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Maeda, Masato

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# Effects of turbo-jav release conditions on distance of javelic throw

M. Maeda <sup>1</sup>

(1) : Tsurukabuto Nada Kobe Japan  
Phone/Fax: +81 78 803 7817  
E-mail : mmaeda @kobe-u.ac.jp

**TOPICS:** Athletics; Biomechanics

**Abstract:** The turbo-jav is used in the javelic throw as an introduction to the javelin throw or as a technical tool with which to practice the javelin throw. The present study investigated the effects of turbo-jav release conditions on javelic throwing distance. Javelic throws of a turbo-jav by 14 university students were measured over 260 trials. Each turbo-jav throw was videotaped using two high-speed video cameras, and four standard-speed video cameras during flight. All conditions of turbo-jav release and flight were measured using the 3-dimensional (3D) DLT method. The results revealed a significant positive correlation between initial velocity and distance thrown using the javelic throw ( $r = 0.775$ ,  $p < 0.01$ ). The turbo-jav was thrown far even when the angle of attack was  $> 25^\circ$ . The actual distance covered by a thrown turbo-jav was less than the theoretical throwing distance without air. In other words, the flight characteristics indicate that the flight of the turbo-jav in the javelic throw differs from that of a thrown javelin.

**Key words:** turbo-jav, javelic throw, initial conditions at release, flight characteristics, angle of attack

## 1 - INTRODUCTION

The javelic throw is a formal track and field event associated with the javelin throw in the Junior Olympic Games in Japan. A long, narrow polyethylene implement called the turbo-jav (length, 0.7 m; weight, 0.3 kg), resembling a javelin is thrown and athletes compete to achieve maximal distance. The men's steel or duralumin javelin used in the javelin throw is 2.6 m long and weighs 0.8 kg. Although the javelic throw is a formal event, less is understood about the characteristics of the turbo-jav compared with the javelin. The developer of the turbo-jav is a previous world record holder of the javelin throw, and he seemed to consider that the turbo-jav has similar flight characteristics to the javelin insofar as the turbo-jav and the javelin appear similar.

Although two studies on the javelic throw have been published (Ae et al., 2001; Ohta et al., 2002), they both compare throwing movements of the javelin, and do not address the features of the turbo-jav. Because the javelic throw is an official competition, the characteristic of the implement thrown should be understood in detail.

The present study investigated the effects of turbo-jav features and release conditions on javelic throwing distance and clarified the flight characteristic of the turbo-jav during the javelic throw.

## 2 - METHODS

### 2.1 – Subjects

Table 1 shows the characteristics of the 14 male university students including their experience of javelin throwing.

### 2.2 – Experiment

The javelic throws during 260 trials by 14 university students were measured. Each throw was videotaped using two synchronized high-speed video cameras (FASTCAM-PCI, Photron Ltd.; 250fps). Each turbo-jav thrown was videotaped and images of range during flight were obtained using four synchronized standard-speed video cameras (XC-009 and DXC-200A, 2 sets each; 60 fps; SONY Co.).

The point where each thrown turbo-jav fell was marked, and the distance thrown from the foul line to that point was measured by trilateration.

**Table 1. Physical characteristics of subjects and their experience in javelin throw.**

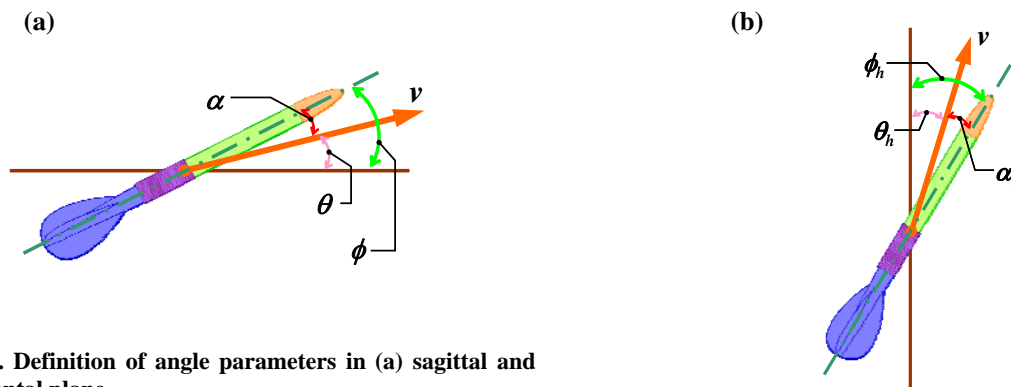
Subject	Height (cm)	Weight (kg)	Age (y)	Experience with Javelin Throw (y)	Trial throws (Attempts)
Experienced [n = 7]	176.0 ± 4.2	67.8 ± 3.3	22.8 ± 1.0	4.5 ± 2.6	154
Inexperienced [n = 7]	174.8 ± 1.7	65.3 ± 3.0	21.0 ± 0.8	0	106

