Isometric and Isokinetic Grip Strength in Normal Young Subjects: A Preliminary Study

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The purposes of this study were to find the normal range of grip strength in normal young subjects and the relationships of grip strength to sex and hand dominance. Gripping strength of 38 subjects (17 male , 21 female) were evaluated by isometric and isokinetic models at two different loading rate (180° /sec, 30° /sec). The isometric torque of the dominant hand is greater than that of the non-dominant hand (p=.000) in both genders. Male has nearly twice the isometric torque to that of female. The isokinetic torque of male subjects is also greater than that of female subjects (p=.000); especially in the slow loading rate of the non-dominant hand. In the dominant hand, isokinetic torque in slow speed is greater than that in fast speed (p=.000), and for non-dominant hand, there is no significant difference between two speed (p=.087). The results of this study provide a data base for grip strength in Chinese young adults. The isokinetic muscle tests can measure the dynamic muscle strength and thus can reflect muscular capability used in daily activities.(JPTA ROC 1999;24(1)9-15)

Key word: Grip strength, Isometric strength, Isokinetic strength

Grip strength represents the combined interaction between the intrinsic and extrinsic muscles strength of the wrist and hand[1]. In clinical medicine, it is usually used to evaluate the effectiveness of treatment, and assess the ability of patients to return to work[2,3]. Mathiowetz et al. demonstrated that the Jamar Dynamometer and the B&L Pinch Gauge are the most accurate instruments in the measurement of the grip and pinch strength[4,5]. However, only isometric muscle strength can be measured by the equipments mentioned above. Evaluations of most activities of daily living by isometric testing may not reflect the muscular capability used in daily

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Received: Oct. 28, 1998. Revised: Nov. 5, 1998. Accepted: Dec. 15, 1998.

activities or sports [6].

The LIDO WorkSET II (Loredan Biomedical Inc., Sacramento, CA, USA) has been designed to provide versatile, functional testing and rehabilitation in a single device. The system can simulate diverse job tasks and daily activities. Besides, it can provide us the quantitative information about the muscle strength and function in upper extremities. With LIDO WorkSET II, the therapists can evaluate the patients or set the appropriate goal for rehablitation[7,8]. The results of Matheson's study demonstrate a very high degree of device validity in torque measurements, power and work [9]. In addition, the test protocols were found to be reliable on an intra-test and inter-test basis. Inter-test comparisons were found to be stable over time.

The purposes of this study are to establish a data base of grip strength tested by LIDO WorkSET II in normal young subjects ranging from 20 to 30 years old. The gender and dominant hand effect of isometric and isokinetic torque are also evaluated.

MATERIALS AND METHODS

Subjects

Thirty-eight healthy volunteers (17 men and 21 female) were included for this study, Informed consent was obtained from each subject participating in the protocol, which was approved by the Investigation Review Board of our medical center. None of them have previous history of trauma over bilateral upper extremities. Most of them (except 1 man) are right-hand dominant. Their ages range from 22 to 30 years old. with the mean age of 25.11 ± 2.59 years old (Table 1).

Table 1. Basic Data of Subjects

	Male	Female
Height(cm)	171.35 ± 6.18	160.91 ± 4.53
(Range)	(160-181)	(150-170)
Weight(kg)	64.29 ± 9.65	53.36 ± 6.37
(Range)	(50- 85)	(45- 75)
Age(y/o)	25.11 ± 2.59	23.41 ± 2.15
(Range)	(22- 30)	(20- 30)

Data were presented as mean ± standard deviation

Instrumentation

LIDO WorkSETII (Loredan Biomedical, Inc., Sacramento, CA, USA) was used to measure isometric and isokinetic grip strength. The system consists of actual framework, including the actuator, the tools and data management system. The actuator linked to a column is the controlling component of the system. The tool is attached to the actuator. The exercise mode and motion are controlled through the unit. It can be rotated, raised or lowered on the column to fit the subjects' height.

The system offers isometric and isokinetic exercise types with concentric and eccentric modes. During testing, the easily understandable screens allows patients to observe their performance. Thus it gives them a very good visual feedback and increases the motivation and accelerates the progress [7].

