INFLUENCES OF SOME SPORTS-SHOES ON THE STRENGTH OF PULLING EXERCISE IN INDOOR TUG-OF-WAR

Hiroh Yamamoto, Shigehiro Makitani, Nobuo Yasuda, and Yoshiaki Watanabe
Biomechanics Lab., Kanazawa University, JAPAN

INTRODUCTION

Sport officials of the national association are generally aware of the tug-of-war sport featured on the Olympic Programme from 1900 till 1920. However knowledge of details from this period in the tug-of-war sport is rather limited. Last year, during the centennial Olympic year, the media revitalised the sentiment of the tug-of-war history in the Olympics, by saying " World indoor tug-of-war is attracting more countries than ever." Tug-of-war is an athletic contest in which two teams pull against each other at opposite ends of a rope. It has gone down historically as being held in various places all over the world as a type of recreational sport or a kind of divine events before God. As for an athletic sport, tug-of-war in Japan has prevailed and become a big sport in recent years. The games of tug-of-war in Japan are basically different from those of other countries in the world. In other words, generally tug-of-war in the world games has been held in the open air, while tug of war in Japan has spread through the country as one type of indoor game. Frictional forces are acting in the contact plane of two bodies and thus, one of them being the earth's surface, horizontal forces can be generated. Friction characteristics between surface and shoe in tug of war have not been investigated.

Therefore, the purposes of this study were to measure the static coefficient of friction at each shoe on three different mats, and to determine a suitable shoe for indoor tug-of-war.

METHODS AND PROCEDURES

Subjects

Several different sports shoes; Tsunahiki105 (TOR105), Tsunahiki107 (TOR107), Tsunahiki109 (TOR109), Tennis shoe (Tennis), Running shoe (Running), and mats were used in this study. The sizes of the shoes and mats are showed in Table 1. Eight healthy males of Kanazawa Rescue Team participated in this study. Their physical characteristics are described in Table 2.

Table 1. Characteristics of sports shoes

Kind of shoe	Size	Weight	Surface
TOR 105	26.5,	0.32	Rubber
TOR107	26.5	0.32	Rubber
TOR109	26.5	0.32	Rubber
Tennis	26.5	0.4	Rubber
Running	26.5	0.32	Rubber

Characteristics of Tug-of-war Mats

Kind of mat	length (cm)	width (cm)	thickness (cm)
English	45	32	2
European	94	59	1.5-1.1
Japanese	59	80	0.5

Table 2. Physical characteristics of subjects

Subject	**Age (year)**	**Height (cm)**	**Weight (kg)**	**Grip Strength right(kg)**	**left(kg)**	**Back Strength (kg)**	**%BF %**
1	32	177	77	67	67	210	12.6
2	25	174	79	64	55	235	13.7
3	29	179	78.5	56	51	205	12.7
4	31	172	84	57	61	184	13.4
5	28	170	71	54	48	179	10.8
6	28	185	83	60	62	220	11.5
7	23	175	68.5	58	52	175	11.4
8	29	178	79.5	66	73	217	11.2
Mean	28.1	176.3	77.6	60.3	58.6	203.1	12.2
SD	2.95	4.65	5.39	4.86	8.63	21.66	1.1

Instrumentation and Procedure of coefficient of friction

In this study static coefficient of friction of five shoes were measured on three different mats: English mat, European mat, and Japanese mat. The mat was placed on the force platform. The shoe onto which was loaded a 3.0 kg weight was placed at the midpoint of mat on force platform. The wire fixed to the shoe tip was pulled through the two blocks by hanging a 7.5kg weight (Fig. 1)