### 2.3 – Analysis

The conditions under which each turbo-jav was released were analyzed using a 3D video motion analysis system (Frame-DIAS II, DKH Ltd.). The tip, center of gravity and edge of each turbo-jav, were digitized, measured using three-dimensional – direct linear transformation (3D-DLT) and the data were smoothed using a digital filter. The flight of each turbo-jav was then similarly measured using 3D-DLT. The x-axis was defined from a point 8 m from the origin of the foul line at the center of the runway in the direction of the throw, the y-axis as the right - left direction of the thrower and the z-axis as the vertical height of the thrower.

The actual distance thrown ( $R_A$ ) was the horizontal distance from the point at which the turbo-jav was released to that where it landed, and this measurement was added to the horizontal distance from the release point to the foul line.

The present study defined the moment of release as that time just before the precise frame in which the turbo-jav left the hand of the thrower. The initial conditions of the turbo-jav, namely initial velocity  $v$ , throwing angle  $\theta$ , height of release  $h$ , attitude angle  $\phi$  and angle of attack  $\alpha$  were calculated at release. These angle parameters were defined as shown in Figure 1. These angles for release of the turbo-jav complied with the definition of Bartlett et al. (1996). Figure 1a defines the throwing angle  $\theta$ , attitude angle  $\phi$  and angle of attack  $\alpha$  on the sagittal plane (x-z plane). Figure 1b subsequently defines each angle on the horizontal plane (x-y plane) as the horizontal throwing angle  $\theta_h$ , horizontal attitude angle  $\phi_h$  and horizontal angle of attack  $\alpha_h$ .



**Figure 1. Definition of angle parameters in (a) sagittal and (b) horizontal plane.**

The theoretical throwing distance  $R_T$  (without air) was calculated from that substitutes measured initial velocity  $v$ , throwing angle  $\theta$  and height of release  $h$  from the following equation (Hubbard, 1989).

$$R_T = \frac{v^2 \cos \theta}{g} \left[ \sin \theta + \left( \sin^2 \theta + \frac{2gh}{v^2} \right)^{\frac{1}{2}} \right]$$

where  $R_T$  is theoretical throwing distance,  $v$  is initial velocity,  $\theta$  is throwing angle,  $g$  is gravitational acceleration and  $h$  is height of release. The  $v$ ,  $\theta$  and  $h$  in this equation corresponded with the measured data in each.

### 3 - RESULTS

Figure 2 shows the points at which all the thrown turbo-javs landed. The range thrown varied from about 15 to 50 m. These throws were useful as trials under various conditions of release.

Figure 3 shows the relationship between the initial velocity of the released turbo-jav and the actual distance thrown. The relationships were very close with significant correlation ( $r = 0.775$ ,  $p < 0.01$ ).

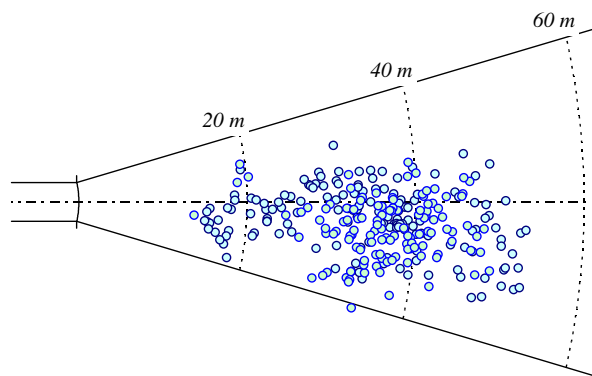
Figure 4 shows the relationship between the throwing angle of the released turbo-jav and the actual distance thrown. The range was widely distributed between 25 and 50°, and the throwing angle was around 30° when the distance thrown was  $> 50$  m. However, throws of over 40 m were achieved despite an increase in the throwing angle to between 40 and 50°.

