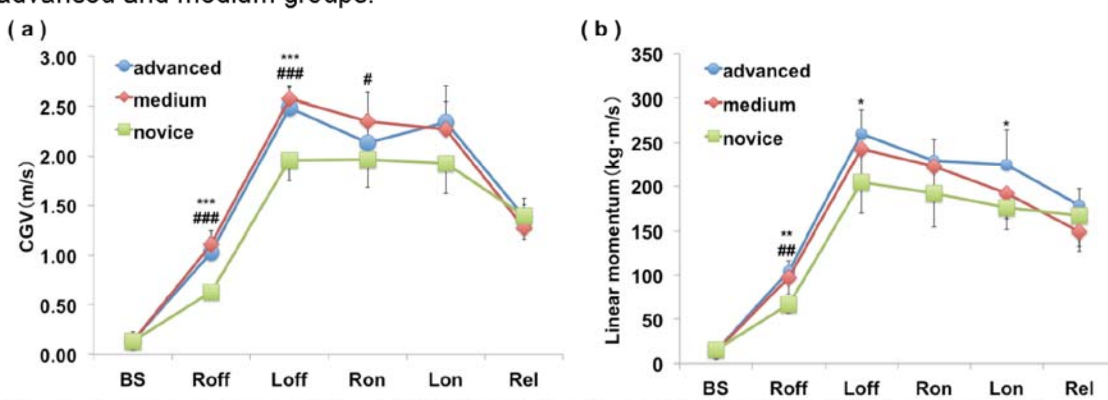

Figure 2: Comparison of the CGV (a) and the linear momentum (b) at each event among the three groups

*Note: * represents statistically significant differences between advanced and novice; # represents statistically significant differences between medium and novice. One symbol (i.e. * or #) means $p < 0.05$; two symbols (** or ##) mean $p < 0.01$; Three symbols (*** or ###) mean $p < 0.001$.*

Figure 3 shows the changes in CGV and linear momentum during the DSP. In both cases, the advanced and medium groups attained significantly greater changes than the novice group; the differences between the advanced and medium groups were not significant.

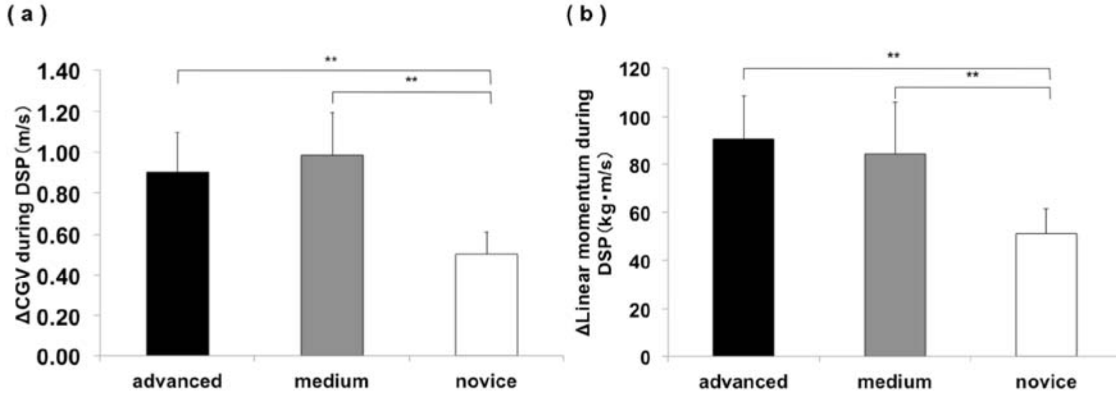

Figure 3: Comparison of the change in CGV (a) and linear momentum (b) during the DSP among the three groups
** Note: * *represents statistically significant differences ($p < 0.01$) between two groups marked (advanced and novice, medium and novice).*

Figure 4 shows the path length of CG through the throwing motion. The advanced and medium groups had significantly longer path length during the FP than novice group. Again, there was not a significant difference between advanced and medium groups.

