A CASE STUDY OF THROWING MOTION OF A MALE PARA- SHORT STATURE JAVELIN THROWER

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The purpose of the present study was to investigate the throwing motion of a male para-short stature javelin thrower (F41) in a real competition using the 3D DLT method, compared with male able-bodied javelin throwers as reference. At the 119th Nippon Sport Science University Athletic Meet (March 27, 2021), one para- athlete who participated in the men's javelin throw was videotaped with two video cameras. The release parameters of javelin such as the initial velocity and projection angle at the release, and body segments angle were calculated for the only one trial, the best. The features of para-athlete were clarified by comparing them with the able-bodied javelin throwers (n=13) as reference. The release parameters of javelin showed that there was large difference in the horizontal velocity of javelin between the para-athlete and the reference throwers (12.59 and 19.35 m/s). The para-athlete of short stature in the present study showed the delayed withdrawal of the left leg at R-on, the delayed initiation of the rotation of the hips and trunk during throwing phase, and the left foot pointing to the right at L-on.

KEYWORDS: 3D-motion analysis, para-athlete, kinematics, javelin throw.

INTRODUCTION: In the javelin throw, the initial speed, projection angle, height at release, and aerodynamic factors determine the distance thrown (Hay, 1993). There is a significant relationship between the initial speed of the javelin and the distance thrown (Murakami et al., 2006).

In the Paralympic Athletics (hereafter Para-Athletics), athletes are divided into several classes according to the types and degrees of their disability. The severity of the disability varies from thrower to thrower in each class. Therefore, it is necessary to provide more individualized guidance to para-athletes who are divided into diverse athletic classes and disciplines. While, there are many reports on able-bodied javelin throwers, few reports on para-javelin throwers. It is necessary to collect actual information and to clarify the movement characteristics of para-short stature javelin throwers and to consider more individualized throwing movements by comparing with the throwing movements of able-bodied athletes.

The purpose of the present study was to investigate the throwing motion of a male para- short stature javelin thrower in a real competition using the 3D DLT method, compared with male able-bodied javelin throwers as reference.

The OFFICIAL WEBSITE OF WORLD PARA ATHLETICS (2018) describes, "Athletes with short stature compete in sport class T40/F40 and T41/F41. There are two classes depending on the body height of the athlete and the proportionality of the upper limbs. Athletes in classes T40 or F40 have a shorter stature than T41 and F41".

METHODS: One para-athlete (height 1.35 m; weight 55 kg; age 22 years old; personal best 33.09 m; right-handed; 5-year experience) in the Men's Javelin Throw (F41) at the 119th Nippon Sport Science University Athletic Meet held in Kanagawa, Japan (27, March. 2021) was videotaped with two video cameras (SONY, AX-700). The sampling rate of cameras was set at 120 Hz and the exposure time was 1/1000 second. A total of 25 points (23 points for

body segments and 2 points for both ends of the grip) were manually digitized by using the motion analysis software, Frame-Dias V (DKH Co. Japan), and the 3D coordinate data of body segment end points were reconstructed using the DLT method.
We defined a right-handed coordinate system with the throwing direction as the Y-axis, the vertical direction as the Z-axis, and the right direction relative to the throwing direction as the X-axis. The range covered was 4 m in the X-axis direction, 7 m in the Y-axis direction, and 3 m in the Z-axis direction. The average calibration errors were 0.006 m in the X direction, 0.010 m in the Y direction, and 0.006 m in the Z direction.
Only one trial, the best, was analysed. The digitized range in the present study was from the last right foot contact (R-on) to the javelin release (REL), and the preparation phase was defined from R-on to the last left foot contact (L-on), and the throwing phase was from L-on to REL. The feature of the para-athlete was identified by comparing with thirteen able-bodied javelin throwers, as reference throwers whose distance thrown was (58.00 ± 2.48 m). The data of the reference throwers were collected in official athletic meets held on April 6, 2019 and August 10, 2019, as similar to the Athletic Meet, mentioned above. The release parameters calculated were horizontal velocity, vertical velocity, resultant velocity (hereafter initial speed) in m/s, angle at release of the javelin, and angles such as forward-backward lean of the trunk, and horizontal rotation of hips in degrees.

RESULTS: Table 1 shows the distance thrown and release parameters of the para-athlete and reference throwers. There was no large difference in the vertical velocity between the para-athlete and the reference throwers, but there was a large difference in the horizontal velocity, and that of the reference throwers was much greater. The para-athlete showed larger projection angle.

Table 1: Distance thrown and release parameters for the para-athlete and reference throwers.