Figure 5a shows that the relationship between the angle of attack of the released turbo-jav and the actual distance thrown fluctuated widely in the range of -5 to 35°. The trial found that throwing distance tended to increase with a decreasing angle of attack. This trial found that the turbo-jav could be thrown over 40 m despite the larger attack angle of 25 to 35°.

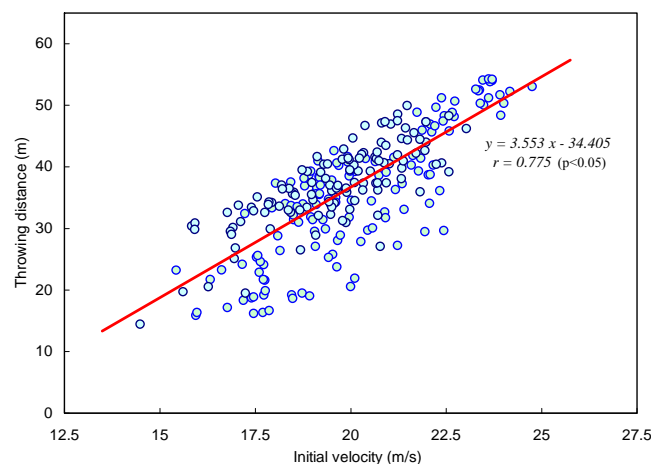
Figure 5b shows that the relationship between the horizontal angle of attack of the released turbo-jav and the actual distance thrown did not significantly correlate. Several trials indicated a long throw despite the horizontal angle of attack being not quite 0°.

Figure 6 shows the relationship between the theoretical (without air) and the actual distance thrown. The dotted line indicates that the actual and theoretical throwing distances were quite similar. Most trials in the present study remained below the dotted line.

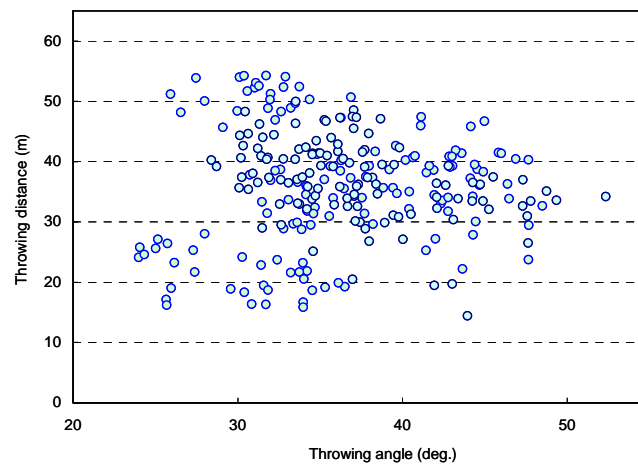
Figure 7 shows examples of turbo-jav flight with an excess angle of attack or throwing angle. These distances reached approximately 40 m despite the angle of attack being  $> 30^\circ$  or the throwing angle being excessive at about  $40^\circ$ .



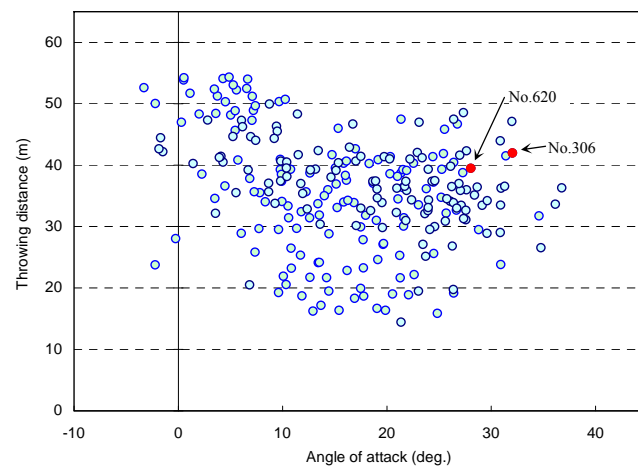
**Figure 2. Landing points of turbo-jav during trials.**