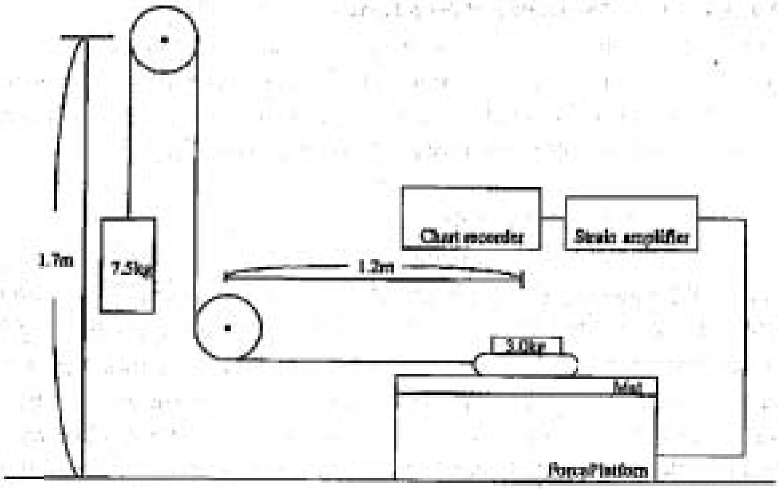

Figure 1. Schematic diagram of coefficient of friction experiment

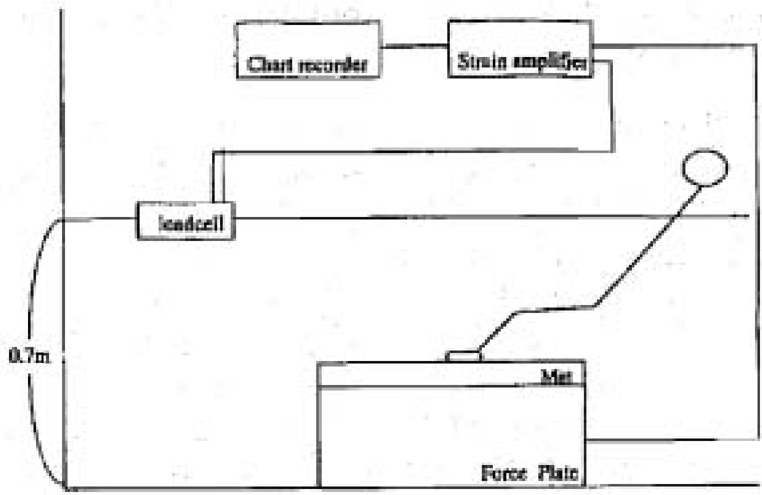

Figure 2. Schematic diagram of pulling strength experiment

Instrumentation and Procedure of Steady Maximum Pulling Strength

Subjects completed exertions at the 0.7m height and were instructed to exert a steady maximal pull on each shoe for 5 seconds, in a direction as close to the horizontal plane as possible. Successive exertions were performed following a minimum period rest of 2 min (Fig. 2).

RESULTS AND DISCUSSIONS

The results of the Least Significantly Difference (LSD) of static coefficient of friction of five different shoes on an English mat are shown in Table 3. However, when tug-of-war was actually attempted on English mat, the results of static coefficient of friction at each shoe didn't prove to be a steady pulling strength at each shoe. A suitable shoe for indoor tug-of-war was determined not by a static coefficient of friction but a horizontal pulling strength on an English mat, because there was no observable moment when shoe stays on the mat. The results of LSD of steady maximum pulling strength at each shoe on the English mat are shown in Table 6. The pulling strength with TOR 107 or TOR 109 on was greater than pulling strengths with Tennis shoe on and with Running shoe on. It is considered that the use of TOR 107 or TOR 109 was more effective than the tennis or running shoe in tug-of-war. It is concluded that, when tug-of-war is attempted on an English mat, the use of TOR 107 or TOR 109 might be much preferable to the tennis shoe or running shoe.

Table 3. LSD matrix including coefficient of friction on English mat

English	ns	Mean	TOR105	TOR107	TOR109	Tennis	Running
TOR105	10	0.714					
TOR107	10	0.679	0.035				
TOR109	10	0.753	0.039	0.074			
Tennis	10	0.622	0.092**	0.058*	0.131**		
Running	10	0.790	0.076**	0.111**	0.037	0.168**	

LSD=0.045, $p<0.05$, "indicates a significant difference

LSD=0.059, $p<0.01$, **indicates a significant difference

Table 4. LSD matrix including coefficient of friction on European mat

European	ns	Mean	TOR105	TOR107	TOR109	Tennis	Running
TOR105	10	0.670					
TOR107	10	0.632	0.038**				
TOR109	10	0.684	0.014	0.052*			
Tennis	10	0.560	0.110**	0.072*	0.124**		
Running	10	0.597	0.073**	0.035**	0.087**	0.037	

