COMPARISON OF SUCCESS AND FAILURE TRIALS BY FEMALE DISCUS THROWERS

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The purpose of this study was to investigate the factors that caused poor records of female discus throwers by comparing their success and failure trials in the same competition. Seven female discus throwers were recorded with two video cameras in competition and their trials were analysed by a three-dimensional DLT method. The increase in discus speed from L-ON (the left foot grounded) to REL (discus was released) was smaller in failure trials than in success trials. The horizontal rotation of shoulders and hips from L-ON to REL was smaller in failure trials than in success trials. The upper limb moved towards throwing direction earlier in failure trials than in success trials. The decrease in twist angle of trunk at L-ON is considered to relate poor records in female discus throwers.

KEYWORDS: discus, throwing, success trial, failure trial.

INTRODUCTION: Discus throw is a throwing event of athletics in which a discus of a regulated weight (Male:2.0 kg, Female:1.0 kg) is delivered from a circle of 2.5m in diameter. The athlete throws the discus after one-and-a-half turn as a preparatory movement from the initial stance. The record of this event is determined by the speed, height, throwing angle at release, and aerodynamic factors. The most important factor is the release speed, as many studies pointed out (Bartlett, 1992; Hay,1985; Hay and Yu, 1995). To identify factors that contribute to greater release speed, investigations have been carried out focused on techniques of elite throwers participated in international competitions such as the Olympic Games and World Athletic Championships (Gregor, Whiting, and McCoy, 1985; Miyanishi, and Sakurai, 2000; Yamamoto, Ito, Taguchi, Murakami, Fuchimoto, Tanabe, Endo, Takesako, and Gomi ,2010). These studies have focused on techniques in success trials for skilled athletes. The coaches give advices to the throwers during competitions, which are almost about throwing techniques in failure trials based on observation by eyes and through video (Abe,2006). It is necessary for coaches to compare success and failure trials and to identify faults in techniques for further improvement. Therefore, it would be meaningful and useful for identification of factors and improvement in performance to compare and analyse success and failure trials, especially for non-elite discus throwers. The purpose of this study is to compare and analyse kinematics of success and failure trials in female discus throwers.

METHODS: Seven, right-handed female discus throwers (personal best : 48.72 ± 6.25m ; height : 1.65±0.04m ; weight:71.07±6.71kg), participated in the 120th Nippon Sport Science University Athletic Meet held in Kanagawa, Japan (May. 2021) were captured with two video cameras (AX-700, Sony) from behind and the right (towards throwing direction). The sampling rate of cameras was set at 120 Hz and the exposure time was 1/1000 second. The best and the worst trials in the competition were analysed using the three-dimensional DLT method. Twenty-three points on the body and a point of the centre of the discus were manually digitized from the start of turn to release of the discus by an experienced digitizer with Frame-DIAS (DKH Co. Japan). The release speed of the discus, the centre of gravity of a thrower (COG), rotation angles of shoulders and hips were calculated.

Pearson's correlation coefficient was calculated to investigate relationships between performance descriptors and the records. Wilcoxon test was used to compare parameters for success and failure trials. The significance level was set at 5%.

Definition of success and failure trials: The best trial in the competition was considered as a success trial and the worst trial was considered as a failure trial, in the present study, excluding invalid trials.

RESULTS: Table 1 shows mean and standard deviation of the record, speed of the discus, and several kinematic parameters for success and failure trials.
The record in success trials was significantly greater than in failure trials (p=0.02). The speed of the discus at L-ON in failure trials was significantly greater than in success trials (p=0.03). The speed of the discus at REL in success trials was not significantly greater than in failure trials. The increase in discus speed from L-ON to REL in the success trials was significantly greater than in failure trials (p=0.02). The change in the horizontal shoulder rotation angle from L-ON to REL in failure trials was smaller than in success trials (p=0.04). The change in horizontal hip rotation angle from L-ON to REL in failure trials was slightly smaller than in success trials.