Procedure

Each subject sat in front of the screen to measure the isometric and isokinetic grip strength. The therapist adjusted the height of the chair and actuator to keep the testing position with shoulder adducted and neutrally rotated, the elbow flexed in 90 degrees, and the forearm and wrist in neutral position [10]. The tool of grip exerciser was used. Before testing, the writing hand was determined to be the dominant hand reported by the subjects. The subjects performed isometric grip test, rested for 5 minutes, and then followed by isokinetic tests. In the isometric

mode, we asked the subject to grasp the tool to get the maximal grip strength. Three times of measurements were taken for bilateral hands. For the subjects of the odd number, the dominant hand was tested first; and for those of the even number, the non-dominant hand was tested first. We collected the highest score of each subject for further analysis.

In the isokinetic mode, 180°/sec and 30°/sec of all fingers grasp were set as fast and slow exercise velocities respectively. Frequency of fast and slow modes was 2 times/sec and 1 time/sec. Test time was 1 minute, and exercise range of motion was 7 degrees. One minute's preloading was allowed for each subjects to familiarize the testing speed, and the highest torque was recorded. For subject of the odd number, the dominant hand is tested with high speed; the non-dominant hand with slow speed. For subject of the even number, the testing content is reversed.

During the two parts of measurement, verbal cues from the therapist and visual cues from the screen were given to enforce the subjects to do their best.

Data Analysis

Pearson correlation coefficient was used to evaluate the correlation between the subjects' height or weight to the isometric torque of the dominant hand. The peak isometric and isokinetic torque of dominant and non-dominant grip strength for male and female was analyzed by repeated measure two way ANOVA.

For isokinetic strength in fast and slow speed, the peak torque for bilateral hands of male and female were analyzed by two way ANOVA. All of the statistics were computed by SPSS software (SPSS for Windows release 6.0, SPSS Inc., Chicago, USA).

RESULTS

Table 1 shows the basic data of the subjects. The correlation between the subjects' height or weight to the isometric torque of dominant hand are not statistically significant ($p>0.05$).

Table 2 and Figure 1 summarizes the mean isometric muscle torque and ratio of dominant to non-dominant hand for male and female subjects. The isometric strength of male subjects is higher than that of the female subjects ($p=0.000$) in both the dominant and non-dominant hand; while for each gender, the dominant hand is greater than that of the non-dominant hand ($p=0.000$). The interaction between gender (male and female) and dominance (dominant and non-dominant hand) is statistically significant ($p=0.012$, Table 3).

The mean muscle torque of isokinetic contration was summarized in Table 4. When tested with fast speed (180°/sec), the isokinetic torque of male subjects is greater that of the female subjects ($p=0.000$, Table 5, Figure 2,3); the difference of peak torque between dominant and non-dominant hand is not stiatistically significant ($p=0.098$, Table5).

For subjects tested with slow speed (30°/sec),

Table 2. Mean Isometric Muscle Torque and Ratio of Dominant to Non-dominant Hand

Torque (Nm)	Non-dominant Side	Dominant Side	Dominant/ Non-dominant
Male	72.77 ± 19.12	82.59 ± 21.90	1.15 ± 0.16
Female	42.38 ± 7.30	44.83 ± 8.18	1.06 ± 0.14

Data were presented as mean ± standard deviation

Table 3. Repeated Measure Two Way ANOVA of Isometric Muscle Torque for the Effect of Dominance (Dominant, Non-dominant Hand) and Gender (Male, Female)

Source of Variation	df	SS	MS	F	Sig of F
Gender	1	222767328.10	222767328.10	56.27	.000
Hand Dominance	1	7223570.01	7223570.00	19.13	.000
Gender by Hand	1	2604066.68	2604066.70	6.90	.012
Error	37	13968269.17	377520.79		