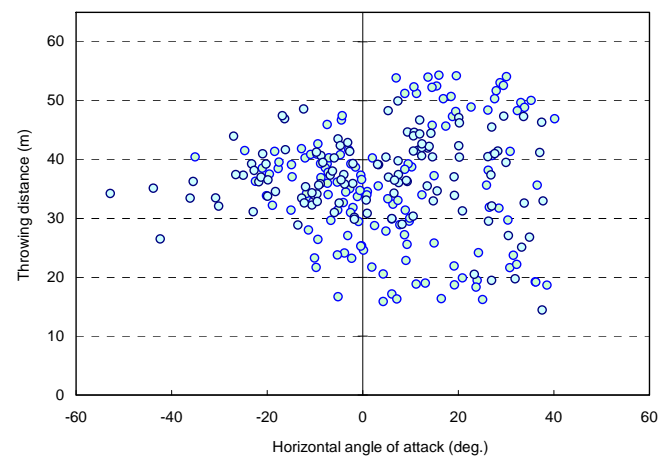
**Figure 3. Relationship between initial velocity and distance thrown.**



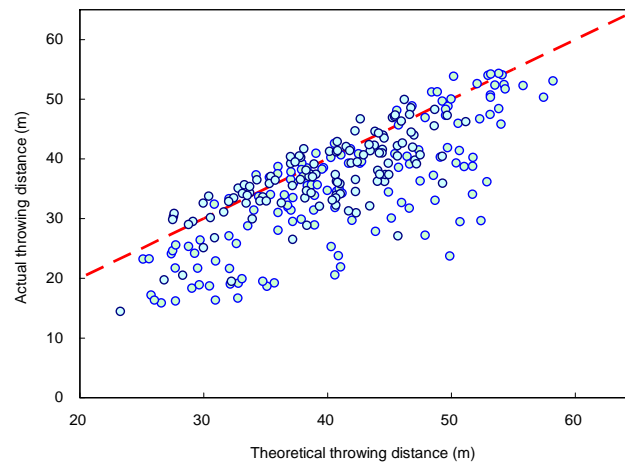
**Figure 4. Relationship between throwing angle and distance thrown.**



**Figure 5a. Relationship between angle of attack and distance thrown.**



**Figure 5b. Relationship between horizontal angle of attack and distance thrown.**



**Figure 6. Relationship between theoretical distance thrown and actual distance thrown.**

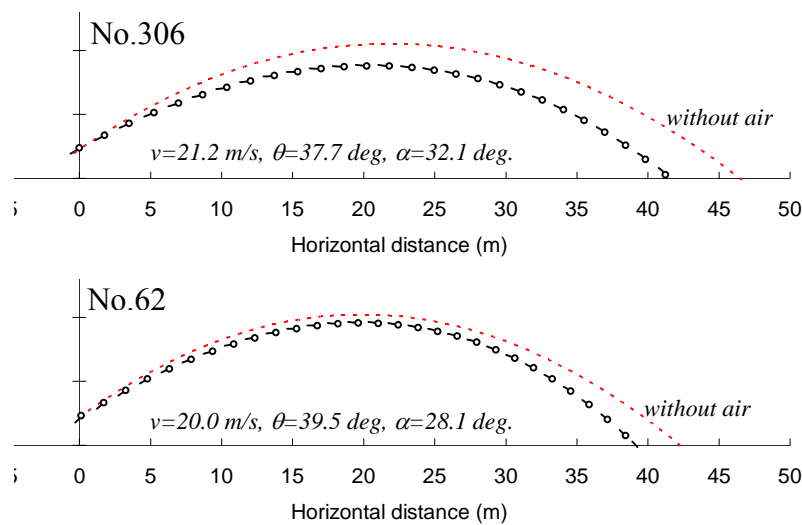


Figure 7. Examples of turbo-jav in flight with excessive angle of attack.