Throwers	Record (m)	Horizontal velocity(m/s)	Vertical velocity(m/s)	Resultant velocity(m/s)	Projection angle(deg)
Para-athlete	33.09	12.59	11.49	17.04	42.39
Reference throwers(n=13)	58.00 ± 2.48	19.35 ± 0.77	11.96 ± 0.71	22.77 ± 0.56	31.7 ± 2.23

Figure 1 shows the stick pictures of the para-athlete (upper) and reference throwers (lower). The left leg in red of the para-athlete at R-on would seem to be delayed and the right elbow was more flexed than the reference throwers. At L-on the left knee was more flexed, and the forward lean of the trunk at REL was less in the para-athlete than that of the reference throwers. The trunk would seem to start to rotate slower in the para-athlete than in the reference throwers. The most remarkable difference was seen in the left toe of the para-athlete, pointing to the right at L-on, as shown in back view of Figure 1.

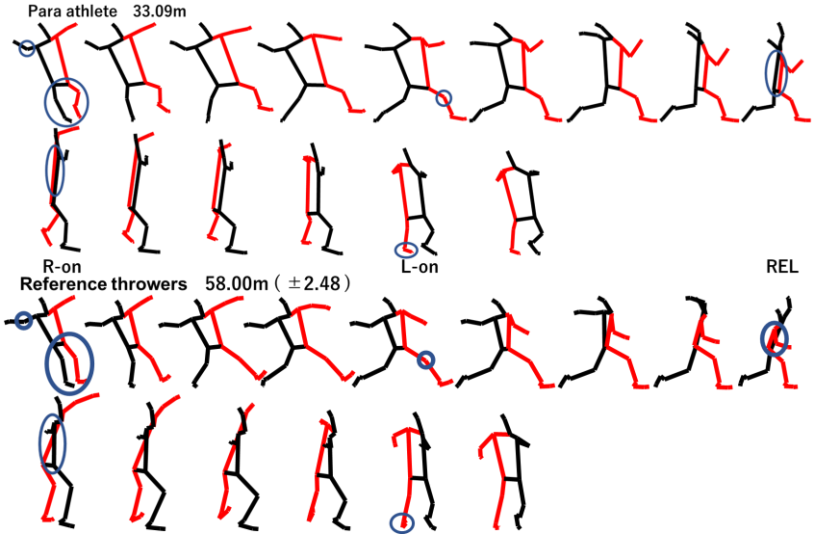

Figure 1: Stick pictures of the para-athlete and reference throwers.

Figure 2 shows changes in speed of joints for para-athlete (a, left) and reference throwers (b, right). In both athletes the speed increased from the shoulder to the javelin in sequence, as the kinematic chain principle. Although the speed peaked almost in the same sequence from the right shoulder, elbow, wrist, hand to the javelin, the speeds for the para- athlete were less. The para-athlete peaked a slightly later than the reference throwers for the right shoulder with a less peak speed.
Figure 3 shows the forward-backward trunk angle (+ forward) (a, left) and horizontal rotation of hips (+ left rotation), (b, right) in the para-athlete and reference throwers. The difference in the trunk angle at R-on and L-on was not so large between para- athlete and reference throwers, but the para-athlete at REL leaned forward much less than the reference throwers. The hips of the reference throwers rotated more to the left in all phases than the para-athlete.

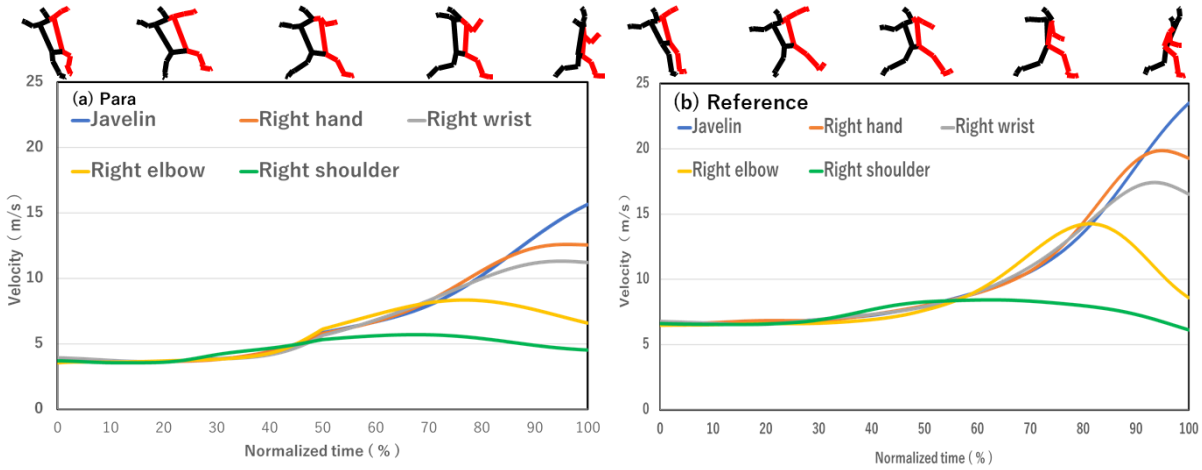

Figure 2: Change in speed of joints for the para-athlete (a, left) and reference throwers (b, right).

