■ 研究論文

*Journal of the Ergonomics Society of Korea*
Vol. 13, No.2, 1994

# Evaluation of Isokinetic Muscular Strength of Elbow Flexors and Extensors for Korean Adults

**Sang-Do Lee and Jae-Min Park* · Byung-Chul Yoo****

## ABSTRACT

It is not difficult to find risky manual material handling which requires various arm exertion for moving and assembling irregular stuffs in industries. Many of workers have been hurt on their muscular and skeletal system due to the manual material handling. This study is to provide data for isokinetic muscular strength elbow flexors and extensors of Korean male and female adults. Provided standard data for isokinetic muscular strength of elbow flexors and extensors can be used for scientific and systematic analysis of arm exertion.

## INTRODUCTION

Recently, manual material handling at industrial work sites and in daily life have been greatly decreased due to mechanization or automation of production processes. However, the manual material handling work which requires arm exertion in various forms of moving goods with unstable motion and of assembling parts which contain danger elements, have been performed at industrial work sites. Because of this type of work, the occurance of physically crippled cases has been increased due to injuries inflicted on the workers in the muscular skeleted system.

The concept of isokinetic can be said to be an isokinetic exercise can change tension and muscle over entire areas at constant speed of exercise. It is different from the isotonic contraction that the length of muscle is shorten with contraction by a certain tension and the isometric contraction that the length of muscle is not changed. It is the evaluation method of muscular strength to measure the resistance of muscle when it is changed with predetermined exercise speeds. Thisle, et al. said that isokinetic exercise was the method that could obtain more outstanding effects than that of isotonic exercise and isometric exercise.

* Department of Industrial Engineering, Dong-A University, Pusan, Korea
** Department of Industrial Engineering, Yang-San College, Yangsan, Korea

Watkins, et al. said that it was possible to see the extentof muscular strength and accurate movement areas objectively by evaluation of muscular strength with isokinetic exercising tools. Burdett, et al. said that it was being applied to various fields for its high reliability. But in our country, its utilization is not only low, as the normal values of muscular strength are not actually standardized in the evaluation of muscular strength, the standard values of muscular strength have to be built by the measurement and evaluation of muscular strength.

This study is to provide data for isokinetic muscular strength elbow flexors and extensors of Korean male and female adults. Provided standard data for isokinetic muscular strength of elbow flexors and extensors can be used for scientific and systematic analysis of arm exertion.

## METHOD OF MEASUREMENT AND CONTENT

In this study, to build up the standard data for isokinetic exercise of elbow joint extensors and flexors, the normal adults as a measurement subject, peak torque, ratio of peak torque, joint angle at peak torque, total work, muscle endurance ratio, average power, were measured and evaluated.

Measurement subjects

For the evaluation of elbow joint isokinetic exercise, the measured were 20 healthy male and female (male 10, female 10) of 20's as subjects who had clinically no external wound and/or no experience of a nurve system disease and who did not do a special exercise with upper limbs. Right hand was dominant side for all of the measured.

Measuring equipment

The equipment used in the measurement were CYBEX 350, an isokinetic exercise tool and U.B.X.T (upper body exercise and testing table). With this equipment muscular strength, endurance and angle of joint exercise can be measured. A recording device in the equipment which keeps the obtained figures and a computer which compares and analyzes the figures are contained. Further, the equipment is designed that the measured person can directly read his/her measured figures of muscular strength reflected in a graph with torque and total work on the screen, measuring his/her muscular strength.

Measuring procedures

The measurment posture is that the measured is laid on the back with two arms freed on U.B.X.T and after the upper body is fixed, the axle of machine movement and that of elbow joint movement are aligned with forearms supinated. The process of practice is that when forearms are stretched starting from the point of bent elbow and returned to the original position is made one exercise. The objective of measurement, the principle of operation of equipment, measurement order and method and measurement processes were precisely explained to the measured and the measured was made to do the exercise 4 times with elbow joint extremely

stretched and elbow extremely bent before measurement. The measurement was carried out on the object muscles on both sides, from dominant side at a low speed of 60°/sec 4 times, and after 3 minutes rest, and at a high speed of 180°/sec 16 times of repeated exercises. The block diagram of measurement for this experiment is the same as Figure 1.

