THE RELATIONSHIP BETWEEN THE DURATION TIME OF TURN AND THE THROWING RECORD IN THE MEN'S HAMMER THROW

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The aim of this study was to examine the relationship between the duration time of turn and the throwing record. We analyzed the duration time of turn for the 116 men's hammer throwers in the competitions. As a result, significant correlation was observed between the total time of turn and the throwing record ($r=-0.83$, $p<0.001$). In addition, the high correlation was observed especially between the total double support phase time and throwing record ($r=-0.67$, $p<0.001$), compared to the correlation between the total single support phase time and the throwing record ($r=0.29$, $p<0.01$). These results suggest that using the duration time of turn is available for the estimation of the throwing record and shortened the duration time of turn leads to the improvement of the throwing record.

KEY WORDS: turn-speed, DSP time, immediate feedback

INTRODUCTION: The hammer throw is a track and field event. The hammer has a 7.26 kg ball-shaped head to which a cable with a handle is attached (the total length of the hammer is approximately 1.2 m from the ball to the inside of the handle). Dapena (1985) reported that there was significant correlation between throwing record and the initial velocity of the hammer's head. The hammer throwers throw the hammer from the circle with a diameter of 2.135m. They use turn technique to accelerate the hammer head in this restricted space. It can be assumed that the hammer throwers require faster turn speed in order to throw further. However, according to relationships between the duration time of turn and the throwing record was seldom studied in previous researches. Isele and Nixdorf (2010) reported that the average of the duration time of turn was 2.09 sec of seven finalist four-turn throwers in the 2009 world championships. In addition, the range of the duration time of turn was 1.81 to 2.39 sec of finalist in the 1999 world championships (Gutieérrez et al., 2002). These studies targeted world finalist class hammer throwers and their competition levels are relatively close. For this reason, it must be useful for athletes and coaches to clarify the degree of the correlation between the duration time of turn and the throwing record by conducting a research targeted for hammer throwers with a wide range of competition level.

METHODS: We analyzed the duration time of turn for the 116 men's hammer throwers in the competitions. Their range of record was 49.11-85.20m and all throwers use 4 turns. These competitions included the Olympic Games, the World Championships, the Asian/European Championships and the Local Championships. We determined the duration time of turn from recorded movies and downloaded publicly available Internet broadcasts. Frame rates of analyzed movies were 30 to 300 fps. In this study, the minimum value of the frame rate was 30fps. It is concerned that 30fps might be too low frequency to analyse the duration time of turn. However, Isele and Nixdorf (2010) analysed duration of turn with 25 fps. Thus, 30fps is a valid frame rate to estimate the duration time of turn. The duration time of turn is measured from instant of right foot takeoff from the ground in the first turn to instant of release in the last turn. Turn motion was divided into stages by foot contact events. There is a double support phase (DSP) when both feet are on the ground and a single support phase (SSP) when only the left foot is on the ground. Pearson's correlation coefficients were calculated between the duration time of turn and throwing record. The level of statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION: Figure 1 shows the relationship between the duration time of turn and throwing record. Significant correlation was observed between the total time of turn and the throwing record ($r=-0.83$, $p<0.001$). From the result of this study, decrease the duration time of turn leads to the improvement of the throwing record. Dapena (1985) reported that there was significant correlation between throwing record and the initial velocity of the hammer's head. Therefore, in order to estimate the throwing record, the hammer's head velocity is needed. From this study, by utilizing the duration of turn, it would be able to estimate the throwing distance without calculating the hammer's head velocity. In addition, the high correlation was observed especially between the total DSP time and throwing record ($r=-0.67$, $p<0.001$), compared to the correlation between the total SSP time and the throwing record ($r=0.29$, $p<0.01$). These results indicate that the total DSP time is more important component to evaluate the throwing record than that of the total SSP time. The throwers rotate while moving horizontally across the ground in the direction of the throw (Bartonietz, 1990). Bartonietz (2000) reported that hammer's head velocity is increased gradually during turn phases. There is a lot of published research indicated that hammer throwers can accelerate the hammer most effectively while they are in double support (Bartonietz, 2000; Jaede, 1991; Morley, 2003; Otto, 1991; Samozvetsov, 1980; Simonyi, 1980). For these backgrounds, Kriwonossov (1972) and Bondarchuk (1981) noted that the double support phase of each turn should last as long as possible. However, our results indicate that reducing the total DSP time leads to the improvement of throwing record. This may suggest that the high-level hammer throwers accelerate of the hammer head in a short time.

