

## CHARACTERISTICS OF PULLING MOVEMENT FOR JAPANESE ELITE TUG OF WAR ATHLETES

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The purpose of this study was to clarify the characteristics of pulling movement for Japanese elite tug of war athletes in the world. In order to examine the pulling movement, 6 joint angles (viz.: shoulder, trunk, knee, body, upper body, and lower body) of each subject were obtained by the DLT motion analysis system during 2004 All Japan Tug of War Championship tournament. It was found that the elite puller of world champion team inclined his upper body more heavily to backwards, and his lower body a little bit more slightly to forwards, extending both the hip and the knee, than that of average team. Therefore, it was concluded that the elite puller of world champion team could be able to push and pull his whole body power totally and quite efficiently.

**KEY WORDS:** indoor tug of war, skill, DLT, TOW championship tournament, push and pull

**INTRODUCTION:** Outdoor Tug of war is common all over the world, Whereas, Indoor Tug of war is more popular than out door Tug of war in Japan. Last year, Kanazawa Rescue Team won 2004 World Indoor Tug of War Championships division under 600 kg. In a general way, Japanese and their muscular tissues are at a disadvantage in power game like tug of war, but Japanese won world championships. This suggests that indoor Tug of war needs sophisticated technique and tactics. All you need is not power, and we must notice the characteristics of pulling movement. Despite the importance of the explaining characteristics of pulling movement, only a few studies have reported pulling movement in match of indoor Tug of war. Therefore, the purpose of this study was to investigate the characteristics of pulling movement for Japanese elite tug of war pullers in these points of view.

### METHODS:

**Settings:** Two matches were recorded by 2 cameras. Cameras were set at left side of No.1 and No.5 player of each team. These matches were trial game of group 2 in All Japan Tug of War Championship lightweight division (A total of weight of 8 people must be less than 560 kg).

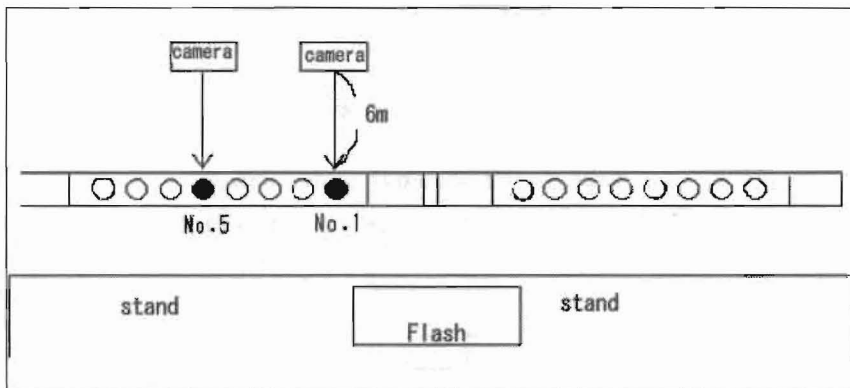


Figure 1 Settings.

**Data processing of motion analysis:** The analysis was done in 2 teams; World champion team (WT) and average team (AT). The objects were 4 second from first 2 second to 6

second. Analysis points on body were 8 points (viz.: head, shoulder, greater trochanter, knee, ankle, toe, heel, and hand). The two-dimensional motion analysis system (Frame-DIAS for Windows, DKH, Japan) was used to digitize the anatomical landmarks of the body. To calculate 2-D coordinate, the direct linear transformation (DLT) method was used. Then, 6 angles are measured.

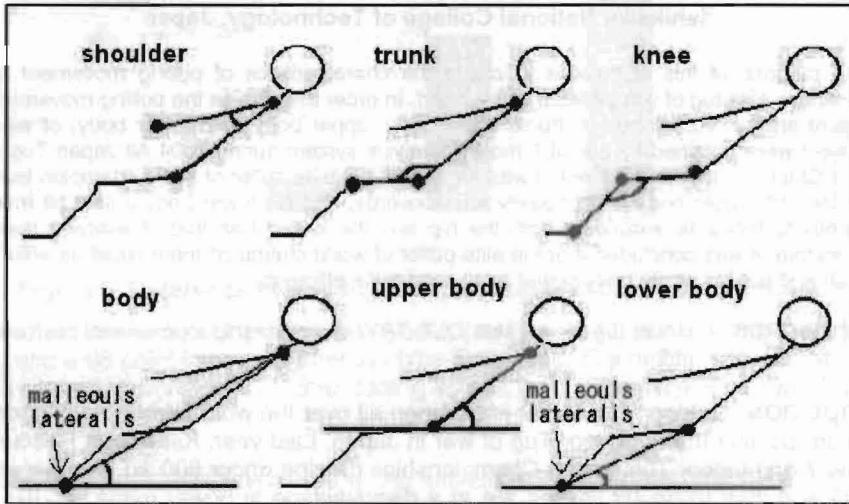


Figure 2 Definition of each angle.

