Physical Factors Affecting the Strength of Arm Wrestling

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Abstract

Arm-wrestling is known as an easy-to-use, friendly play or competition. Since arm-wrestling is won by involving the opponent's arm and falling down, it is said that the size of the body frame, the grip strength, which is the gross muscle strength of the entire arm, or the effective mechanical activity of the muscle groups is important. However, there has been no research on the factors that are effective in winning arm wrestling. Therefore, we examined the factors necessary to win arm wrestling by examining the arm wrestling rate and forearm length, weight, grip strength, and maximum internal rotation vector value of the shoulder joint by using 16 healthy 20-22 years old as subjects. The relationship was examined statistically by Spearman's correlation coefficient. Then, using a multiple regression analysis, the winning rate of arm wrestling was analyzed as a dependent variable, and items with significant correlation were analyzed as independent variables. As a result, it was found that the winning rate of arm wrestling has a high correlation between forearm length and the maximum internal rotation vector value of the shoulder joint, and the latter is particularly involved.

Introduction:

In recent years, it is said that public awareness of health has increased. In particular, fitness club users are increasing year by year due to a growing tendency to improve muscle strength. [1] Arm wrestling has become a quiet boom with competitions held all over Japan in that trend. Arm wrestling does not require any special skills or places and can be easily performed by anyone of all ages. While it has been used as a general play since ancient times, it is also a world-renowned sport, with international competition regulations established by the World Arm Wrestling Federation. In recent years, arm wrestling has been actively studied in the field of human interfaces such as virtual models and robot systems, but few studies have performed kinetic analysis of arm wrestling performed by humans. [2-5] the actual movement of the upper limb during arm-wrestling is kinematic analyzed to be the internal rotation of the shoulder joint with the elbow axis. Therefore, in this experiment, a floor reaction force meter reproduced the same situation as arm wrestling, analyzed the three forces of the longitudinal component, horizontal component and vertical component, and calculated the maximum internal rotation vector value for the shoulder joint. Then, forearm length, weight, grip strength, which is an index of coarse muscle strength of the entire upper limbs, and maximum internal rotation vector value of the shoulder joint were measured as factors for winning arm wrestling, and the relationship with the winning rate by round-robin arm wrestling were examined.

Materials and Methods:

Subjects were 16 healthy males with right-handed ages 20 to 22. In addition, the body weight was 65 kg or more and less than 70 kg according to the class of the arm wrestling All Japan Games. First, the forearm length and weight of all 16 subjects were measured, and the experimental limb position was a sitting position, and the grip strength was measured with the experimental limb as the upper right limb. Next, trials of arm-wrestling were performed at the elbow joint 90 °, wrist joint 0 °, and forearm intermediate position on the force plate (CFP03000A, Leptrino Co., Ltd, Nagano, Japan) (Figure1). Then, the longitudinal component value (Fx) and the horizontal component value (Fy) at the time of exerting the maximum floor reaction force vertical component (Fz) were analyzed. The resultant force was defined as the maximum internal rotation vector value of each subject's shoulder joint(Figure2). The experiment was performed three times, and the maximum values of the grip strength and the maximum internal rotation vector value of the shoulder joint were adopted. Next, the 16 subjects performed an arm-wrestling round-robin battle, and examined the relationship between forearm length, weight, grip strength, maximum internal rotation vector value of the shoulder joint, and the winning rate of arm-wrestling using Spearman's rank correlation coefficient. The time limit for the match was 30 seconds or less, and if the match was not reached within 30 seconds, it was judged as a draw. Next, using a multiple regression analysis, the winning rate of arm-wrestling was analyzed as a dependent variable, and items with significant correlation were analyzed as independent variables. In addition, this study was approved by Hiroshima cosmopolitan University Ethics Committee (approval No. 1824), all subjects received an adequate description of the experiment and agreed before participating in the experiment.

Figure1: Trials of arm-wrestling was performed at the elbow joint 90 °, wrist joint 0 °, and forearm intermediate position on the floor reaction force meter
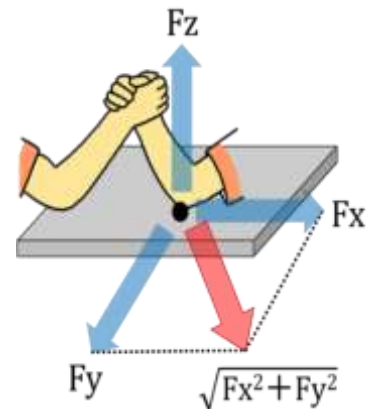

Figure2: Definition of shoulder joint maximum internal rotation vector value on the floor reaction force meter.
The resultant force of the floor reaction force sagittal component (Fx) and the floor reaction force horizontal component (Fy) when the maximum floor reaction force vertical component (Fz) appears.