Table 4. Peak Muscle Torque of Isokinetic Contraction

Torque(Nm)	Non-dominant	Dominant
Male		
Fast	29.78 ± 4.74	33.56 ± 4.95
Slow	33.18 ± 5.90	38.66 ± 3.48
Female		
Fast	18.66 ± 2.32	19.29 ± 3.64
Slow	20.67 ± 5.60	24.39 ± 4.10

Data were presented as mean ± standard deviation

the male subjects still has greater isokinetic torque than female subjects (p=0.000, Table 8, Figure 2,3). However, the peak torque of dominant is greater than that of non-dominant hand. The difference is statistically significant (p=0.006, Table 6)

DISCUSSION

Grip strength is an important parameter of hand function. It is generally agreed that male have greater strength than female[5,11,12,13]. Similar results were found in this study. It was stated that height and weight were positively correlated with grip strength[12,13,14]. In this study, we found that the correlation between height or weight and the isometric torque of dominant hand is not statistically significant. This is probably due to the smaller sample size in the present study.

In 1954, Bechtol[15] found that there is 5% to 10% difference in the isometric muscle torque between dominant and non-dominant hands. Recently, Bassey and Harries[16] found that the difference is 10% between both hands. Similar to previous study, there is significant differences existed in the isometric muscle torque of dominant and non-dominant hands. The difference in

Table 5. Two Way ANOVA (Gender, Dominance) of the Isokinetic Muscle Torque Tested by Fast Speed

Source	df	SS	MS	F	Sig of F
Gender	1	15417407.23	15417407	96.17	.000
Hand	1	463914.45	463914.45	2.89	.098
Gender by Hand	1	238317.86	238317.86	1.49	.231
Error	35	561102460	160314.99		

Table 6. Two Way ANOVA (Gender, Dominance) of the Isokinetic Muscle Torque Tested by Slow Speed

Source	df	SS	MS	F	Sig of F
Gender	1	17160478.37	17160478	73.09	.000
Speed	1	2025873.41	2025873.40	8.63	.006
Gender by Speed	1	7378319	73783.19	.31	.579
Error	35	8217337.42	234781.07		

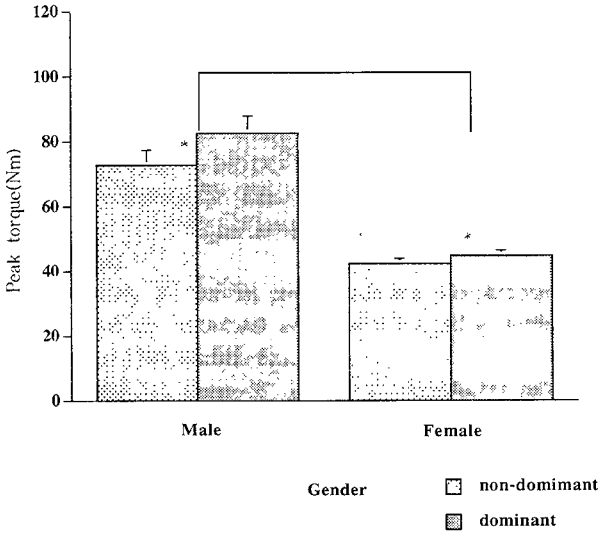

Fig 1. Isometric muscle torque of non-dominant and dominant hands for male and female subjects

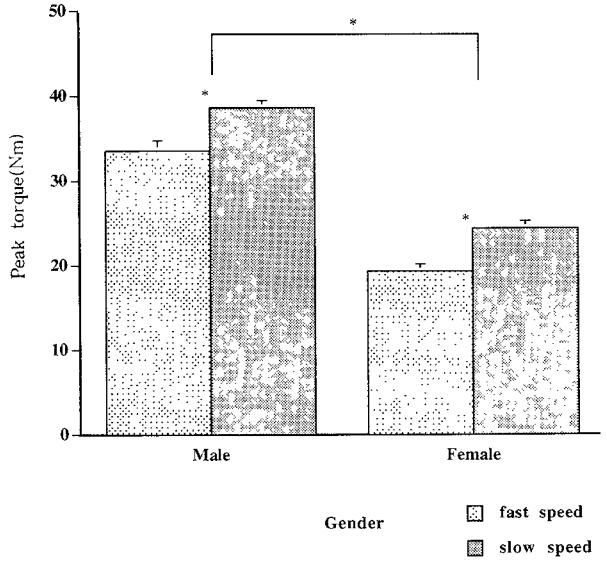

Fig 2. Isokinetic muscle torque of dominant hand

isometric muscle torque of dominant and non-dominant hands is 15% in male and 6% in female subjects.

