ANALYSIS OF TIMING SKILL OF DROP EXERCISE IN ELITE INDOOR TUG OF WAR ATHLETES

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In order to describe the timing skill of the elite athletes of indoor Tug of War, the purpose of this study was to determine the relationships between peak force time (PT) differences and the peak force (PF) exerted by two pullers. The team holding the gold medal record for the World Indoor TOW Championships 2004 participated in this study (N=22). Also eight novice male students participated. Our data revealed that the sum of individual PF in two pullers was 305.9±41.4kgw and PF exerted by the two pullers was 286.3±38.8kgw, which was 93.6% of the sum PF in skilled pullers. There was approximately 6% loss of PF in skilled pair. A correlation coefficient of .926 and a regression equation in the form of Y=64.193X+2.454 ($p<0.001$) were calculated. It is concluded that the smaller PT differences are in two pullers, the smaller is the reduction of PF in pair.

KEY WORDS: tug of war, timing skill, pulling exertion.

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. There are very few studies focused on Indoor Tug of war. Tug of war consists of two exercises: drop exercise and hold exercise. Drop exercise is the stage starting to exert force right after the signal of "pull". The PF is produced in this exercise. On the other hand, hold exercise is the stage withstanding against the force produced by the opponent. The important key of drop exercise is to pull a rope right after hearing the signals as rapid as possible with maximal force. However, the timing of each member prefers to exert his peak force is various. We established the hypothesis that time differences among members exerted PF cause force reduction during drop exercise in team. In this point of view, the purpose of this study was to examine the loss of force exerted in pair during drop exercise concerning the time differences of the actual PF.

Photo 1: Kanazawa Rescue Team is the world champion for 2004

METHODS: The team holding the gold medal record for the world indoor tug of war championship 2004 and 8 male novice participated in this study. The physical characteristics of skilled and novice subjects are shown in Table1. Load cells (TCLP-200KA, TOD) with a strain amplifier (6M46, SAN - EI INSTRUMENTCO, LTD) connected to a pen oscillograph (RECTI-HORIZ-8K, SAN-EI INSTRUMENTCO, LTD), in paper speed of 25mm/sec, were used to obtain forces data. A strobe light synchronized with a pen oscillograph was employed to calculate the peak pulling force time (PT). The underfoot surface was an official mat of indoor Tug of War. The shoes and the rope employed in this study were specifically designed for Indoor Tug of War. The pulling height was adjusted to 70cm from the floor.

During drop exercise, Individual PF, Pair PF and PT were measured. Similarly, during hold phase, Individual PF and Pair PF were measured. Each subject was instructed to produce PF as quickly as possible after signal in a horizontal direction with maximal efforts. PF were

exerted with both hands. Subjects were given no restriction for pulling postures. All trials took place indoor. PF produced in individual were measured first, and PF produced in pair was measured afterward. Each subject was allowed three 5s trials, in which they attempted to pull as hard as possible against the rope. Subjects were allowed enough rest between trials. PF produced during the drop exercise in each trial was recorded, then the mean value of three trials for subsequent analyses was calculated. After measurements of individual PF produced, two subjects were randomly chosen as a pair. The PF produced by the pair as a unit was measured in the same way. The PT was calculated by the data recorded with pen oscillograph in each trial. The Δforce and Δtime were analyzed to examine the timing skill during drop exercise in this study. The Δforce is the ratio of how much potential PF was lost by subjects in the pair compared with the sum of Individual PF exerted. The Δtime represents the time differences between players in pair. To calculate Δforce and Δtime, the following equations were used.

RESULTS AND DISCUSSION: The individual PF exerted by novice subjects was 78.5±8.3kgw. The individual PF exerted by skilled subjects was 152.9±22.7kgw. Skilled subjects could produce Individual PF twice as much as beginners. Pair PF is shown in Table2. It shows that not only in Individual PF, but also in Pair PF skilled subjects could produce PF two times more than that of novice.