**RESULTS AND DISCUSSION:** Table 1-7 shows the angle of each joint.

Table 1 The mean of angle of each joint (deg).

	shoulder	Trunk	knee	body	upper body	lower body
WT/ No.1	17.1	142.5	133.7	31.5	39.0	25.3
AT/ No.1	31.3	135.5	142.2	26.5	45.1	16.3
WT/ No.5	21.2	151.9	135.1	46.3	29.5	22.6
AT/ No.5	34.3	139.5	161.1	20.6	41.3	9.9
WT/mean	19.2	147.2	134.4	38.9	34.3	24.0
AT/mean	32.8	137.5	151.7	23.6	43.2	13.1
mean	26.0	142.4	143.0	31.2	38.7	18.5

**Shoulder angle:** The mean of shoulder angle for WT was 19.2 degrees, and AT was 26.0 degrees. Both in No.1 and No.5 puller, shoulder angle for WT was smaller than AT. This proved that WT held arm to body, AT didn't.

Table 2 The shoulder angle (deg).

Shoulder	WT-No.1	WT-No.5	AT-No.1	AT-No.5
Max	20.6	28.1	46.6	52.6
Min	12.6	14.6	21.6	25.4
Mean	17.1	21.2	31.3	34.3
SD	1.7	2.7	5.8	8.5

**Trunk angle:** The mean of trunk angle for WT was 147.2 degrees, and AT was 137.5 degrees. Both in No.1 and No.5 pullers, trunk angle for WT was greater than AT. This proved that WT swept back their body.

**Table 3 The trunk angle (deg).**

Trunk	WT-No.1	WT-No.5	AT-No.1	AT-No.5
Max	149.7	160.8	148.6	150.5
Min	133.0	123.8	115.9	118.3
Mean	142.5	151.9	135.5	139.5
SD	6.1	7.9	8.6	9.8

**Knee angle:** The mean of knee angle for WT was 134.4 degrees, and AT was 151.7 degrees. Both in No.1 and No.5 pullers, Knee angle for WT was smaller than AT. Generally, ideal knee angle in tug of war is 120 degrees. WT was near to this angle, but AT was near to 180 degrees. This is too wide to stand firm.

**Table 4 The knee angle (deg).**

Knee	WT-No.1	WT-No.5	AT-No.1	AT-No.5
Max	148.1	158.1	146.5	166.9
Min	112.6	102.9	138.3	152.7
Mean	133.7	135.1	142.2	161.1
SD	7.8	13.4	2.2	3.6

**Angle of body, upper body, lower body:** The mean of body angle for WT was 38.9 degrees, and AT was 23.6 degrees. The mean of angle of upper body for WT was 34.3 degrees, and AT was 43.2 degrees. The mean of angle of lower body was 24.0 degrees and 13.1 degrees. Both in No.1 and No.5, the body angle and lower body for WT were greater than AT, but the angle of upper body for WT was smaller than AT. This proves that AT inclined lower body more than WT, but WT inclined upper body more than AT. This enabled WT to hold arm to body while oxtering tug. Figure.3 shows the image following these results.

**Table 5 The body angle (deg).**

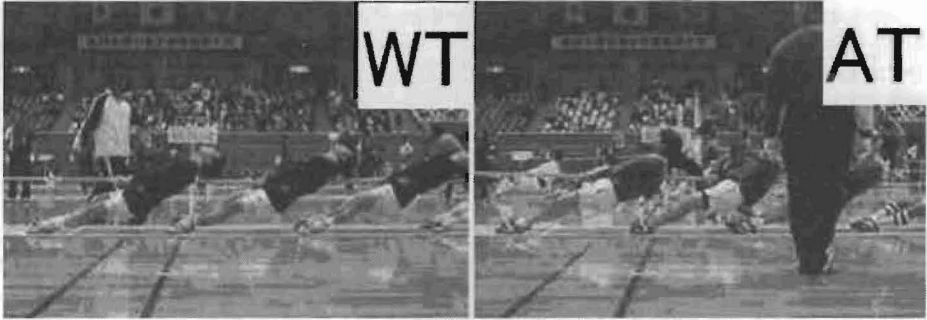
Body	WT-No.1	WT-No.5	AT-No.1	AT-No.5
Max	35.5	58.1	27.9	27.5
Min	25.3	28.4	24.8	17.8
Mean	31.5	46.3	26.5	20.6
SD	2.5	7.5	0.8	2.3

**Table 6 The angle of upper body (deg).**

Upper body	WT-No.1	WT-No.5	AT-No.1	AT-No.5
Max	43.1	45.3	57.5	59.2
Min	32.9	19.9	36.1	33.6
Mean	39.0	29.5	45.1	41.3
SD	2.1	4.9	5.6	8.0

**Table 7 The angle of lower body (deg).**

Lower body	WT-No.1	WT-No.5	AT-No.1	AT-No.5
Max	29.9	30.8	20.8	13.0
Min	15.3	11.9	8.9	6.9
Mean	25.3	22.6	16.3	9.9
SD	3.4	4.9	2.9	1.6



**Figure 3 The image of pulling action.**

(“WT” means world champion team, and “AT” means average team.)

**CONCLUSION:** To conclude, elite tug of war pullers produced the motion to pull by not only arm but also body. To hold arm to body, elite tug of war athletes closed their side, extended their Trunk, inclined their body and lower body heavily, and also inclined their upper body slightly in comparison with average team. Pulling by throughout the body, that enable to pull a tug with all one's might.

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