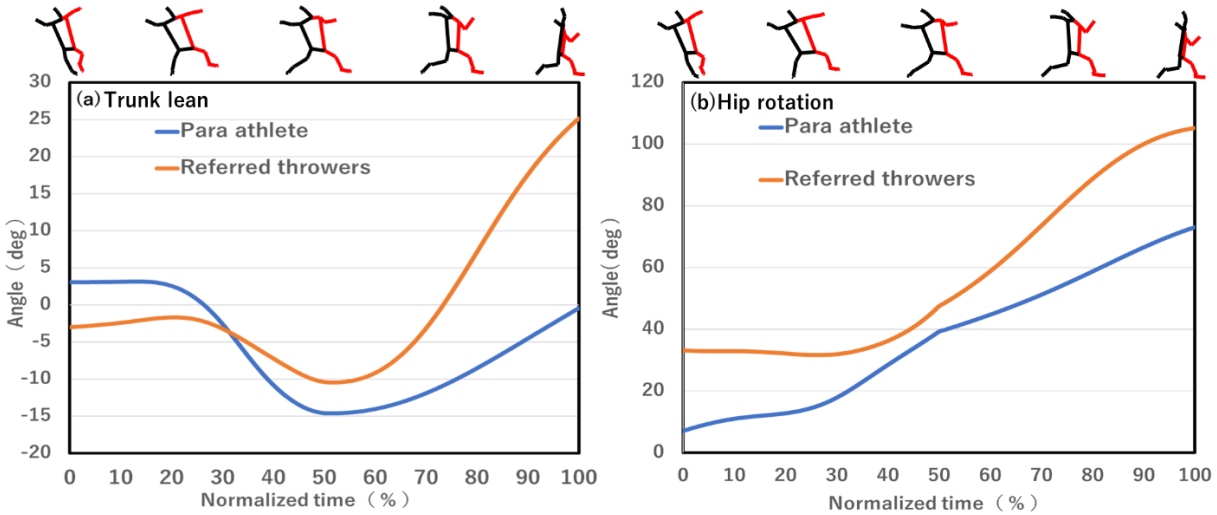

Figure 3: Forward-backward trunk angle (+ forward) (a, left) and horizontal rotation of hips (+ left rotation) (b, right) in the para-athlete and reference throwers.

DISCUSSION: In the javelin throw, the initial speed has the greatest effect on the distance thrown (Mero et al., 1994；Bartlett et al., 1996；Murakami et al., 2006). In the present study, the projection angle of the para-athlete was larger than that of reference throwers. The forward rotation of the trunk of the para-athlete was very small from L-on to REL, indicating the para-athlete was unable to use the trunk to pull the javelin forward during throwing phase (Tauchi et al.,2008.).
It is inferred that the mass and moment of inertia of the trunk for the para-athlete can be accounted for a large proportion of the total mass and moment of inertia due to the short legs,

compared with the reference throwers. This implies that the motion of the trunk may have significant effects on motions of other body segments and javelin, including the delayed left leg and the left foot that remained pointing to the right at L-on. It was thought that the delayed withdrawal of the left leg and the rotation of the hips and the trunk may have caused the left foot to remain pointing to the right at L-on.
Therefore, earlier initiation of the left leg and the trunk rotation may be considered as a critical point for the para-athlete in this study. If the suggested motions were achieved, the rotation of the hips and trunk and the forward lean of the trunk can be increased at REL. In addition, the left foot pointing to the right at L-on can be corrected by appropriate rotation of the hips prior to L-on.

CONCLUSION: The para-athlete of short stature in the present study showed the delayed withdrawal of the left leg at R-on, the delayed initiation of the rotation of the hips and trunk during throwing phase, and the left foot pointing to the right at L-on, which would seem to be caused by larger proportion of inertia of the trunk.
For the improvement in the techniques of the present para- athlete, earlier initiation of the hips and trunk motions would be recommended.

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