Table 1: The record, speed of the discus and selected kinematic parameters for success and failure trials. (n=7)

		success trials	failure trials	difference
Record	**[m]**	**45.76 ± 6.24**	**42.04 ± 6.41**	**S>F**
Speed of the discus at L-ON	**[m/s]**	**7.00 ± 0.77**	**7.49 ± 0.62**	**F>S**
Speed of the discus at REL	**[m/s]**	**18.48 ± 1.36**	**17.95 ± 1.30**	**n.s**
Increase in discus speed from L-ON to REL	**[m/s]**	**11.48 ± 0.89**	**10.47 ± 1.07**	**S>F**
Change in the angle of horizontal shoulder rotation	**[deg]**	**165.5 ± 10.1**	**145.3 ± 10.4**	**S>F**
Change in the angle of horizontal hip rotation	**[deg]**	**105.2 ± 14.4**	**84.0 ± 13.8**	**n.s**

p<0.05

Figure 1 shows the relationship between the records (success trials, 45.76 ± 6.24 m; failure trials, 42.04 ± 6.41 m) and the increase in discus speed from L-ON to REL in both trials (success trials, 11.48 ± 0.89 m/s; failure trials, 10.47 ± 1.07 m/s). There were significant correlations between the record and the increase in discus speed from L-ON to REL (success: r=0.83, p=0.02; failure: r=0.83, p=0.02).

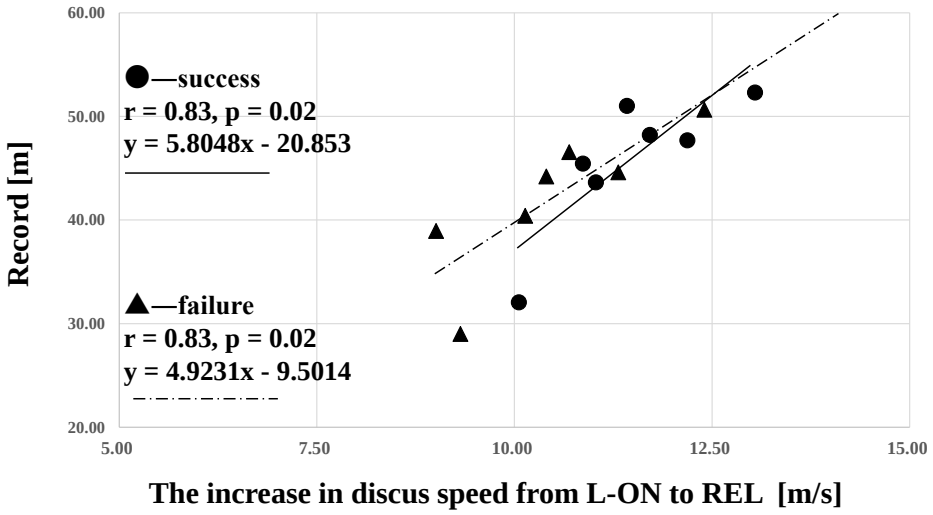

Figure 1: Relationships between the record and the increase in discus speed from L-ON to REL

Figure 2 shows stick pictures of the success and failure trials of a typical case. In her success trial, from R-ON (the right foot grounded) to L-ON, the torso was well twisted because the shoulders rotation was smaller than the hip rotation (shoulders: 106.5±22.1[deg], hips: 116.0±18.6[deg]). In her failure trial, from R-ON to L-ON, the torso was not well twisted as the shoulders and hips were rotated in similar range of motion (shoulders: 127.4±14.8 [deg], hips: 129.6±23.1 [deg]).

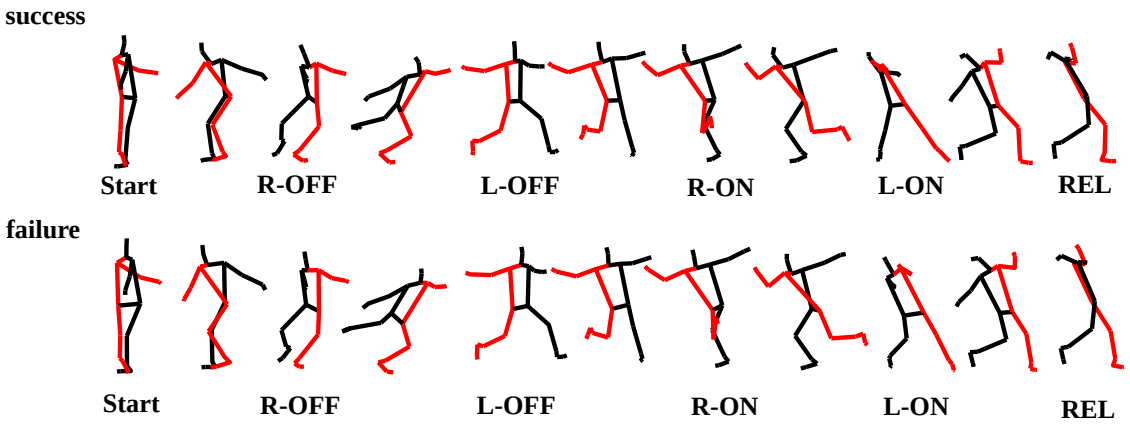

Figure 2: Stick pictures of the success and failure trials of a typical case.