The adavntage of isometric measurement is its simplicity and low cost. But, the isometric testing can not reflect the muscular performance

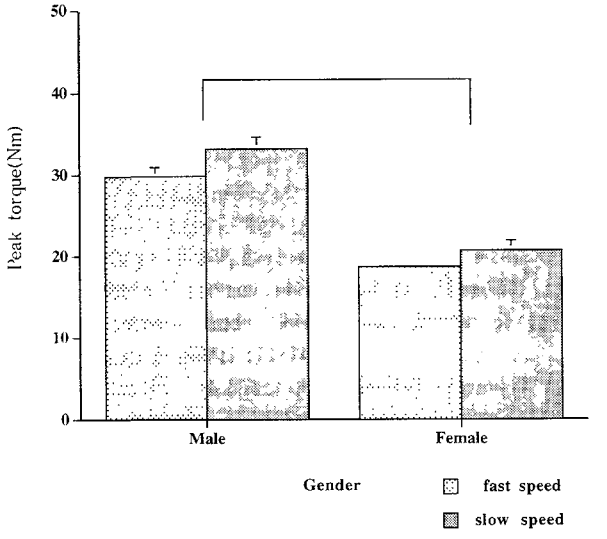

Fig 3. Isokinetic muscle torque of non-dominant hand

used in daily activities or sports[7]. On the contrary, isokinetic testing can provide a highly reproducible technique for dynamic strength testing. The isokinetic testing has gained popularity as an approach to the measurement of dynamic human strength[17,18,19,20]. In the isokinetic testing, peak torque decreases the as angular velocity increases[21,22,23]. In this study, peak torque in slow speed (30°/sec) is greater than that in high speed (180°/sec) of both hands and there is significant difference in dominant hand but not in non-dominant hand. Besides, peak torque in dominant hand is greater than that in non-dominant hand both in slow and high speed isokinetic muscle testing. In slow speed, the difference between bilateral hands is statistically significant, the difference was not observed in high speed group.

Generally, the isometric and isokinetic muscle strength of the limbs was generally measured by Cybex isokinetic dynamometer; LIDO WorkSET was rarely used for the same purpose. Despite differences between the Cybex and LIDO systems, our results from LIDO Work-

SET support previous work done by the Cybex®. The limitation of this study is the limited ranges of age, small subjects number, and only two different angular velocity were used in isokinetic muscle testing. The preliminary normal data still can provide a good reference for the younger population in the clinical medicine. Further studies will expand into different ages and angular velocities.