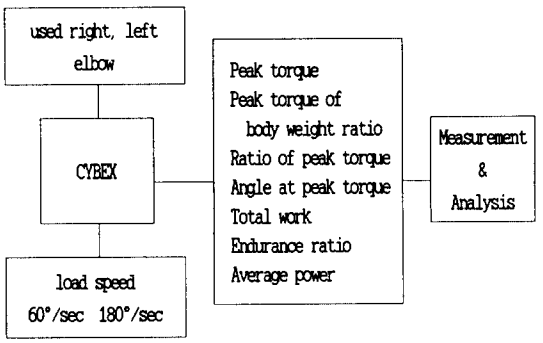


Figure 1. Experimental block diagram

## ANALYSIS OF MEASURED DATA

General characteristics of the measured

The average ages of the measured subjects were male 27.3 and female 24.6, respectively; average weight were 136.8 lbs and 110.2 lbs, respectively, and all the measured were dominant side at right.

Table 1. Physical characteristics of subjects

| Sex | Age(years) | Weight(lbs) | Height(cm) |
|---|---|---|---|
| Male | 27.3±3.4 | 136.8±21.4 | 171.6±5.4 |
| Female | 24.6±2.6 | 110.2±16.7 | 159.6±4.2 |

mean±s.d.

Peak torque

The average peak torque of elbow joint extensor as shown in Table 2, when exercise was carried out from dominant side at a slow exercise of 60°/sec, in case of extensor for male and female were 24.3 ±4.3 ft-lbs and 12.8±2.4 ft-lbs, respectively; peak torque of flexor for male and female were 27.5±4.8 ft-lbs and 11.9± 2.5 ft-lbs, respectively. On the other hand, when exercise was carried out at a high speed of 180°/sec, in case of extensor for male and female were 16.9±5.1 ft-lbs and 8.4±1.9 ft-lbs, respectively; in case of flexsor for male and female were 19.4±5.9 ft-lbs, 7.5±1.8 ft-lbs, respectively, which, as compared to a low speed, showed peak torque extensor and flexor significantly decreased.

Table 2. Peak torque of isokinetic test of elbow joint

| sex | Velocity | 60°/sec | | 180°/sec | |
|---|---|---|---|---|---|
| | Side | Extensor | Flexor | Extensor | Flexor |
| Male | Right | 24.3±4.3 | 27.5±4.8 | 16.9±5.1 | 19.4±5.9 |
| | Left | 23.1±5.4 | 25.2±5.2 | 15.6±5.7 | 15.4±6.1 |
| Female | Right | 12.8±2.4 | 11.9±2.5 | 8.4±1.9 | 7.5±1.8 |
| | Left | 12.0±2.9 | 11.4±2.2 | 7.1±1.7 | 6.3±1.9 |

mean±s.d.(ft-lbs)

When peak torque of female against that of male was calculated in percentage, shown in Table 3, in case of extensor, at a low speed of 60°/sec, was 53%; at a high speed of 180°/ sec, was 50%; in case of flexor as compared to male shows female's peak torque of extensor and flexor was significantly decreased to 43%, 39%, res-

pectively. This showed a significant difference from Laubach reported as generally peak torque of female was 66.3% of that of male.

Table 3. Ratio of peak torque of subjects

| Velocity | Extensor | Flexor |
|---|---|---|
| 60°/sec | 53 | 43 |
| 180°/sec | 50 | 39 |

mean(%)

Relations between peak torque and body weight

The relations between peak torque and body weight mean strength emittid from unit weight pound and the peak torque value (ft-lbs) of body weight is expressed in percentage. The ratio of peak torque of muscle on body weight of the measured at a low speed test of 60°/sec was, in case of extensor, male and female were 17.7±2.2% and 11.6±2.1%, respectively; in case of flexor, male and female were 20.1±2.3% and 10.7±2.2%, respectively; and also at a high speed test 180°/sec, in case of extensor, male and female were 12.3±2.3% and 7.6±1.7%, respectively; in case of flexor, male and female were 14.1±2.5%, 6.8±1.9%, respectively.

