BIOMECHANICAL CHARACTERISTICS OF THE WRIST JOINT MUSCLE IN CHINESE ADULTS

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The purpose of this study was to (1) establish the biomechanical characteristics of the wrist muscle in normal Chinese adults, (2) provide scientific information for the evaluation of sports techniques, strength training, sports injuries, and rehabilitation, (3) provide basic data for muscle building, injury and rehabilitation in the general population. A total of 69 adults cross-country participated in this study. The following conclusions were drawn: (1) With increasing angular velocity, peak torque and total work declined, but average power increased, (2) Peak torque, total work and average power of wrist flexion were greater than wrist extension.

KEY WORDS: isokinetic, concentric, wrist muscle, normal adult, biomechanics

INTRODUCTION: The wrist joint is an important contributor to a lot of sports, such as ball games, fencing, throwing etc. Although studies exist into shoulder, knee, elbow, and ankle function in various sports for athletes, there are very few in adults, particularly on the wrist joint. The characteristics of Chinese adults' muscle joint strength might be different from those of people from other countries because of different races, hence there is a need to study the biomechanical characteristics of Chinese adults' wrist muscles. The purpose of this study was to (1) establish the biomechanical characteristics of the wrist muscle in Chinese adults, (2) provide scientific information for the evaluation of sports techniques, strength training, sports injuries, and rehabilitation,(3) provide basic data for muscle building, injury and rehabilitation in the general population. A total of 69 adults cross-country participated in this study.

METHODS: A total of 69 adults (35 male, 34 female; Table 1) volunteered as subjects for this study. All subjects were healthy, and had not performed muscular strength training before testing. None reported history of wrist injures or surgery.

Table 1 Descriptive Data for Subjects

Sex	Number	Age (year)		Height (cm)		Mass (kg)	
		Mean	SD	Mean	SD	Mean	SD
Male	35	20.0	1.2	170.3	5.8	62.0	8.6
Female	34	20.1	1.3	158.3	5.7	53.2	6.4

A Cybex-6000 isokinetic dynamometer system using computer-aided program, as well as an Upper Body Exercise Testing Table (UBXT) (Cybex Division of Lumex, Inc., Ronkonkoma, NY), were used to measure wrist flexor and extensor muscular strength, total work and average power. Measurements were performed with the subjects in the sitting position on the UBXT, with the elbow flexed to 90°. The forearm was immobilized in a V-pad with a Velcro strap. The dynamometer rotation axis was slightly oblique through the wrist just distal to the tubercle of the radius and the head of the ulna (approximately where the hand met the wrist). Isokinetic strength was determined from three repetitions at the constant velocities 30°/sec, 60°/sec, 120°/sec, 180°/sec and 240°/sec (concentric contraction), with 2 minutes rest between measurements. The order of speeds was randomized. When all subjects had completed the concentric test, each performed an isokinetic eccentric test. Full information about the equipment and test protocol was provided. After a warm-up, the test started. During the test, subjects were asked to exert maximal effort, and were verbally encouraged.

Two submaximal repetitions were performed before recording data at each speed.

A SPSS statistical software package was used to analyze the data. Differences between mean values were tested for significance using Student's t test. An alpha level of 0.05 was selected as the level of significance for all analyses.

RESULTS: The mean and standard deviation (SD) of peak torque, total work, average power, their flexion/extension ratio and corresponding relative values (divided by body mass) are presented in Table 2.

1.Peak torque. The peak torque declined with increasing angular velocity. When angular velocity increased from 30º/s to 240º/s, peak torque of wrist flexion and extension for males declined from 13.06 N.m, to 7.63 N.m, and 9.94 N.m to 6.91 N.m respectively; for females, peak torque declined from 7.27 N.m, to 4.54 N.m, and 6.62 N.m to 4.26 N.m respectively. The trend for relative peak torque was the same as that for peak torque. Peak torque of wrist flexion was slightly greater than wrist extension, and peak torque and relative peak torque for males were greater than for females.

2.Total work. Total work values of the wrist isokinetic concentric contractions are shown in Table 3. For isokinetic concentric contractions, total work and relative total work declined with increasing angular velocity. When angular velocity increased from 30º/s to 240º/s, the total work of wrist flexion and extension for males declined from 18.06 J, to 10.26 J , and 13.37 J to 8.17 J respectively . For females, total work declined from 8.73 J, to 5.43 J, and 8.19 J to 4.91 J respectively. Total work of wrist flexion was greater than for wrist extension, and values for males were greater than for females. The change in flexion: extension ratio was non-significant at all angular velocities ($P > 0.05$).

3. Average power. From Table 4, it can be determined that the average power and relative average power increased with increasing angular velocity. When angular velocity increased from 30º/s to 240º/s, the average power of wrist flexion and extension increased from 4.49 W to 21.69 W, and 3.31 W to 16.26 W respectively. For females, average power increased from 2.04 W to 11.94 W, and 1.85 W to 10.43 W. Average power of wrist flexion was greater than wrist extension, and values for males were greater than for females. The change in flexion: extension ratio was non-significant at all angular velocities ($P > 0.05$).

Table 2 Peak Torque (PT), Relative Peak Torque (RPT) and their Flexion/Extension Ratio (Ratio) of Peak Torque (Unit: PT was N.m, RPT was N.m/kg.)

