RELATION BETWEEN RELEASE PARAMETERS AND THROWING DISTANCE OF THE JAVELIN THROW

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The present study undertook three-dimensional examination of release parameters and throwing distances, in order to understand the initial flight characteristics of the javelin throw. 57 right-handed javelin throwers were investigated. The measured throwing distances ranged from 45.25 m to 87.17 m. The elite throwers had a tendency to significant positive correlation between theoretical distance and initial velocity of javelin release. Throwers who achieved throwing distances of over 70m were observed to have throwing distances that were shorter than their theoretical distances, while those whose throwing distances were under 70 m group displayed throwing distances that were longer than their theoretical distances. When the data were applied to initial velocity of javelin release, it was equivalent to 26 m/s.

KEYWORDS: javelin throw, release parameters, correlation.

INTRODUCTION: The javelin throw is one of the throwing sports included in track and field events. The javelin is long, thin, and light (total length: 2.6-2.7 m, diameter: 0.025-0.03 m, weight: 800 g). Javelin throwers are requested to adjust not only internal factors, such as release speed of javelin but also adjust for external factors, such as wind speed and direction, in order to achieve longer throwing distances. A previous study examined the relationship between the initial velocity of javelin release (sagittal plane) and throwing distances in elite throwers (Komi & Mero, 1985). In their study of release parameters using the horizontal plane, Bartlett et al. (1996) pointed out that it was difficult to elucidate any relation to throwing distance due to the small sample size used. Murakami et al. (2017) confirmed the relationship between release parameters and throwing distance using the sagittal plane and a large number of subjects. Since the horizontal plane was not investigated in this study, they were unable to identify any detailed initial release parameters that resulted in longer throwing distances. In this study, we aimed to analyze the release parameters in detail, and to clarify the characteristics of flight of elite javelin throwers at the javelin release.

Methods: The subjects were 57 right-handed javelin throwers including some world elite throwers. The throwing distances ranged from 45.25 m to 87.17 m. In this study, data were collected with the consent of the authorities in charge of operating the sporting competitions. The throwing movements were filmed with two cameras positioned at the top of the spectator stands where the event was held. In this research, the specifications of the camera used differ depending on the power supply of the stadium. These cameras were filmed from the side (sagittal) and back (coronal) of the throwing direction. The cameras were set to film at a rate of 200 fps and 60 fps. The three-dimensional coordinates were calculated using the direct linear transformation (DLT) method (200 fps and 60 fps, respectively). Right and left (z-axis) were established by using the y-axis as the vertical direction, and the x-axis as the throwing direction. Calculations of the data were performed as described below. Filtering was conducted using a four-dimensional digital Butterworth filter (4.5-20.5 Hz).
The data consisted of the measured throwing distance, the initial velocity of the javelin, the theoretical distance (distance calculated without consideration of air resistance), the release angle, the attitude and angle of attack on the sagittal plane (XY plane) and the horizontal plane (XZ plane), which averaged about 0.03s after the javelin release. And we also measured the release height. The following formula was used to calculate the theoretical distance:

$$D = \frac{1}{g} V \cos\theta \left[V \sin\theta + \sqrt{(V \sin\theta) 2 + 2gh} \right]$$

Here, *D* is the theoretical distance, *V* is the initial velocity of the javelin, *θ* is the angle of the throw, *g* is the gravitational acceleration, and *h* is the height of the throw. Data on throwing distance and initial velocity of javelin release in this study follows a normal distribution. And, statistical processing of the relation between two variables was performed using Pearson's product moment correlation coefficient. The standard of significance (2-tail) was set at $\alpha = 0.05$.

Results: Significant positive correlation was observed between the throwing distance and initial velocity of javelin release ($r = 0.904$; $p < 0.001$; Figure 1). And significant positive correlation was observed between the throwing distance and theoretical distances. ($r = 0.912$; $p < 0.001$; Figure 1). There was no significant correlation between the release angle and the throwing distance on the XY plane, but a significant positive correlation was found in the athlete of 70 m over on the XZ plane ($r = 0.492$, $p < 0.001$). Although there was no significant correlation between the attitude angle and the throwing distance on the XY plane, a significant negative correlation was found in the athlete of 70 m over on the XZ plane ($r = 0.470$, $p < 0.001$). About attack angle, there was significant negative correlation between the attack angle and the throwing distance on the XY plane ($r = -0.303$, $p < 0.05$), but there was no significant correlation in the athlete of 70m under ($r = -0.414$, $p < 0.01$). Moreover, a significant negative correlation was only found in the athlete of 70m over on the XZ plane ($r = 0.471$, $p < 0.001$).