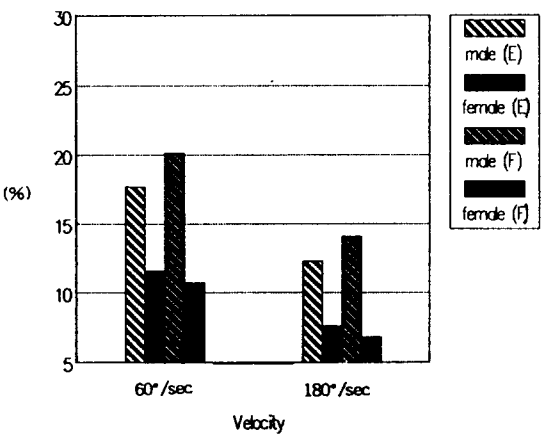


Figure 2. Peak torque of body weight ratio

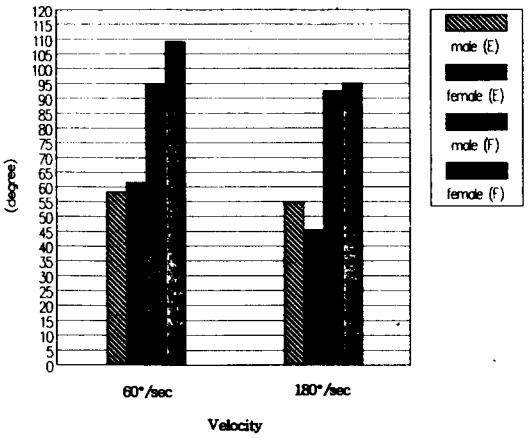


Figure 3. Angles at torque generated

Ratio of peak torque

Table 4. shows ratio of peak torque of extensor against elbow joint flexor. Especially, for female, it showed that strength of extensor was stronger than that of flexor. The result of evaluation by Davies on elbow joint muscular strength of American skiiers showed 155% at 45°/sec, 196% at 240°/sec, which is similar to this study. This was a result the more exercise speed was increased, the more ratio of torque of extensor increased but on the contrary, the result of test of Beasley's study with teenagers revealed a ratio of strength of flexor and extensor was 1.2:1(83%), which showed strength of flexor was much stronger than that of extensor.

In summary, the result of studies of these people, as for athletes who need muscle strength of upper limbs and young men who do vigorous activities, it is considered that generally extensors would develop.

Table 4. Ratio of peak torque of extensor flexor

| Velocity | Male | Female |
|---|---|---|
| 60°/sec | 88.3±13.6 | 107.5±17.3 |
| 180°/sec | 87.1±14.2 | 112.0±16.6 |

mean±s.d. (%)

Joint angle at peak torque

When comparing peak torque of elbow joint extensor and flexor on right with that of elbow joint extensor and flexor on left, regardless of exercise speed of male and female, peak torque on the right was dominant side of all measured, was greater than that of the left. As most muscles at stable length show peak torque, in cases isotonic exercise is carried out, the angle of joint acts as an important factor that would determine peak torque. But Basmajjian said that, in case of biceps brachii, torque would become greatest at elbow joint angle 90°and Van Zuylen, et al. reported that peak torque would occur at 80°. In the measurement of this study, the reason that peak torque occured at curved position as compared to the results of other studies, was because even greatest strength from all areas of joint exercise at the time of measurement, could not be emitted. (Figure 3.)

Total work, muscle endurance ratio, average power

The total work means a total work muscle could do during 16 times repeated exercises at a speed of 180°/sec. In case of extensor, the total work for male and female were 348.7±13.5 ft-lbs, 124.5 ±3.6 ft-lbs, respectively; in case of flexor, 301.4 ±13.9 ft-lbs and 86.7±3.3 ft-lbs, respectively, which represented that male and extensor were significantly greater.

Table 5. Total work, Endurance ratio, Average power

| | | Male | Female |
|---|---|---|---|
| Total work (ft-lbs) | Extensor | 348.7±13.5 | 124.5±3.6 |
| | Flexor | 301.4±13.9 | 86.7±3.3 |
| Endurance ratio (%) | Extensor | 62.4±12.6 | 53.1±15.8 |
| | Flexor | 53.3±13.4 | 41.2±18.2 |
| Average power (watts) | Extensor | 34.7±13.8 | 12.6±3.7 |
| | Flexor | 31.1±14.1 | 8.6±3.4 |

mean±s.d.