Speeds			30º/s	60º/s	120º/s	180º/s	240º/s
Fle	PT	M	13.06±3.00	10.86±2.90	10.14±2.46	8.74±2.47	7.63±2.20
		F	7.27±1.87	6.17±1.84	5.40±1.33	5.09±1.40	4.51±1.29
	RPT	M	0.21±0.05	0.17±0.05	0.16±0.04	0.14±0.04	0.12±0.04
		F	0.13±0.03	0.11±0.03	0.10±0.02	0.09±0.02	0.08±0.02
Ext	PT	M	9.94±2.30	8.80±2.19	8.17±2.18	7.29±2.16	6.91±2.03
		F	6.62±1.65	6.20±1.57	5.11±1.51	4.54±1.48	4.26±1.17
	RPT	M	0.16±0.04	0.14±0.04	0.13±0.04	0.11±0.04	0.10±0.03
		F	0.23±0.60	0.11±0.03	0.09±0.03	0.08±0.03	0.07±0.02
Ratio	M		1.37±0.38	1.28±0.41	1.30±0.39	1.27±0.46	1.15±0.33
	F		1.15±0.31	1.05±0.33	1.11±0.29	1.17±0.28	1.09±0.26

Note: Flx, Flexion. Ext, Extension. M, male, F, female.

Table 3 Total Work (TW), Relative Total Work (RTW) and their Flexion/Extension Ratio(Ratio)of Total Work (unit: TW is J, RTW is J/kg)

Speeds			30º/s	60º/s	120º/s	180º/s	240º/s
Fle	TW	M	18.06±4.95	15.14±3.91	13.34±3.12	11.74±3.05	10.26±3.13
		F	8.73±2.38	7.97±2.48	6.80±2.10	6.31±2.36	5.43±1.94
	RTW	M	0.30±0.08	0.24±0.06	0.21±0.05	0.19±0.05	0.16±0.05
		F	0.16±0.04	0.15±0.04	0.12±0.04	0.11±0.04	0.10±0.03
Ext	TW	M	13.37±3.01	11.69±3.45	10.26±3.00	8.94±2.76	8.17±2.53
		F	8.19±2.19	7.46±2.06	6.23±1.77	5.51±1.48	4.91±1.27
	RTW	M	0.21±0.06	0.19±0.06	0.16±0.05	0.14±0.05	0.13±0.05
		F	0.15±0.04	0.14±0.04	0.11±0.04	0.10±0.03	0.09±0.03
Ratio	M		1.41±0.43	1.36±0.38	1.37±0.36	1.39±0.41	1.31±0.37
	F		1.13±0.36	1.11±0.31	1.12±0.30	1.15±0.30	1.10±0.28

Table 4 Average power (AP), Relative Average Power (RAP) and their Flexion/Extension Ratio (Ratio)of Average (unit: AP is w, RAP is w/kg)

Speeds			30º/s	60º/s	120º/s	180º/s	240º/s
Fle	AP	M	4.49±1.42	7.83±2.16	13.94±3.27	18.00±4.61	21.69±6.10
		F	2.04±0.77	4.11±1.35	7.31±2.27	10.00±3.52	11.94±4.28
	RAP	M	0.07±0.02	0.12±0.03	0.22±0.05	0.29±0.07	0.35±0.10
		F	0.03±0.01	0.07±0.02	0.13±0.04	0.19±0.06	0.22±0.08
Ext	AP	M	3.31±0.93	5.86±1.91	10.46±3.02	13.69±4.05	16.26±5.00
		F	1.85±0.67	3.83±1.04	6.46±1.84	8.57±2.34	10.43±2.54
	RAP	M	0.05±0.02	0.09±0.03	0.17±0.05	0.22±0.07	0.26±0.09
		F	0.03±0.01	0.07±0.02	0.12±0.04	0.16±0.05	0.20±0.05
Ratio	M		1.46±0.64	1.43±0.50	1.40±0.40	1.39±0.40	1.41±0.45
	F		1.27±0.67	1.10±0.29	1.17±0.30	1.18±0.30	1.15±0.29

DISCUSSION: Results showed that peak muscle torque declined with increasing speed. These results agreed with previous findings (Li Guoping,1988; Jorgensen,1976; Perrine and Edgerton,1978; Knapik and Jones,1982) and Hill's (1938) equation**.** Concentric muscle torque was not only related to contraction speed, but also to the degree of muscle activation (excitability and muscle recruitment number). Baltzopoulos et al. (1989) presented a possible reason that there are differences in muscle fiber recruitment during muscle contraction. At 30º/s, shortening speed was low, hence shortening time increased, so participating muscle groups reached higher activation, resulting in a large peak torque. Muscular strength is lost when cross bridges detach, and when they are reformed. In addition, overcoming liquid viscosity of the contraction unit and connective tissue led muscular strength to decrease. Viscosity is positively related to contraction speed. Westing, S. H. et al., (1991) suggested that isokinetic contraction fully dependent on the contractile components of muscle, and that inhibition from the central nervous system increases at higher speeds, resulting in a decline in peak torque.

Muscle contraction is realized by changing chemical energy into heat and mechanical energy. During energy turnover, the muscle overcomes the resistance, displacement occurs, and it performs the work. In the concentric phase, the muscle performs positive work. Total work and relative total work declined with increasing angular velocity because peak torque declined with increasing speed.

Muscle power is an important parameter in many sports. Average power increased with increasing angular velocity when speed increased, the gradient of total work was less than that for time.

In daily life, people perform wrist flexion more often than wrist extension, which may contribute to the greater peak torque, total work and average power of wrist flexion. The difference between wrist flexion and extension in peak torque, total work and average power was non-significant ($P > 0.05$). The non athletic adult's wrist strength was less than that of the badminton athlete because the badminton athletes had training (Lu Deming, 1996).
The data above were useful for the evaluation of sports techniques, strength training, sports injuries, and rehabilitation.

CONCLUSION: The following conclusions were drawn:

1. With increasing angular velocity, peak torque and total work declined, but average power increased.
2. Peak torque, total work and average power of wrist flexion were greater than wrist extension.

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