LSD=0.045, p<0.05, *indicates a significant difference
LSD=0.059, p<0.01, **indicates a significant difference

Table 5. LSD matrix including coefficient of friction on Japanese mat

Japanese	ns	Mean	TOR105	TOR107	TOR109	Tennis	Running
TOR105	10	0.584					
TOR107	10	0.432	0.152**				
TOR109	10	0.432	0.152**	0.000			
Tennis	10	0.389	0.195**	0.043	0.043		
Running	10	0.385	0.199**	0.047*	0.047*	0.004	

LSD=0.045, p<0.05, *indicates a significant difference
LSD=0.059, p<0.01, **indicates a significant difference

Table 6. LSD matrix including pulling strength at each shoe on English mat

English	ns	Mean	TOR105	TOR107	TOR109	Tennis	Running
TOR105	8	99.2					
TOR107	8	105.0	5.8				
TOR109	8	106.1	6.9	1.1			
Tennis	8	96.6	2.6	8.4*	9.5*		
Running	8	92.5	6.7	12.5**	13.6**	4.1	

LSD=8.2, p<0.05, *indicates a significant difference
LSD=10.8, p<0.01, **indicates a significant difference

Table 7. LSD matrix including pulling strength at each shoe on European mat

European	ns	Mean	TOR105	TOR107	TOR109	Tennis	Running
TOR105	8	103.2					
TOR107	8	105.5	2.3				
TOR109	8	105.9	2.7	0.4			
Tennis	8	101.4	1.8	4.1	4.5		
Running	8	101.3	2.0	4.2	4.6	0.1	

LSD=8.2, $p<0.05$, *indicates a significant difference
LSD=10.8, $p<0.01$, **indicates a significant difference

Table 8. LSD matrix including pulling strength at each shoe on Japanese mat

Japanese	ns	Mean	TOR105	TOR107	TOR109	Tennis	Running
TOR105	8	91.6					
TOR107	8	92.0	0.4				
TOR109	8	94.1	2.5	2.1			
Tennis	8	78.0	13.6**	14.0**	16.1**		
Running	8	77.3	14.3**	14.7**	16.8**	0.7	

LSD=8.2, $p<0.05$, *indicates a significant difference
LSD=10.8, $p<0.01$, **indicates a significant difference

The results of LSD of static coefficient of friction for five different shoes on a European mat are shown in Table 4. However, when tug-of-war was actually attempted on the European mat, the results of static coefficient of friction at each shoe didn't prove to be a steady pulling strength at each shoe, as was found on the English mat. The results of LSD of steady maximum pulling strength at each shoe on European mat were showed in Table 7. There were no significant differences between all shoes, because European mat has characteristically uneven surface and is not as slippery. When forces were added on it, it is seemed that the shoe was held in place by the uneven surface. Therefore there was no significant difference between all shoes on steady maximum pulling strength. The results of LSD of static coefficient of friction at five different shoes on Japanese mat are shown in Table 5. However, when tug-of-war was actually attempted on Japanese mat, the results of static coefficient of friction at each shoe didn't prove to be a steady pulling strength at each shoe, as well as other mats. The results of LSD of steady maximum pulling strength at each shoe on Japanese mat are shown in Table 8. Steady maximum pulling strength, with TOR105, TOR

107, and TOR 109 on was significantly greater than that with tennis shoe and running shoe on Japanese mat. It is concluded that the use of TOR 105, TOR 107, and TOR 109 might be more effective than the use of Tennis and Running shoe on Japanese mat.

REFERENCES

Frederick, E.C. (1984); Sport shoes and playing surfaces-Biomechanical Properties. Champaign, IL: Human Kinetics.

TWIF (Tug of War International Federation) Newsletter, (1997). "The Tug of War sport in The Olympic Games (1)," Vol.10, No. 1 (pp: 1-41, Dalen, Netherland.