The muscle endurance ratio can be obtained by calculating total work in percentage obtained from the last 4 times repeated exercises on total work obtained from the first 4 times repeated exercises during 16 times repeated exercises at a high speed. In case of extensor for male and female were 62.4±12.6% and 53.1± 15.8%, respectively ; in case of flexor, 53.3 ±13.4%, 41.2±18.2%, respectively, which showed not a significant difference between male and female. The average power is performance ability muscle could do at a unit time. In case of extensor, the performance ability for male and female were 34.7±13.8 watt and 12.6±3.7 watt, respectively ; in case of flexor, 31.1±14.1 watt, 8.6±3.4 watt, respectively, as well as

total work, male and female extensor were showed a significant difference.

## CONCLUSIONS

Through the measruement of strength of elbow joint extensor and flexor of male and female and its evaluation by using isokinetic exercise equipment, the basic data such as the extent of weakening muscular strength and muscular movement areas, etc. have been derived objectively and reliably from this study.

In this study, the following conclusion has been obtained by carrying out evaluation of isokinetic exercises on arm elbow joint muscles.

First, the peak torque of arm elbow joint extensor and flexor from female as compared to male and from a low speed as compared to a high speed, shown as decreased. Second, the ratio of peak torque of body weight at a low speed showed no significant difference between male and female but male was higher than female at high speed. Third, when comparing muscular strength of extensor with that of flexor, muscular strength of flexor of male was stronger, but muscular strength of female extensor was stronger and also at a high speed as compered to a low speed, muscular strength ratio of extensor on flexor was increased for all male and female. Fourth, when comparing peak torque of dominant side with that of nondominant side, there was a significant difference regardless of sex and exercise speed. Fifth, muscle endurance ratio, in case of extensor for male and female were 62.4% and 53.1%, respectively; in case of flexor, 53.3% and 41.2%, respectively, and except flexor of female, all showed over 50%.

The further study direction will be: With the subjects of workers engaged in manual material handling, the standard data is to be built up by evaluating muscular strength of principle spot. Thus through evaluation of muscular strength along with age increase and multi-regression analysis along with sex, age, height and weight, the study using more various basic data should be performed continuously in terms of muscular strength measurement values and grasp of relations of factors which may affect the measurement values comparison of white color and blue color emplyees, etc. As the situation is that most adequate repeatation number, frequency of exercise, break, etc. for isokinetic exercises have not been firmely established due to the difference of exercise method, amount of exercise, exercise period, etc. The study on these areas should also be continued.

## REFERENCES

1. Baltzopoulos V., Brodie D.A.(1989), Isokinetic dynamometer applications and limitation, Sports Medicine, 8(2), 101-116.
2. Burdett, R.G., Swearingen, J.V.(1987), Reliability of isokinetic muscle tests, J. orthopaedic sports physical theraphy, 8, 484-488.
3. Burnie, J., Brodie, D.A.(1986), Isokinetic in the assesment of rehabilitation,

Clinical Biomechanics, 140-146.
4. Hislop, H.J., Perrine, J.J.(1967), The isokinetic concept of exercise, Phys. Ther., 47, 114-117.
5. Moffroid, M., Whipple, R., Hofkosh. J., Lowman, E.W., Thistle, H.G.(1969), A study of isokinetic exercise, Phys. Ther., 49, 735-746.
6. Murray, M.P.(1985), Age-related differences in knee muscle strength in normal women, Journal of gerontology, 40(3), 275-280.
7. Murray, M.P., Gardner, G.M., Mollinger(1980), L.A., Strength of isometric and isokinetic contractions. Knee muscle of men aged 20 to 86, Phys. Ther, 60, 412-419.
8. Thistle, H.G., Hislop, H.J., Mafford, M., Lowman, E.W.(1967), isokinetic contraction ; A new concepts of resistive exercise, Arch. phys. Med. Rehabil., 48, 279-282.
9. Watkins P.M., Harris A.R., Kozlowski R.A.(1984), Isokinetic tranining in patients with hemiparesis, Phys. Ther. Vol. 64, 184-189.