THE ANALYSIS OF PULLING FORCE CURVES IN TUG-OF-WAR

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The purpose of this study is to analyze the pulling force curves in DFB and AFB movements that produced by elite tug-of-war athletes. The subjects are 11 female high school athletes who have been trained more than two years for tug-of-war. Data is analyzed by paired-sample t-test. The results show that force-related parameters are all different significantly between two movements, and time-related parameters are not significant. The DFB movement has higher value in MaxF, AveF, FS and lower value in MinF. We suggest to avoid the decay of pulling force while adopting DFB movement, and increase MaxF, AveF, and FS while adopting AFB movement. Within the start of 2sec we suggest the team to take the DFB movements in order to produce powerful pulling force, then transform to the AFB movements to keep the team formation.

KEY WORDS: tug-of-war, pulling force, defend fast break, attack fast break.

INTRODUCTION: Tug-of-war produced a kind of sport type that pulling force contrast with each other through both sides of tug-of-war rope. It was once one of the formal events of the Olympic games had already to develop had formal tug-of-war international federation (TWIF). The players of every team are eight athletes, grade in accordance with the weight and the rule is extremely clear. It is a sport with development potentiality. The tendency is increasing for the relevant research of the theme gradually to move with the tug-of-war in recent years. By different studying purposes, scholars study and discover through biomechanical (Chiang, 2003; Kuo, 2004; Tu, 2002; Wong, 2002), technological, physiological, psychological aspects. Depend on different tactics, at the beginning of the match, the player, in accordance with producing pulling force and contending with the other side with attack fast break [AFB] and defend fast break [DFB]. The duration of the competition is about 2 minutes. The right tactics in the start movement will largely increase the probability of success. Both coaches and athletes concern the difference of pulling force performances between AFB and DFB movements. The related parameters of pulling force curves produce by different start movements are necessary to discuss by the point view of biomechanics. The purpose of this study is to analyze the pulling force curves in DFB and AFB movements that produced by elite high school female tug-of-war athletes.

METHODS: The subjects, definitions, experimental design, data analysis, the system of data collection of this study are as following:

Subjects: The subjects of this study are 11 female elite high school athletes. They have been trained more than two years for tug-of-war. The age, height, and weight are 17.8 ± 0.99 years, 163.9 ± 2.98 cm, 59.1 ± 4.21 kg, separately.

The definitions of defend fast break and attack fast break: The tug-of-war posture of defend fast break means that the subject keep static posture after the transformation from P1 to P2 and don't move their foots backward after the start of the competition (Figure 1a). The tug-of-war posture of attack fast break means that subjects keep the rhythmical backward-forward steps after the start of the competition (Figure 1b).

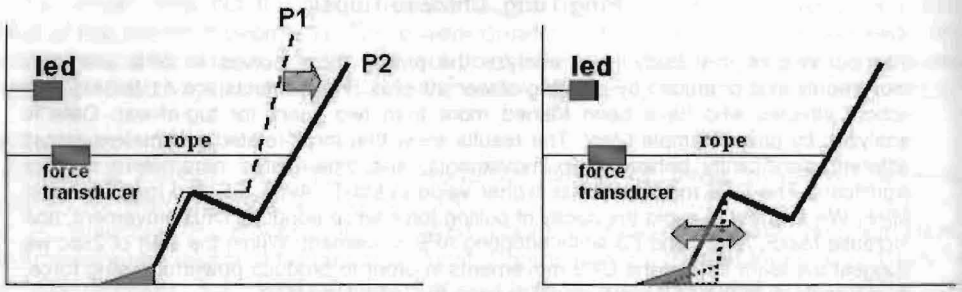
Parameters' definition of pulling force curves: As Figure 2 shows, the parameters' definitions are as follow:

Maximal pulling Force Value [MaxF]: The peak value of pulling force within five seconds after the start of the competition.

Minimum pulling force value [MinF]: The minimal value of pulling force within five seconds after the start of the competition.

Average Force Value [AveF]: The average value of pulling force within five seconds after the start of the competition.

Reaction Time [RT]: The duration time from the LED signal brightens to the pulling force value starts to change.
Force Slope [FS]: (MaxF-MinF)/(the time of MaxF-the time of MinF).



a.defend fast break movement b.attack fast break movement

Figure 1 The defend break movement (a) and attack break movement (b).

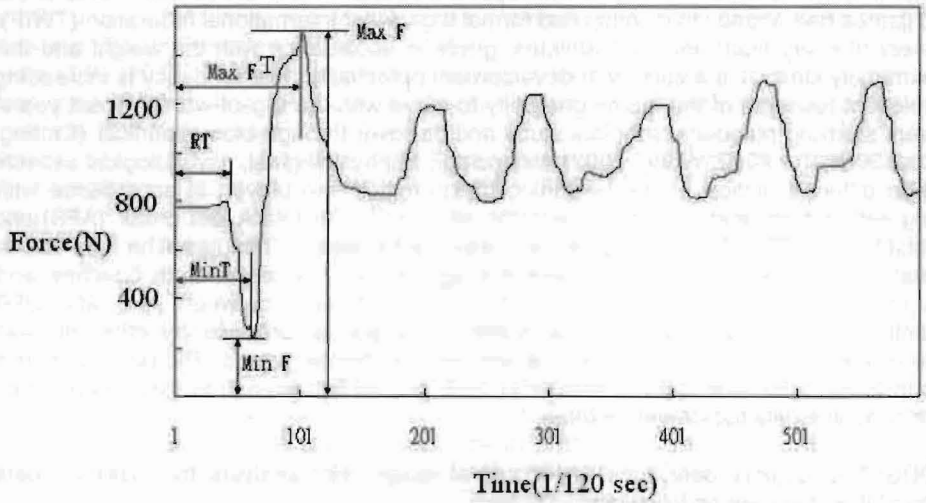


Figure 2 The parameters of pulling force curve.