Results:

Table 1 shows the results of the winning percentage of arm wrestling, forearm length, weight, grip strength, and maximum internal rotation vector value of the shoulder joint of all 16 subjects. Table 2 shows the results of the arm wrestling round-robin battle of all 16 subjects. The results of Spearman's rank correlation coefficient are shown in Table 3. The winning percentage ranking showed a high positive correlation with the internal rotation vector value of the shoulder joint (R = 0.75, p <0.05), followed by forearm length (R = 0.64, p <0.05) and grip strength (R = 0.45, p <0.05). It showed a moderate positive correlation. The correlation with body weight was low, with R = 0.31, p <0.05. Table 4 shows the results of analysis using multiple regression analysis with the shoulder joint internal rotation vector value, forearm length, and grip strength, which were correlated with the winning percentage ranking of arm wrestling, as independent variables. In multiple regression analysis, shoulder joint internal rotation vector value (standardization coefficient -0.26, p <0.01),

forearm length (standardization coefficient -0.37, p <0.01), grip strength (standardization coefficient-0.42, p <0.01)) are related factors for the round-robin win rate ranking of arm wrestling.

Discussion:

It is generally said that in order to win in arm wrestling, the forearm is longer as a lever arm, the weight that can be loaded on the arm is heavier, and the strength of the entire arm is stronger. All of these refer to mechanical advantages. Aikawa et al. study also states that the relationship between force and position is important when performing special exercises such as arm wrestling. [6] On the other hand, in the case of trauma caused by arm wrestling, damage to the subscapularis muscle, which is pushed by the opponent during arm wrestling and has an internal rotation of the shoulder joint, and spiral fracture of the humerus trunk are likely to occur. In addition, it is often reported that biceps tendon rupture is likely to occur due to forced elbow joint extension and forearm supination. [7-9] All of these indicate that a strong force in the external rotation direction is applied to the upper arm during arm wrestling. This also supports that the internal

rotation of the shoulder joint is greatly involved as a kinematic factor in addition to the mechanical factor in order to win in arm wrestling. In an experiment conducted by Yamada to analyze human arm wrestling and reflect it in a robot, the internal rotation of the shoulder joint has also attracted attention. [10] In this study, we investigated the relationship between the round-robin battle results of arm wrestling and the factors required to win, including the evaluation of the internal rotation muscle strength of the shoulder joint. As a result, the winning percentage ranking had the highest correlation with the internal rotation vector value of the shoulder joint, and the R value = 0.75, showing a high positive correlation. Next, the correlation with forearm length was R value = 0.64, and the correlation with grip strength was R value = 0.45, showing a positive correlation. The correlation with body weight showed a low correlation with R value = 0.31. From these facts, it was found that by strengthening the shoulder joint internal rotation muscle group and efficiently exerting the shoulder joint internal rotation vector, it is possible to win the arm wrestling or prevent the trauma that occurs during the arm wrestling.
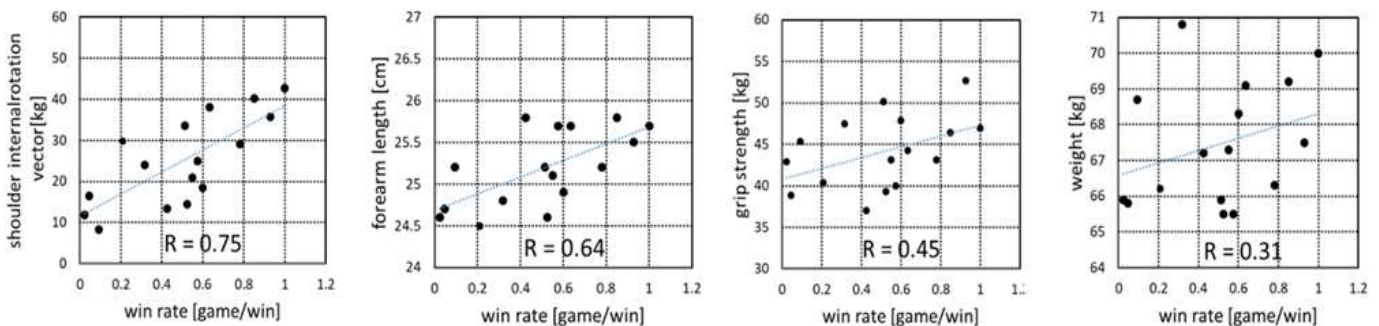
Table1: Round-robin arm wrestling win rate, forearm length, grip strength, maximum internal rotation vector value of shoulder joint for all subjects