#### 4 - DISCUSSION

Tom Petranoff, a previous world record holder for the javelin throw, developed the turbo-jav as a means of practicing the javelin throw. Therefore, the features of the turbo-jav during the javelic throw and of the javelin during the javelin throw were apparently considered equal.

The present study found that the distance thrown was associated with an initially higher initial velocity of the turbo-jav, which is similar to the findings of others:  $r = 0.97$  (Komi and Mero, 1985) and  $r = 0.80$  (Murakami and Ito, 2003), indicating that the relationship between initial velocity and distance thrown is similar in the javelic throw between the turbo-jav and the javelin. After all, the initial velocity affected javelic throwing distance using the turbo-jav almost as well as in the javelin throw.

Figure 4 shows that the throwing angle of turbo-jav ranged from about 25 to 50°. In the javelin throw, Murakami and Ito (2003) reported that this is distributed between about 25 to 40° and Wakayama et al. (1994) reported a distribution from about 30 to 45°. As compared with similar data from the javelin throw, the throwing angles in the present study were distributed more widely, since half of our participants were unskilled.

Wakayama et al. (1994) reported that the optimum throwing angle of the javelin throw is 35° at the 60-m skill level, and 33° at that of 30 m. That is, a lower skill level is associated with a lower optimum throwing angle. The optimum throwing angle cannot be applied to the javelic throw, because if the characteristics of the turbo-jav and the javelin are equal, the thrower cannot throw further by increasing the throwing angle during the javelic throw. The present study recognized that some throws reached over 40 meters even though the throwing angle was excessive at 40 - 50°. That is to say, the excessive throwing angle in the javelic throw might not be the cause of a shorter throw.

Maeda et al. (1996) reported that a slightly positive or negative excess angle of attack does not increase the thrown distance even in the javelin throw; that is, an angle as close as possible to 0° is desirable. The angles of attack in the present study ranged from about -5 to 35° and those who attempted to decrease the angle of attack threw the turbo-jav further. These results agree with those of others, whereas distance thrown always increased even when the angle of attack, the horizontal angle of attack and the throwing angle were large. That is, the turbo-jav differs from the javelin insofar as it could be thrown farther even when the angle of attack or throwing angle was excessive. Either of these conditions causes a stall in the javelin throw, which results in no gains in distance (Terauds, 1985). An excessive throwing angle or angle of attack during the javelic throw does not particularly affect the distance thrown.

Figure 6 indicates that the actual distance travelled by the thrown turbo-jav did not significantly increase compared with the theoretical distance based on the initial conditions at release. In contrast, the actual distance achieved by the javelin throw tends to be farther than the theoretical distance in the absence of the air (Maeda, 1996). That is to say, the turbo-jav does not confer a significant benefit compared with the javelin.

The flight characteristics of the turbo-jav in the javelic throw differ from those of the javelin in the javelin throw. Although the turbo-jav was introduced as a technical tool with which to practice the javelin throw, the increased distance achieved in the javelic throw would not always result in throwing the javelin further.

#### 5 – CONCLUSION

The present study examined the influence of the initial release conditions on the distance travelled by a turbo-jav in the javelic throw and clarified the flight characteristics of the turbo-jav. Fourteen experienced and inexperienced individuals performed the javelic throw and the distance thrown was measured. The initial conditions at the moment of release were recorded during 260 turbo-jav throws by 14 throwers using two high-speed video cameras, and information about the flight conditions of the turbo-jav was obtained using four normal-speed video cameras after release. The recordings analyzed using 3D-DLT revealed the following results.

The correlation between the initial velocity and distance travelled during the javelic throw was close and positive, and the initial velocity was the critical influence on distance thrown.

Since the flight characteristics differ between the turbo-jav and the javelin, the turbo-jav was thrown farther even when the angle of attack or throwing angle was comparatively large.

The actual distance thrown was often shorter than the theoretical distance thrown during the javelic throw, suggesting that the turbo-jav does not confer a significant benefit on the distance thrown compared with the javelin.

The turbo-jav should be regarded as having different flight characteristics from the javelin.

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