THE STUDY OF TEAM RESULTANT FORCE VANISHING PERCENTAGE IN ELITE TUG OF WAR PLAYERS

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This study was to analyze the factor of team pulling force vanishing percentage between groups with different numbers players and the largest pulling force with unsteady motion in tug of war after sitting posture between players. The motion of nine female senior high school players(age = 16.9 ± 0.6 years, height = 163.8 ± 2.7 cm, mass = 58.7 ± 4.3 kg) in tug of war was synchronized with a high-speed camera(JVC9800, 60 Hz)and a tensile (TEDEA, 900 Hz). The pulling force was gained by DASYlab6.0. The variance of the angle between the rope and ground was analyzed by Silicon Coach from the film, consisted by two to eight players. Results: The team pulling resultant was smaller than the sum of individual players. The vanishing percentage of pulling force was increase with the number of players. The factor of force vanishing was the coordination between players. The larger numbers players are, the lower coordination was. This is so called Ringlemann effect; the factor was timing of the maximal pulling force with each player, therefore coordination was decreasing with the numbers of players, so was force.

KEY WORDS: tug of war, pulling force, force vanishing, vanishing percentage

INTROUCTION: In tug-of-war, it is a key point of winning that the maximal effort between players. Whenever vanishing percentage of the team is not 100%, the vanishing of motivation will occur. In Ringlemann's study, to investigate the relation between individual and team work with variance of player's numbers (1 player, 2 playesrs,3 players,8 players) found that the correlative work from each individual was decreased with the increasing player's numbers of the team (93% for individual –two players, 85%-three players, 49%-eight players). It is so called Ringlemann's effect. Ivan Steiner (1972), developing a model to describe the relation between the work of individual and coordination in players, said that the actual team performance was equal to work of individual minus the vanishing work dual to vanishing percentage of the team. Tu (1997) said that the deficiency was mainly dual to coordination between individual. Thus, this study was to investigate the vanishing force resulted from body coordination and the relationship between body posture and the team horizontal pulling force in biomechanical viewpoint. The purpose of this study was to analyze the factor of team pulling force vanishing percentage between groups with different numbers players and the maximal pulling force with unsteady motion in tug of war after sitting posture between players.

METHODS: Nine female senior high school players in tug of war (age = 16.9 ± 0.6 yrs, height = 163.8 ± 2.7 cm, weight = 68 ± 6.04 kg) participated in this study. Before the trail, the tensile meter connected by an amplifier, a Biovision feedback system, an A/D card and a computer with DASY Lab6.0 software. The tensile meter rectified by two weights (0 kg and 50 kg). Then participants were instructed to perform six kinds of team pulling, (A) two players (8 group in all, 1-2, 3-4, 5-6, 7-8, 1-3, 2-4, 5-7, 6-8); (B) three players (5 group in all, 1-2-3, 4-5-6, 7-8-9, 1-3-5, 2-4-6); (C)four players (3 group in all, 1-2-3-4, 5-6-7-8, 1-3-5-9); (D)five players(3 group in all, 1-2-3-4-5, 6-7-8-9-1, 1-3-5-7-9); (E) six players (2 group in all, 1-2-3-4-5-6, 7-8-9-4-5-6); (F) seven players (2 group in all, 1-2-3-4-5-6-7, 8-9-3-4-5-6-7); (G) eight players (2 group in all, 1-2-3-4-5-6-7-8, 9-2-3-4-5-6-7-8), which discussed the maximum. tensile value and the vanishing work dual to vanishing percentage of team. The calculation of vanishing percentage showed in equation (1).

$$F_l = \frac{\sum_{i=1}^{8} F_i - F_t}{\sum_{i=1}^{8} F_i} \times 100\% \qquad (1)$$

(Where F_l was the vanishing percentage, $\sum_{i=1}^{8} F_i$ was the sum of pulling of individual, the F_t was Team of maximal pulling force)

A high-speed camera (JVC980, 60 Hz) were used to two-dimension cinematograph analysis at sagittal plane, and were used to sample the raising movement after sitting of tug-of war. The Silicon Coach Software used to calculate the angle of rope of tug of war and horizontal floor.

RESULT AND DISCUSSION: Two dimensions of our results: 1. the discussion about the maximal pulling force after unsteady sitting posture and the team pulling force with different player's numbers in tug-of war.2.the factor of team pulling force vanishing: From Table1, the sum of maximal individual pulling force were larger than team maximal pulling force. The vanishing percentage of team pulling force with different player's numbers from our experiment: 8.82 ± 5.59%, for two players, 10.72 ± 3.63%, for three players, 19.74 ± 2.22%, for eight players. Comparing with Ingham and colleagues (1974) study's result that 7%, for two players, 15% for three players, 51% for eight players, the vanishing percentage of team pulling force in our experimental data was small. The factors were possibly due to the level of participant's skill and type of skill practice. Ivan Steiner (1972) said this was what we called "the actual output pulling force within the team was equal to the sum of individual maximal performance minus the vanishing force resulted from vanishing percentage of the team".

Table 1   Sum of individual maximal pulling force, team of maximal pulling force and force vanishing percentage.