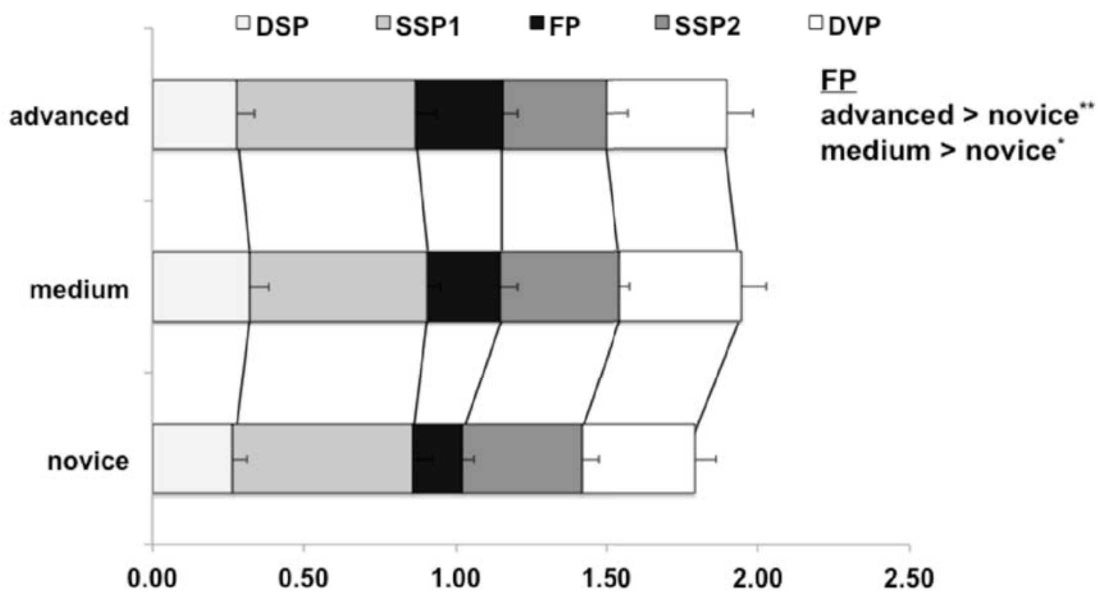

Figure 4: Comparison of the path length of CG among the three groups
*Note: Asterisks denote statistically significant differences; *$p < 0.05$, **$p < 0.01$.*

DISCUSSION: With respect to the parameters in this study, there were no significant differences between the advanced and medium groups. Thus, the factors that enable advanced competitors to out-throw medium competitors are apparently not related to body translation. In addition, since there was no significant difference between the groups in height and body mass, the differences in the movement are likely to influence the distance thrown. The results regarding CGV and the linear momentum, suggest that the advanced and medium throwers may start to increase their body's velocity at the beginning of their motion and then gain linear momentum from their motion. Tauchi et al. (2007) indicated that novices should start their motion slowly in the initial phase so that they can carry out their motion in the last phase appropriately. It is possible that the novices who participated in this study followed thin advice. Moreover, Hay (1985) recommended that it is important for the ultimate success of the throw to adjust the position of the left foot by rotating it toward the throwing direction with a shifting of the CG to the left and over the left foot. Therefore, for novices to create a greater amount of momentum, the dynamic shifting of CG to the left would be effective.

The path length during FP was also longer in advanced and medium groups than in novice group. This result indicates that advanced and medium throwers moved their body farther than novices during the FP. Yu et al. (2002) suggested that a discus thrower should drive his or her body (plus discus system) as vigorously as possible towards the throwing direction during the SSP1. Matsuo and Yuasa (2005) indicated that if throwers could push into the ground and increases their CGV with increasing angular momentum around their CG, they could improve their velocity at release. Based on these considerations, it may be that advanced and medium throwers push into the ground vigorously before L-off and then drive their body farther toward the throwing direction. Considering these results and those of previous studies, the technical requirement for novices would be to push into the ground as vigorously as possible at L-off to drive their body toward the throwing direction during the FP. Mastering these technical skills would be important for them to reach a higher performance level. However, as with beginners, it is necessary to start the motion slowly in the initial phase in order to carry out the motion in the last phase appropriately.

CONCLUSION: The important results of this study are as follows: (1) CGV at Roff and Loff and linear momentum at Roff were significantly larger in advanced and medium throwers than novices; (2) the changes in CGV and linear momentum during SSP1 were significantly larger in advanced and medium throwers than novices; (3) the path length during the FP was significantly longer in advanced and medium throwers than in novices. From these results, it appears that the technical requirement for novices to improve would be a dynamic shifting of CG to the left. Furthermore, pushing into the ground vigorously before Loff to drive the body toward the throwing direction during the FP could enable novices to achieve higher performance levels.

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