The results of the mean Individual pulling force during the hold exercise in beginners and skilled subjects were 52.6±7.9kgw, 115.6±22.6kgw, respectively. The result of PF during the hold phases was 82.1±14.7kgw; 96.6kgw was the maximum value and 64.2kgw was the minimum value in pairs of beginner subjects. The result of PF during the hold exercise was 203.3±33.5kgw, and 267.7kgw was the maximum value and 163.1kgw was the minimum value in pairs of skilled subjects. The ratio of PF during hold exercise compared with PF during drop exercise was 66.8±6.6%; 74.9% was the maximum and 54.7% was the minimum in individual beginner subjects. Also, in pairs of beginner subjects, the ratio was 55.0±4.1%; 58.9% was the maximum and 50.9% was the minimum. On the other hand, the ratio in individual skilled subjects was 75.4±6.5%; 85.6% was the maximum and 60.1% was the minimum. Also in pairs of skilled subjects the rate was 74.6±7.3%; 85.5% was the maximum and 64.1% was the minimum. The ratios shows that there are significant differences between skilled and beginner subjects ($p<0.01$). It indicates that the reduction of force during hold exercise in skilled subjects was smaller than that of novices.

The sum of individual PF during drop exercise in beginner and skilled subjects were 156.9±14.8kgw and 305.9±41.4kgw respectively. Skilled subjects exerted PF almost two times greater than that of novice The mean value of Pair PF in novice was 148.4kgw, and the mean value of Pair PF in skilled was 286.3kgw. The results show that there are loss forces between sum of individual PF and Pair PF in both novice and skilled subjects. The mean loss force in beginner was 8.6kgw, which was 5.5% of the sum of Individual PF. The mean loss force in skilled was 19.6kgw, which was 6.4% of the sum of Individual PF. ΔPF and ΔPT were calculated using the equations mentioned and are shown in Table 3. During drop exercise of beginner subjects, the ratio of loss force was 5.5±2.4%, and the difference of PT was 0.08±0.03sec. On the other hand, in skilled subjects, the ratio of loss force was 6.4±3.0%, and the difference of PT was 0.06±0.05sec. A correlation coefficient of .3971 and a regression equation in the form of $Y=45X+2.15$ ($p<0.001$) were calculated in novice pair. A correlation coefficient of .926 and a regression equation in the form of $Y=64.193X+2.454$ ($p<0.001$) were calculated in skilled pair (Figure2). There was a high correlation between loss force and a difference of PT. These results revealed that there was approximately 6% loss of pulling force in novice and skilled pair. These results indicate that the greater difference of PF times, the greater loss of PF in pair.

Skilled Kanazawa Rescue Team can pull a tug with hardly any time difference and they can pull a rope almost perfectly with less PF loss during drop exercise. This study reveals that it's essential to synchronize pulling the rope among members. Accordingly, this study emphasizes that to improve timing skill is one possible way to increase PF of team in Tug of War.

CONCLUSION: Results from this study suggest that the PT will influence the magnitude of horizontal PT in pair, and the smaller the time difference of PT, the smaller the loss of PF in pair. This emphasizes the importance of timing skill among members of the team to increase PF during drop exercise in Tug of War.

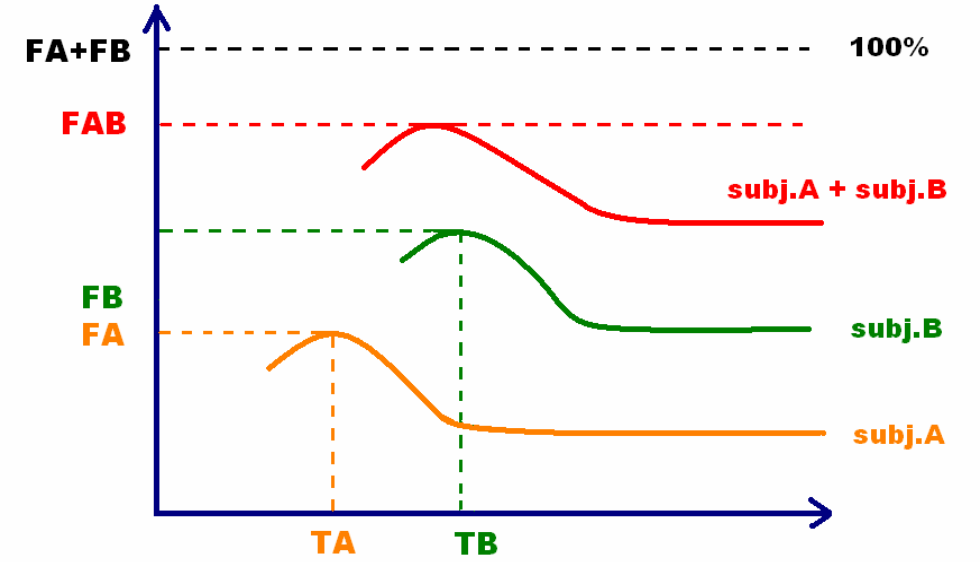

Figure 1: Image of force curves in two pullers. Y: ΔForce={(FA+FB)-FAB}/(FA+FB)×100 (%), X: ΔTime =|TA-TB| (sec), FA=Individual PF of subject A, FB= Individual PF of subject B, FAB= Pair PF of subject A and B, TA= PT of subject A and TB= PT of subject B.