Discussion: The present results indicated that elite throwers had higher theoretical distances and higher initial velocity of javelin release (Figure 1). We observed a phenomenon in which throwers who achieved throws of over 70 m had actual throwing distances that were shorter than their theoretical distances (above the dotted line), while in contrast those with throwing distances of under 70 m who had the actual throwing distances that were longer than their theoretical distances (below the dotted line). When these results are applied to the relation between throwing distance and initial velocity of javelin release, we found that the initial velocity of javelin release was equivalent to approximately 26 m/s (throws of 70 m), which is a high initial velocity of javelin release. Moreover, we assumed that the throw distances and the initial velocity of javelin release cross the 45-degree line at the 70 m point. Therefore, we divided trials into groups of over 70 m and groups of under 70 m, and examined release parameter characteristics of throwers who achieved longer throwing distances. The results indicated that the attitude angle on the sagittal plane (XY plane) was not significantly correlated to the throwing distance. However, in the over 70m group, throwers who achieved longer throwing distances tended to have larger release angles and those who had longer throwing distances tended to have smaller angles of attack. On the horizontal plane (XZ plane), although we found no significant correlation between the release angle and the throwing distance, investigation of the attitude and angle of attack indicated that both tended to be smaller when the throwing distance was longer. These results indicated that elite throwers with longer throwing distances had smaller angles of attack due to a decrease in drag generation at the moment of javelin release.

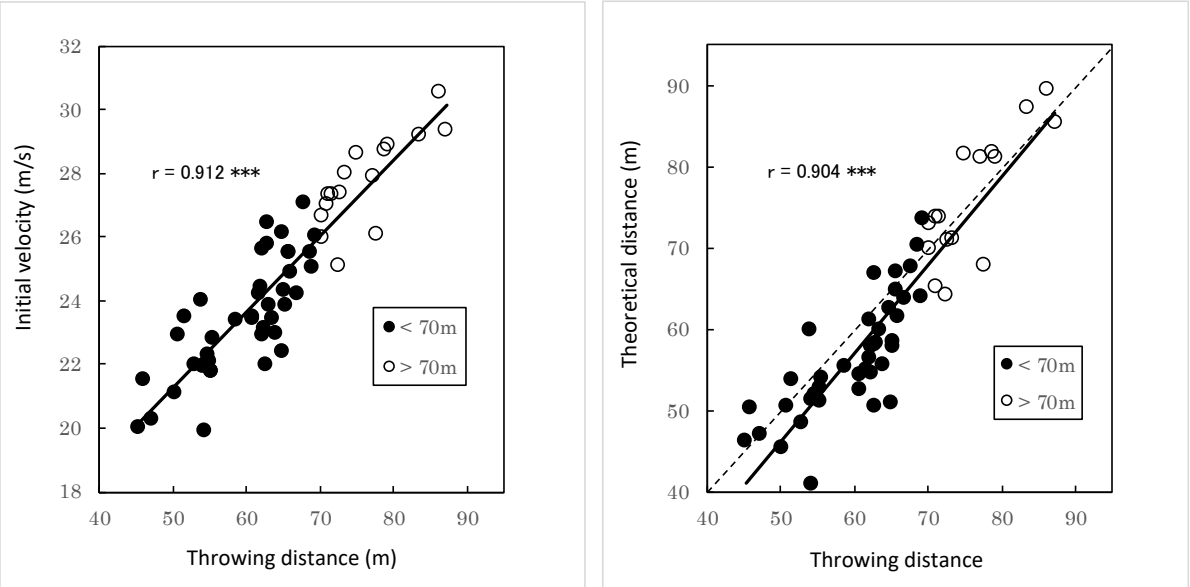

Figure 1. Relationships between the throwing distance and initial velocity of javelin (left) and between throwing and theoretical distances (right).

Conclusion: The elite throwers who threw javelins over 70m had smaller angles of attack at the moment of javelin release when observed in both the sagittal and the horizontal planes. Specifically, the present study suggests that elite throwers who have longer throwing distances appear to form an optimal attitude angle of javelin that reduces the amount of drag on the javelin at the moment of javelin release.

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Remarks: A portion of data related to release parameters that were utilized in this study were quoted from a doctoral thesis by Murakami (2018).