Force \ Player	*Sum of individual maximal pulling force (kgf)	Team of maximal pulling Force (kgf)	Force vanishing percentage (%)
2 players	190.05±19.17	173.29±7.99	8.82±5.59
3 players	283.91±9.64	253.47±16.90	10.72±3.63
4 players	371.16±16.44	330.07±9.18	11.07±3.63
5 players	440.20±4.29	390.75±17.35	11.11±6.53
6 players	511.37±11.29	459.03±19.24	10.23±3.98
7 players	602.53±6.78	544.62±9.64	9.61±1.43
8 players	707.12±15.11	567.54±10.68	19.74±2.22

* Sum of individual maximal pulling force: individual maximal pulling force add individual maximal pulling force (ex: No.1 player maximal pulling force add No.2 player maximal pulling force)

Figure 1 show the vanishing percentage at two players, three players, until eight players, and the large numbers players were, the lower coordination were. In six players and seven players, the vanishing percentage had less than four players and five players at this study which was not the same result as the Ita (1993). It might be the factor of different participants' experience, age, sex of this study caused the appearance of lower coordination. However, there was increased in vanishing percentage of the eight players. These results showed the more number of players, the high vanishing percentage.
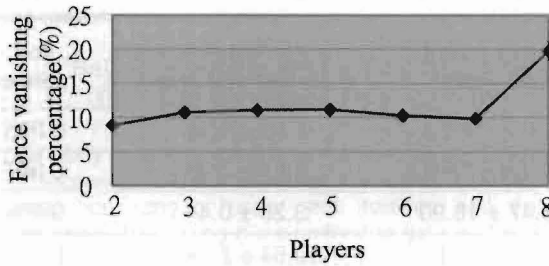
Figure 1 Team of different player's numbers and force vanishing percentage.

The analyses of team pulling force vanishing percentage:Force is an vector with proportion and direction, in our data (Table 2) Every individual of maximal pulling force time is different(Number one to nine player of maximal pulling force time: 0.6 ± 0.2 sec, 0.4 ± 0.2 sec, 0.7 ± 0.2 sec, 1.0 ± 0.3sec, 0.4 ± 0.2 sec, 0.8 ± 0.2 sec, 0.3 ± 0.1 sec, 0.5 ± 0.3 sec, 0.5 ± 0.2 sec) the player mean of maximal pulling force time was 0.5 ± 0.2 sec, the mean of maximal pulling force was 94.60 ± 12.16 kg, maximal pulling force time was mean to player form to prepare to twinkling the time of maximal pulling force. Because were different time of the maximal pulling force with every player, therefore coordination were decreasing with the number of players, and force was decreasing, too, and the team pulling resultant was smaller than the sum of individual players. Tu (1997) said that the deficiency was mainly dual to coordination between individual.

Table 2 The time of maximal pulling force of tug-of-war player individual.

Subject	1	2	3	4	5	6	7	8	9	M±SD
Individual of maximal pulling force time(s)	0.6± 0.2	0.4± 0.2	0.7± 0.2	1.0± 0.3	0.4± 0.2	0.8± 0.2	0.3± 0.1	0.5± 0.2	0.5± 0.3	0.5± 0.2
Maximal pulling force(kgf)	82.9 ±4.25	93.3 ±6.81	115.2 ±9.46	111.74 ±10.61	91.9 ±9.33	86.18 ±6.10	86.12 ±3.18	104.5 ±7.56	79.56 ±5.48	94.6 ±12.16

Table 3 show the angle between rope and ground was decreasing with the number of players, the angle between rope and ground of one player was 4.89 ± 1.16°, two players 3.97 ± 0.49°, three players 3.26 ± 0.44°, four player 2.54 ± 0.34°, five players 2.17 ± 0.27, six players 2.16 ± 0.22, seven players 1.47 ± 0.20, and eight players 1.11 ± 0.16°, and the value of cos number be close to 1, because to increase players and the center of gravity was decreasing, too, The reason was to maintain the power and shape of the team. The smaller the angle was the larger horizontal pulling force was.

CONCLUSION: The vanishing percentage of pulling force was increase with the number of players. The factor of force vanishing was the coordination between players. The larger numbers players are the lower coordination was. This is so called Ringlemann effect; The angle between rope and ground was decreasing with the number of players. The reason was to maintain the power and shape of the team. The smaller the angle was the larger horizontal pulling force was.

Table 3 Compare largest pulling force and horizontal pulling force.

Parameter / Player	Maximal pulling force(kgf)	The angle between rope and ground of number(°)	cos number	Horizontal pulling force(kgf)
1 player	64.47 ± 18.23	4.89 ± 1.16	0.996	64.24 ± 18.23
2 players	173.29 ± 7.99	3.97 ± 0.49	0.997	172.77 ± 7.98
3 players	253.47 ± 16.90	3.26 ± 0.44	0.998	252.96 ± 16.89
4 players	330.07 ± 9.18	2.54 ± 0.34	0.998	329.41 ± 9.17
5 players	390.75 ± 17.35	2.17 ± 0.27	0.999	390.35 ± 17.35
6 players	459.03 ± 19.24	2.16 ± 0.22	0.999	458.57 ± 19.23
7 players	544.62 ± 9.64	1.47 ± 0.20	0.999	544.08 ± 9.64
8 players	567.54 ± 10.68	1.11 ± 0.16	0.999	566.97 ± 10.68

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