DISCUSSION: There were significant correlations between the record and the increase in discus speed from L-ON to REL both in success (r=0.83, p=0.02) and failure (r=0.83, p=0.02) trials, as shown in Figure 1.

Yamamoto et al. (2008) investigated the relationship between the record and the speed of discus in twelve world-class and eight Japanese male discus throwers and found that the elite throwers had higher speed of discus not only at REL but also at L-ON. However, in the present study, the speed of the discus at REL in success trials was greater than that in failure trials, while the speed in failure trials at L-ON was a faster than in success trials. Therefore, large speed of discus at L-ON would not always mean large release speed of the discus in the present throwers.

The small acceleration of discus speed would result from small horizontal rotation of the shoulders. Yamamoto et al. (2020) implied that the increase in discus speed from L-ON to REL

might be related to the difference in the distance that discus was accelerated. In the present study, it would be considered that the decrease in the angle of horizontal shoulder rotation caused poor record.
Figure 2 revealed that the head and upper limb in failure trial were moving towards the throwing direction earlier before the R-ON than in success trial.
Maeda et al. (2017) showed that the aggressive weight shift to the left foot at the start of the turn (Start) produced a greater speed of COG and improved record. In addition, the increase in the speed of COG at left foot take-off (L-OFF) was resulted in the increase in rotation of the hips (Maeda et al. 2019). In the present study, it seems that the increase in speed of COG from Start to L-OFF in failure trials was smaller than in success trials. As a result, twist angle of the trunk at R-ON in failure trials was smaller than in success trials.

CONCLUSION: Failure trials were caused by small increase in discus speed from L-ON to REL. The reason for this was small change in the rotation of shoulders and hips from L-ON to REL. In failure trial, the thrower could not create enough twist of trunk.
The failure trials seemed to be induced by a poor shift of the COG at the start of turn to the throwing direction at Start-L-OFF.

REFERENCES

Abe, S. (2006) Coach's advice for athletics matches: Journal of Tokyo Women's College of Physical Education. No.41,25-33. (in Japanese)
Gregor, R.J., Whiting, W.C.and McCoy, R.W. (1985) Kinematic analysis of Olympic discus throwers. International Journal of Sports Biomechanics,1(2):131−138.
Hay, J.G. (1985) Track and Field: Throwing.In: Chrzanowski, C.(eds.) The Biomechanics of Sports Techniques (3rd Edition). Prentice−Hall, pp.475−519.
Hay, J.G.and Yu, B. (1995) Critical characteristics of technique in throwing the discus. Journal of Sports Sciences,13(2):125−140.
Maeda, K. Ohyama B.K. Hirose, K. and Ogata, M. (2017) Relationship between parameters related to body translation and the initial velocity of discus in the discus throw. Japan journal of studies in athletics Vol.15-1,35-46. (in Japanese)
Maeda, K. Ohyama B.K. Seki, K. Mizushima, J. Hirose, K. and Ogata, M. (2019) Causal relationships among motion factors for achieving a high release velocity in the discus throw. Japan Journal of Physical Education, Health and Sport Sciences.Vol.64,21-36. (in Japanese)
Miyanishi, T. and Sakurai, S. (2000) Angular momentum analysis of men’s discus throwers in 1998 USA Track & Field Championships. The18th International Symposium on Biomechanics in Sports.
Yamamoto, D. Ito, A. Tauchi, K. Murakami, M. Fuchimoto, T. Tanabe, S. Endo, T. Takesako, H. and Gomi, K. (2010) Kinematics of Discus-Throw in IAAF World Championships in Athletics Osaka 2007. The 11th World Championships in Athletics Report of the JAAF Biomechanics Research Group Performance and Technique of World Class Athletes,189-200. (in Japanese)
Yamamoto, D. Ito, A. Tauchi, K. Murakami, M. Fuchimoto, and Tanabe, S. (2008) Comparison of the discus acceleration movements of the world's best and Japan's best male discus throwers. Bulletin of Studies in Athletic of JAAF Vol. 4, 124-127, 2008. (in Japanese)
Yamamoto, D. Takigawa, H. Nonaka, E. and Murakami, M. (2020) Kinematics of the top three female discus throwers at the 2020 Japanese Championships. Bulletin of Studies in Athletic of JAAF Vol. 16, 207-212, 2020. (in Japanese)

ACKNOWLEDGEMENT: We thank female discus throwers and the Track club of Nippon Sport Science University for cooperation of our videotaping.