REFERENCES

1. Stanley BG, Tribuzi SM. Concept in Hand Rehabilitation. Chap 3. Philadelphia: F.A. Davis company, 1992.
2. Chow SP, Ng C. Hand function after digital amputation. J Hand Surg 1993;18:125-128.
3. House JH. Reconstruction of the thumb in tetraplegia following spinal cord injury. Clin Orthop 1985;195:117-128.
4. Mathiowetz V, Weber K, Volland G, et al. Reliability and validity of grip and pinch strength evaluations. J Hand Surg 1984;9A:222-226.
5. Mathiowetz V, Kashman N, Volland G, et al. Grip and pinch strength: Normative data for adults. Arch Phys Med Rehabil 1985;66:69-72.
6. Watkins MP, Harris BA. Evaluation of isokinetic muscle performance. Clin Sports Med 1983; 2:37-53.
7. LIDO WorkSET II System, User's Guide, Loredan Biomedical-Inc. West Sacramento, CA, 1992.
8. Hudak P, Hannah S, Knapp M, et al. Reliability of isometric wrist extension torque using the LIDO WorkSET for late follow-up of postoperative wrist patients. J Hand Ther 1997; 10: 290-296.
9. Matheson LN, Mangseth G, Segal JH, et al. Validity and reliability of a new device to simulate upper extremity work demands. J Occu Rehabil 1992;2:109-122.
10. Fess EE, Moran CA. Clinical assessment recommendations. 1981. American Society of Hand Therapists.
11. Agnew PJ, Maas F. Hand function related to age and sex. Arch Phys Med Rehabil 1982;63:269-271.
12. Carla AC, Marwan AW, Bryn M. Hand Strength: normative values. J Hand Surgery 1994;19A:665-670.
13. Chong CK, Tseng CH, Wong MK, et al. Grip and pinch in Chinese adults and their relationship with anthropometric factors. J Formos Med Assoc 1994;93:616-621.
14. Schmidt RT, Toews JV. Grip strength as measured by the Jarmar dynamometer. Arch Phys Med Rehabil 1970;51:321-327.
15. Bechtol C. Grip test: the use of a dynamometer with adjustable handle spacings. J Bone Joint Surg 1954;36A: 820-832 1954.
16. Bassey EJ, Harries UJ. Normal values for handgrip strength in 920 men and women aged over 65 years, and longitudinal changes over 4 years in 620 survivors. Clin Sci 1993;84:331-337.
17. Moffroid M, Whipple R, Hotkosh J, et al. A study of isokinetic exercise. Phys Ther 1969;49:735-747.
18. Mawdsley RH, Knapik JJ. Comparison of isokinetic measurements with test repetitions. Phys Ther 1982;62:169-172.
19. Osternig LR. Isokinetic dynamometry: implications for muscle testing and rehabilitation. Exerc Sport Sci Rev 1986; 14:45-80.
20. Lord JP, Aitkens SG, McCrory MA, et al. Isometric and isokinetic measurement of hamstring and quadriceps strength. Arch Phys Med Rehabil 1992;73:324-30.
21. Pentland WE, Vandervoort AA, Twomey LT. Age-related changes in upper limb isokinetic and grip strength. Physiother theory pract 1995;11:165-173.
22. Knapik JJ, Ramos MU. Isokinetic and isometric torque relationships in the human body. Arch Phys Med Rehabil 1980; 61:64-67.
23. Knapik JJ, Wright JE, Mawdsley RH, et al. Isometric, isotonic and isokinetic torque variations in four muscle groups through a range of joint motion. Phys Ther 1983;63: 938-947.

正常年輕人等長及等速握力初步研究

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本研究的主要目的在於利用 LIDO WorkSET II 建立 20 至 30 歲青年男女握力的正常值範圍，並且比較男女之間及慣用手、非慣用手之間在等長肌肉收縮與等速肌肉收縮表現的異同。受試者共 38 人，包括男性 17 人，女性 21 人；分別接受等長肌肉收縮與快 (180°/ 秒) 慢 (30°/ 秒) 兩種等速肌肉收縮的測試。結果發現：等長肌肉收縮方面，男性不論是慣用手或非慣用手的平均握力都約爲女性的兩倍，且不論男女性別，慣用手之握力均大於非慣用手 (p=.000) 。在等速肌肉收縮方面，男性握力亦比女性大；且不論男女，對慣用手而言，以慢速測試時之握力較快速測試時爲大 (p=.000) ，對非慣用手而言，以慢速或快速測試則無明顯差異 (p=.087) 。本研究等長收縮握力方面之結果可提供國人 20 至 30 歲年輕人握力正常值範圍之參考。等速收縮握力測試可以測量不同收縮速度間之肌力變化，反應出手部日常活動的實際狀況。藉此，也可提供臨床治療師擬定治療計畫時的參考，以注意到不同性別、不同側手及不同速度間病人不一樣的表現。

(中華物療誌 1999;24(1):9-15)

關鍵詞：握力，等長肌力，等速肌力

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收件日期：87年10月28日 修訂日期：87年11月5日 接受日期：87年12月15日