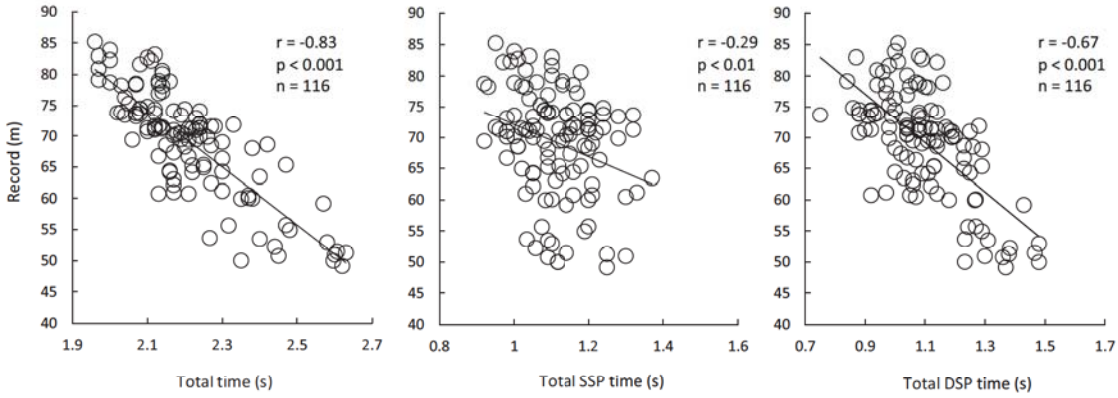

Figure 1 Relationship between the duration time of turn and throwing record

We collected two different competition level hammer thrower. Subject A is an Olympic champion (personal best: 84.86m, range of record: 70.40-84.86m, season: 1996-2013, n=21, frame rate: 30fps) and subject B is an elite thrower in the national level (personal best: 70.46m, range of record: 56.75-70.46m, season: 2010-2015, n=44, frame rate: 30fps). Figure 2 shows that relationship between the duration time of turn and throwing record in the same subjects' multiple attempts. Significant correlations were observed between the total time of turn and the throwing record (subject A: $r=-0.80$, subject B: $r=-0.81$) and the total DSP time and the throwing record (subject A: $r=-0.51$, subject B: $r=-0.79$). In contrast, there were not significant correlations between the total SSP time and the throwing record in each subject. These results indicate that shortening of the total DSP time is related to the shortening of the total time of turn in the individual. The radius of rotation of the hammer throw depends on the length of the hammer and thrower's arm. The thrower who has long arm may turn at a low angular velocity to achieve the same hammer head speed than the short arm thrower. Figure 1 is targeted to the large number of throwers and their physical constitutions may be different. We investigated the correlation in the same subject with no difference in physical constitution

(figure 2). Hence, it is assumed that the shortened the duration time of turn to be an important factor to improve in the throwing record of the individual.

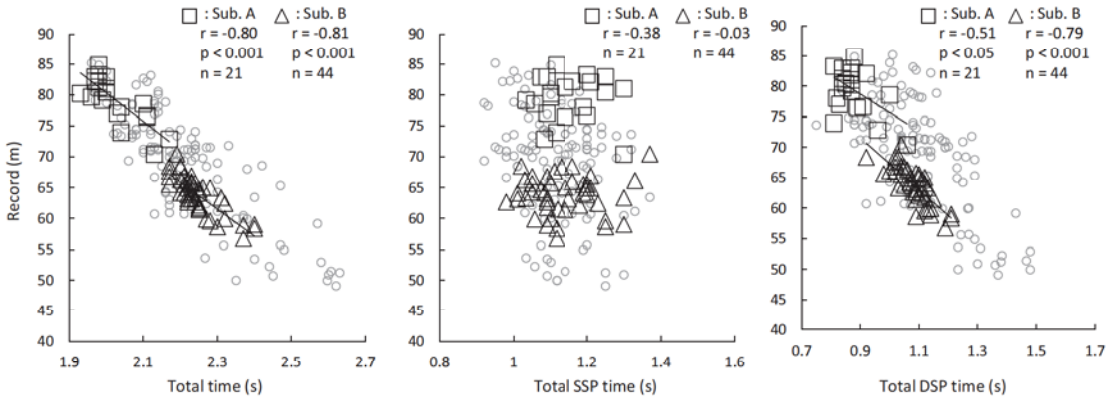

Figure 2 Relationship between the duration time of turn and throwing record in the same subjects' multiple attempts

CONCLUSION: The aim of this study was to examine the relationship between the duration time of turn and the throwing record. As a result, significant correlation was observed between the total time of turn and the throwing record ($r=-0.83$, $p<0.001$). In addition, the high correlation was observed especially between the total double support phase time and throwing record ($r=-0.67$, $p<0.001$), compared to the correlation between the total single support phase time and the throwing record ($r=0.29$, $p<0.01$). These results suggest that decrease the duration time of turn leads to the improvement of the throwing record.

REFERENCES:

Bartonietz, K. (2000) Hammer throwing: Problems and prospects. In Zatsiorsky, V. M. (Ed.), *Biomechanics in sport: Performance enhancement and injury prevention* (4th edition). Oxford: Blackwell Science.

Bondarchuk, A. (1981) Modern trends in hammer throwing. *Modern Athlete and Coach*, 19: 30-32.

Dapena, J (1985) Factors affecting the influences of hammer speed in a throw. In Winter, D.A. (Ed.) *Biomechanics IX-B*. Illinois: Human Kinetics.

Gutiérrez, M., Soto, V.M., and Rojas, F.J. (2002) A biomechanical analysis of the individual techniques of the hammer throws finalists in the Seville Athletics World Championship 1999. *New Studies in Athletics*,17: 15-26.

Isele, R. and Nixdorf, E. (2010) Biomechanical Analysis of the Hammer Throw at the 2009 IAAF World Championships in Athletics. *New Studies in Athletics*, 25: 37-59.

Jaede, E. (1991) The main elements of modern hammer throwing technique. *Modern Athlete and Coach*, 29: 16-19.

Kriwonossov, M. (1972) J. Gamski throws the hammer. *Yessis Review*, 7: 65-99.

Morley, M. (2003). Hammer throwing: The turns, Part 1. *The Coach*, 16: 21-25.

Otto, R. M. (1991). A kinematic analysis of Yuriy Sedikh's world record hammer throw. *Modern Athlete and Coach*, 29: 3-7.

Samozvetsov, A. (1980) Acceleration of the hammer. In Jarver, J. (Ed.), *The throws*. Los Altos: Tafnews Press.

Simonyi, G. (1980) Notes on the technique of hammer throwing. *Track and Field Quarterly Review*, 80: 29-30.