	win rate	forearm length	weight	grip strength	shoulder internal rotation vector/weight
A	1.00	25.7	70.0	46.9	42.7
B	0.93	25.5	67.5	52.7	35.8
C	0.85	25.8	69.2	46.4	40.1
D	0.78	25.2	66.3	43.1	29.2
E	0.63	25.7	69.1	44.2	38.0
F	0.60	24.9	68.3	47.8	18.4
G	0.58	25.7	65.5	40.0	24.9
H	0.55	25.1	67.3	43.1	20.9
I	0.53	24.6	65.5	39.3	14.4
J	0.51	25.2	65.9	50.1	33.6
K	0.43	25.8	67.2	37.0	13.4
L	0.32	24.8	70.8	47.4	24.1
M	0.21	24.5	66.2	40.4	29.8
N	0.09	25.2	68.7	45.3	8.2
O	0.05	24.7	65.8	38.8	16.5
P	0.02	24.6	65.9	42.8	11.9

Table2: Results of arm wrestling round-robin battle for all subjects

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	win	lose	draw	win rate
A		3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	45	0	0	1.00
B	0-3-0		2-0-1	2-0-1	2-0-1	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	39	3	3	0.93
C	0-3-0	0-2-1		2-0-1	2-0-1	2-0-1	3-0-0	2-0-1	2-1-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	34	6	5	0.85
D	0-3-0	0-2-1	0-2-1		3-0-0	2-0-1	2-0-1	2-1-0	2-1-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	32	9	4	0.78
E	0-3-0	0-2-1	0-2-1	0-3-0		2-1-0	1-1-1	2-1-0	2-1-0	1-1-1	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	26	15	4	0.63
F	0-3-0	0-3-0	0-2-1	0-2-1	1-2-0		2-1-0	2-1-0	1-1-1	1-1-1	2-0-1	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	24	16	5	0.60
G	0-3-0	0-3-0	0-3-0	0-2-1	1-1-1	1-2-0		2-1-0	1-1-1	1-1-1	2-0-1	3-0-0	3-0-0	3-0-0	3-0-0	3-0-0	23	17	5	0.58
H	0-3-0	0-3-0	0-2-1	0-2-1	1-2-0	1-2-0	1-2-0		1-1-1	2-1-0	2-0-1	2-0-1	3-0-0	3-0-0	3-0-0	3-0-0	22	18	5	0.55
I	0-3-0	0-3-0	1-2-0	0-2-1	1-2-0	1-1-1	1-1-1	1-1-1		1-2-0	1-1-1	2-1-0	3-0-0	3-0-0	3-0-0	3-0-0	21	19	5	0.53
J	0-3-0	0-3-0	0-3-0	0-3-0	1-1-1	1-1-1	1-1-1	1-1-1	2-1-0		1-1-1	1-1-1	3-0-0	3-0-0	3-0-0	3-0-0	20	19	6	0.51
K	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-2-1	0-2-1	1-1-1	1-2-0	1-1-1		2-1-0	2-0-1	3-0-0	3-0-0	3-0-0	17	23	5	0.43
L	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-2-1	1-2-0	1-1-1	1-2-0		2-0-1	2-0-1	3-0-0	3-0-0	13	28	4	0.32
M	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-2-1	0-2-1		3-0-0	3-0-0	3-0-0	9	34	2	0.21
N	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-2-1	0-3-0		1-1-1	3-0-0	4	39	2	0.09
O	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	1-1-1		1-1-1	2	41	2	0.05
P	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	0-3-0	1-1-1		1	43	1	0.02

Table3: Correlation between the round-robin win rate of arm wrestling and related factors

Conclusion:

We investigated the relationship between the Round-robin arm wrestling win rate results and the factors required to win, including the evaluation of the internal rotation muscle strength of the shoulder joint. As a result of investigating using Spearman's rank correlation coefficient, the winning percentage rank showed a high positive correlation with the shoulder joint internal rotation vector value, and showed a moderate positive correlation with forearm length and grip strength. In multiple regression analysis, the shoulder joint internal rotation vector value, forearm length, and grip strength were extracted as factors related to the winning percentage ranking of arm wrestling. From these results, it was found that the internal rotation vector value of the shoulder joint is greatly involved as a factor for winning in arm wrestling.

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