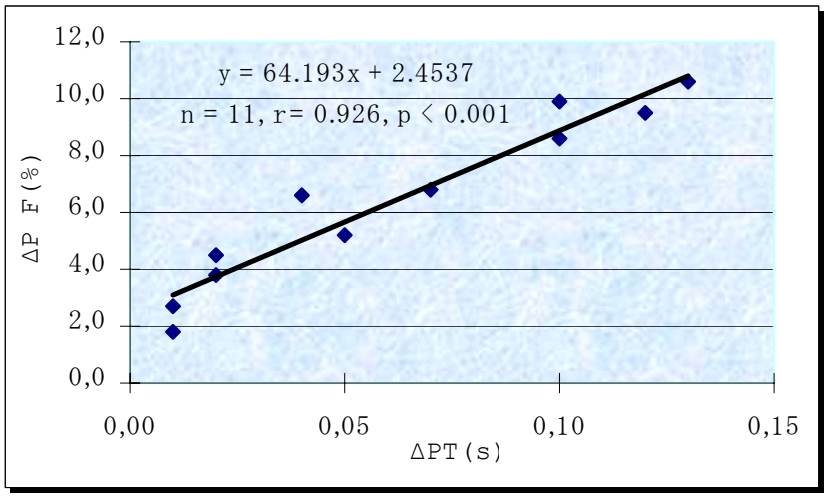

Figure 2: The relationship between ΔPF(%) and ΔPT(s) in skilled subjects

Table1 Physical characteristics of subjects (n=30)

	Skilled (n=22)		Novice (n=8)	
	Mean	**SD**	**Mean**	**SD**
Age (yrs)	28,7	4,1	22,4	1,41
Height (cm)	174,4	4,9	174,4	4,63
Weight (kg)	71,9	4,9	64,5	3,63
PF (kgw)	152,9	22,7	78,5	8,3

Table 2 The forces of two pullers in drop exercise in PT

	skilled (n=11)				Novice (n=4)			
Pair	pair weight (kg)	Sum of Forces (kgw)	Pair Force (kgw)	Loss Force(kgw)	Pair weight(kg)	Sum of Forces (kgw)	Pair Force(kgw)	Loss Force (kgw)
ab	155	279,9	253,3	26,6	132	138,1	126,1	12,0
cd	129	257,3	240,3	17,0	135	165,0	155	10,0
ef	143	308,1	287,3	20,8	123	152,9	146,1	6,8
gh	143	282,5	252,6	29,9	126	171,7	166,3	5,4
ij	148	314,8	283,6	31,2				
kl	152	283,8	271,0	12,8				
mn	144	282,0	276,9	5,1				
op	141	264,0	256,9	7,1				
qr	137	352,9	334,6	18,3				
st	147	381,8	348,6	33,2				
uv	144	357,5	343,9	13,6				
Mean	143,9	305,9	286,3	19,6	129,0	156,9	148,4	8,6
SD	11,9	41,4	38,8	9,7	5,5	14,8	17,1	3,0

Table 3 Loss force and differences

	Skilled (n=11)		Novice (n=4)	
Pair	ΔPF (%)	ΔPT (sec)	ΔPF (%)	ΔPT (sec)
ab	9,5	0,12	8,6	0,11
cd	6,6	0,04	6,0	0,08
ef	6,8	0,07	4,4	0,03
gh	10,6	0,13	3,1	0,08
ij	9,9	0,1		
kl	4,5	0,02		
mn	1,8	0,01		
op	2,7	0,01		
qr	5,2	0,05		
st	8,7	0,1		
uv	3,8	0,02		
Mean	6,4	0,06	5,5	0,08
SD	3,0	0,05	2,4	0,03

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