Experimental design: Every subject has three times of pulling force curves to be collected in DFB and AFB movement separately, and seven parameters are computed from each force curves. The rest time is more than ten minutes between each data collection. The statistic analysis tool, SPSS for Windows 12.0 and paired-sample t-test, is used to analyze the data.
Main equipments: Main equipments of this study contain pulling force transducer (600 Hz), high speed camera (120 Hz), multi-function biovision feedback system, and synchronous signal generator (Figure 3).

RESULTS AND DIOCUSION: The Table 1 shows the parameters of pulling force curves that produced by the subjects both in AFB and DFB movements. The statistic result shows that force-related parameters are all different significantly between two movements ($p < .001$ in MaxF, MinF, and FS; $p < .005$ in AveF), and the time-related parameters are not significant. The DFB movement has higher value in MaxF, AveF, FS and lower value in MinF. In the DFB movement, the subjects decrease their knee and hip joints to get lower MinF. In the AFB movement, the subjects try to move their foot as fast as possible for not decreasing their knee and hip joints obviously and getting higher MinF. The pulling force is equal to the

frictional force that subjects contact with the ground. In the DFB movements, the subjects get the static frictional force that is higher than the dynamic frictional force. However, in the AFB movements, the subjects get the dynamic frictional force. The DFB movements could produce more powerful pulling force than the AFB movements. The risk will increase that opponents can destroy your team formation if you always keep in the static formation.

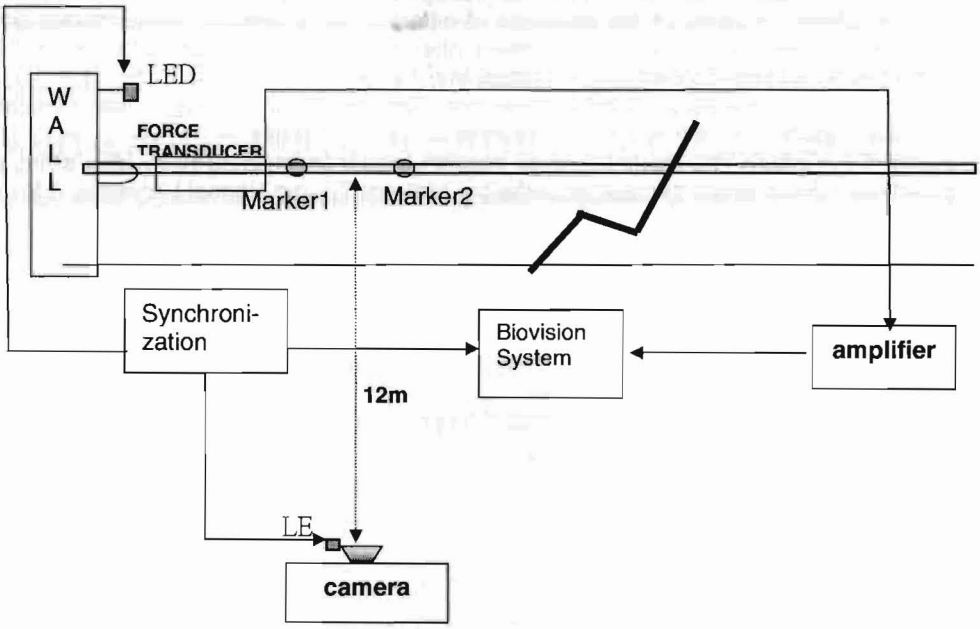


Figure 3 Main equipment.

Table 1 The value of parameters in different start movements and the summary of paired-sample t-test.

Dependent variance	movement	n	M	SD	t	sig.
MaxF(N)	AFB	11	927.4	193.6	4.971***	0.000
	DFB	11	1235.8	115.4		
MinF(N)	AFB	11	505.1	91.6	-7.280***	0.000
	DFB	11	263.1	69.1		
AveF(N)	AFB	11	666.0	56.2	3.551**	0.004
	DFB	11	709.1	50.6		
FS(N/sec)	AFB	11	1893.8	1108.4	7.276***	0.000
	DFB	11	4024.9	736.9		
MaxT(sec)	AFB	11	0.84	0.13	-0.380	0.712
	DFB	11	0.82	0.11		
MinT(sec)	AFB	11	0.62	0.12	-1.035	0.325
	DFB	11	0.58	0.09		
RT(sec)	AFB	11	0.45	0.09	-1.715	0.117
	DFB	11	0.39	0.05		

*p<.01, **p<.005, ***p<.001

CONCLUSION: As regards technological view, we suggest to avoid the decay of pulling force value while adopting DFB movement, and increase MaxF, AveF, and FS while adopting AFB movement. Within the start of 2sec we suggest the team to take the DFB movements in order to produce powerful pulling force, then transform to the AFB movements to keep the team formation.

By the point of the parameters of pulling force curves to diagnose the tug-of-war's technology is a feasible and effective way.

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