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KINEMATIC AND ELECTROMYOGRAPHIC ANALYSIS OF UPPER EXTREMITY IN ARM WRESTLING

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Few studies of the kinematic features of arm wrestling exercise have been published. The purpose of this study was to initiate a concrete analysis of the kinematic characteristics and muscular activities involved in arm wrestling exercise. 12 healthy male volunteers were recruited in this study. The pectoralis major (PMJ) showed significantly higher muscle activity in winning position than in losing position (p=.039) and had significant influence on arm wrestling outcome (p<.01), but it did not have significant impact on the other three muscles. The flexor carpi ulnaris (FCU) of winners showed higher muscle activity than losers. Our investigation revealed that PMJ was an important muscle in arm wrestling, and FCU may play key role in arm wrestling match to gain advantaged position.

KEY WORDS: elbow joint; EMG; injury.

INTRODUCTION: Arm wrestling, a sport with two participants and palm-to-palm grip at thumb, has been one of the most popular contests in some countries. Free hand will grip the hand peg provided at the table edge (United States Arm Wrestling Federation). Technique and overall arm strength are the two greatest contributing factors to winning an arm wrestling match. Secondary factors are the length of wrestler's arm, muscle, arm mass/density, hand grip size, wrist endurance, flexibility and reaction time. Studies of arm wrestling have been very limited; furthermore, those studies were mostly case reports on fractures. The distal third of the humerus spiral fracture along with the fracture type of butterfly fragment was often found in fracture case studies on adults (Ogawa & Michimasa, 1997; Whitaker, 1977). One of two possible reasons is that the distal third of the humerus is the smallest part of the complex, and therefore the moment of inertia is the lowest; the other one is in the diaphyseal-metaphyseal junction that is thinner than humeral in any area (Nyska, et al., 1992). This fracture of the humerus is usually caused by the power of bending, the axial compression and torsional forces. But unlike adults, medial epicondyle avulsion fracture is frequently observed in youth's arm wrestling (Moon, et al., 1980). To our knowledge, few studies of the kinematic features of arm wrestling exercise have been published. The purpose of this study was to initiate analysis of the kinematic characteristics and muscular activities involved in arm wrestling match.

METHODS: Twelve healthy male volunteers (ages: 22.6 ± 1.98 yrs; height: 177.3 ± 4.85 cm; weight: 71.2 ± 5.81 kg) who did not have any surgery experience on limbs nor any injury on limbs in last six months were recruited in this study. None of the participants had neuromuscular system related diseases. Participants were grouped into pairs who were similar in body weight, and anthropometric data of the dominant upper limb were provided in Table 1. Winning or losing a match was determined by the rules of WAF (World Arm Wrestling Competition Federation). The raw EMG signals were digitized at 1000 Hz by the EMG system (MA300-16, Motion Analysis Corporation, USA) with the surface electrode to record the activity of pectoralis major (PMJ), latissmus dorsi (LSD), infraspinators (IFS), and flexor carpi ulnaris, (FCU) and comparison of the muscle activities between winners and losers was to be done. On the detected muscles, two active shoulder internal rotators, PMJ and LSD, functioned for winning the arm wrestling. Wrist flexor controlled the motion of wrist. Hand was the only segment attached to the competitor and transferred the force produced by

the trunk, upper arm and forearm muscles against the competitor. The Eagle® motion system (Motion analysis Corp., Santa Rosa, CA, USA), including the host computer system and eight digital cameras (Eagle CCD cameras) and camera hosts (Eagle Hub) at sampling rate of 100 Hz, was used to capture the kinematics during the race tracks. One successful trial (from preparatory position to winning position which finished the match in 30 seconds) was collected for data analysis. An arm wrestling worktable with reference to WAF was used. Bandpass filter (5 to 300Hz) was used for filtering, and the root mean square (RMS) value was taken to represent the data. The activity level and the figure used the mean of RMS value for every 0.5 s during the game to compare winning and losing positions in four muscles. MATLAB was applied to find out the change of joint angles through the Newton's Euler equations. In this study, independent t-test was used to analyze relative activation of four different muscles' EMG between the winner and loser, and relative differences in muscle EMG activation between the winning and losing positions were compared. Regression analysis was used to show if some of the muscles could influence match outcome or position. Statistical significance level was set as $\alpha = 0.05$.

Table 1
Anthropometry of the dominant upper extremity

	Winner/winning position	Loser/losing position	*p*-value
Length			
Upper arm	32.6±1.14	33.2±2.17	0.357
Forearm	28±0.35	28.3±1.86	0.082
Hand	19.2±0.91	19.3±1.3	0.463
Circumference			
Chest	89.4±5.87	88.5±4.58	0.736
Upper arm	28.6±2.13	28.3±1.35	0.621
Forearm	22.5±1.32	22.8±1.35	0.936

RESULTS: Available results were recorded in only four of six groups which were defined wining. The muscle activity ratio had been normalized by the maximum manual muscle strength test (MMT). Only PMJ has showed the significantly higher muscle activity in winner/winning position than in loser/losing position (p=.039). FCU of wining position showed higher muscle activity than of losing position. Figure 1 showed the comparison of four muscles activity level in winning and losing positions and the mean of RMS value for every 0.5 s was used during the game.

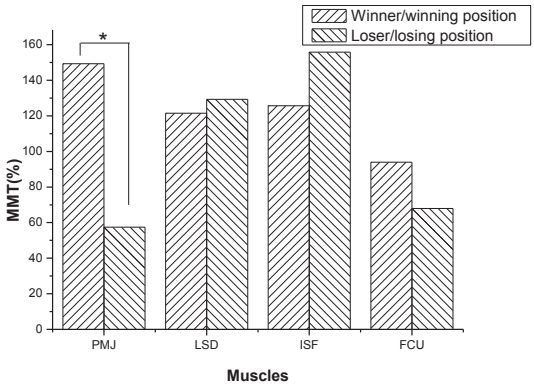

Figure 1: Comparing winning and losing positions during arm wrestling (*p<.05)

Regression analysis showed that PMJ had significant influence on arm wrestling outcome (p<.01) but no significant impact on the other three muscles. The upper arm, forearm, hand, chest, upper arm and forearm of subjects did not show significant differences in both positions. The elbow joint movement showed flexion during first half of the match and extension later in winner; extension first and flexion later in loser; the winners had more wrist flexion (about 15 degrees) than losers. The mean range of motion was 18 degrees in winner (highest at 43 degrees) and 26 degrees in loser (highest at 45 degrees).

DISCUSSION: Studies regarding the arm wrestling have not been abundant, and previous studies mostly focused on fracture (Khashaba, 2000; Ogawa & Michimasa, 1997; Moon, et al., 1980; Nyska, et al., 1992; Parker, 2008; Torchia, 1998; Whitaker, 1977). Therefore, it is challenging to compare this study with others. All of winning positions (149 MMT%) demonstrated higher muscle activity than losing position (57 MMT%) in PMJ. Furthermore, significant influence of PMJ on arm wrestling match indicated that PMJ was the important muscle in arm wrestling. In our study, the activity of PMJ was higher in winning position than in losing position. It might be due to a good effort in winning position of PMJ. Winners' elbow flexed, while the trunk attached closely to the table in the first half of match. That could be explained by the fact that elbow flexion and closeness between the trunk and the table were important elements to gain advantage position in arm wrestling match. On the contrary, losers lost the advantaged position and found it difficult to exert force. Competitor had to press the opponent, therefore winner had to press the back of a hand of loser to the pad with elbow extension while loser had flexion. Winners had pressed their chest to table and elbow flexion might be a good way to PMJ contraction. Therefore PMJ was more active in winners than in losers.
The same condition on another internal rotator LSD was not found. The trunk position might affect the muscle length and activity of LSD. Participants would use different trunk position to assist force production. No rule was made for them to hold the trunk position. It also occurred in IFS muscle. It was not clear how the winning and losing positions during the game affected the muscle activity.
The FCU did not show significant differences between winning and losing positions. However, the higher activity in FCU for winning position and low activity for losing position might be due to the wrist position during the game and muscle activity level in the beginning of the game. Wrist is the key joint to transfer force to against competitor. Thus, the wrist position may affect muscle activity level and force production. Usually, winner's wrist position will keep in neutral to slight flexion that is contributive to force production and transfer. Some winners have more wrist flexion than losers, which may explain that winners have more grip and wrist flexor strength than losers. Therefore winners take the advantaged position to win. Grip strength may be an important factor in arm wrestling match to get the advantaged position. IFS is an antagonist muscle during the process of arm wrestling and maintains joint stability (Baratta, et al., 1988). But in this study significant differences between winning and losing positions were not observed.
Arm wrestling match have some characteristics, such as maximum effort and long maintenance of force. Different people have different tactics and different dominant muscles properties. Therefore, muscle property adapts to changing activity, which may activate the potential in arm wrestling, and this is the reason why the MMT is mostly larger than 1 in this study. Since the arm wrestling survey is limited, finding match property is important to training guidelines for arm wrestlers and coaches.

CONCLUSION: PMJ showed significantly higher muscle activity in winning position than in losing position and had significant influence on arm wrestling outcome, but it did not have significant impact on the other three muscles. FCU of winners showed higher muscle activity than of losers. Our investigation revealed that PMJ was the most important muscle in arm wrestling, and FCU may be an important muscle in arm wrestling match to gain advantaged position. Winners having elbow flexion in the first half of match might take advantaged

position. Further investigation is required in order to determine whether it is possible to promote the performance by improving the strength of PMJ in the arm wrestler.

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