STATIC BACK STRENGTH - A STUDY AMONG YOUNG ADULTS

Anisah. H[1], Hardianto Iridiastadi[2], Zulfa Fitri Ikatrinasari[1]

[1] Universitas Mercu Buana, Jakarta, Indonesia
[2] Institut Teknologi Bandung, Bandung, Indonesia
just.nazha@gmail.com

ABSTRACT

The aim of this study was to describe static back strength among a group of young adults. Furthermore, this study sought to see if there were relationships between this variable with other biomechanics and anthropometric variables (e.g., pinch grip, height, or weight). For this purpose, an experiment was carried out involving 69 males and 52 females between 18 to 28 years of age. Results of this study showed that mean static back strength for males was about 907 N. Back strength for female subjects was 445 N, about 51% less than that of the males. Average pinch grip for female subjects was 44-48% less than that for the males. This study also found strong correlation between back strength and pinch grip strength. In addition, back strength could be sufficiently modeled as a function of other biomechanics and anthropometric variables, including pinch grip strength, gender, weight, and age. It is concluded in this study that differences in strength between genders exist, and that back strength can be predicted by other more practically measured variables.

Keywords*: back strength, key pinch strength, manual handling*

1. INTRODUCTION

Manual handling is any activity that involves lifting, lowering, pushing, pulling, carrying, moving, holding or restraining. It may also include stretching and bending, sustained and awkward postures, and repetitive movements. Manual handling can result in musculoskeletal injuries to workers. One of the musculoskeletal injuries is low back pain. Back pain is one of the most common health complaints in the United States and around the world and also the most common cause of job-related disability and a leading contributor to missed work. It affects 8 out of 10 people at some point during their lives. Chou (2007) reported that approximately one quarter of U.S. adults reported having low back pain lasting at least one whole day in the past three months and 7.6% reported at least one episode of severe acute low-back pain within a one-year period (National Institute of Neurological Disorders and Stroke, 2013). In 2001 in Alberta, out of a total of 37,927 work loss claims, 26.8 percent were associated with low-back pain. It is also a very costly condition, in large part because it is associated with time off from work.

Work-related low back pain and low back injuries are the most common kind of musculoskeletal disorders caused by manual handling, and these are a significant and increasing problem in Europe. About 25% of European workers consider that their work affects their health in the form of back pain, which tops the list of all reported work-related disorders (European Foundation for the Improvement of Living and Working Conditions, 2005).

The risk factors, particularly for back injury, are related to four aspects of manual handling: the load, the task, the environment and the individual. Safe and health are primary aspect at working environment. In ergonomics, workload should be designed such that it is always within worker's capacity. Measurements of back strength and other muscle groups (finger, hand, or arm) have been done in many industrialized countries (Kumar et al., 1988; Shivers et al., 2002; Y-Kong et al., 2011). These type of data, however, are not widely available among developing nations.

Based on previous studies, muscle strength is associated with functional performance, work productivity, and efficiency of movement. Muscle strength (e.g., back strength) data are collected for the purpose

of understanding individuals' capability. Furthermore, safe manual handling task can be design accordingly, that can reduce the risk of injury during manual handling activities.

Though the importance of studying back strength is immense, literature related to back strength is scanty, especially in Indonesian context. The objectives of the present study were to provide back strength data among Indonesian young adult, and quantify differences between genders. In addition, it was interesting to find out if back strength was related to other anthropometric variables. In the workplace, back strength measurement is somewhat not practical. The ability to predict back strength by employing other strength variables (e.g., pinch grip) could be interesting to investigate.

2. THEORETICAL BACKGROUND

A great deal of time and effort has been expended by many investigators to develop a means by which a person's capability to lift and carry loads safely can be predicted. Recent studies have resulted in suggested limits for maximum permissible weight of the load for various percentiles of male and female populations both for occasional and repeated lifting. The criteria for these recommendations range from opinion to complex biomechanical and physiological modelling (Staker et al. 1997, Ayoub and Dempsey 1999). For occasional lifting, more recent recommendations for 'safe' maximum acceptable weights are based on either job specific static strength (Koley et al., 2012) or a psychophysical method wherein various workers have demonstrated their capabilities to lift such loads in a controlled (Ayoub & Dempsey, 1999).

By comparing Chaffin's and Snook's results, it can be concluded that static and dynamic lifting strengths from Garg's study are in general agreement with the past data. Both the static and the dynamic lifting strengths decrease with an increase in the horizontal distance of the hands away from the body. The former decreases non-linearly. There is not sufficient information to study the exact relationship between the dynamic lifting strength and the horizontal distance.

In Koley (2012), it was found strong correlations of back strength with almost all the anthropometric characteristics. The men strength in 17 years is (43.2 ± 13.88) and women (5.33 ± 5.65) kg. In 18 years, men (44,83 ± 13.02) and women (11.7 ± 7.13) kg.

3. RESEARCH METHOD

3.1 Subjects

The present study was based on randomly selected 121 normal, healthy Indonesian student (69 men and 52 women) aged 17–28 years. A written consent was obtained from the subjects. A scale was utilized for measuring weight (kg), height (cm), and body fat (%).

3.2 Back Strength Measurement

The back strength was measured using Dorsal Electric Dynamometer type BCS-400. The subject was positioned with body flexed 45^0 from vertical, knees straight and hand straight. The respondent was asked to lift the chain of the dynamometer, and pull the dynamometer handle. The strength of the back muscle was recorded on the dial of the dynamometer as the greatest of three trials. The data were later converted into newton (N). Two minutes time interval was maintained between each back strength testing.

3.3 Pinch Strength Measurement

The B&L pinch gauge used to measure key pinch strength. Scores were read on the needle side of the red out marker. It measured key pinch strength on right and left hand, and was recorded as the maximum of three trials each hand.

3.4 Statistical Analysis

Descriptive statistics such as mean, standard deviation, minimum and maximum value and percentile 5%, 10%, 50%, 90% and 95% was determined. Analysis of variance was used for the comparison of the variables between genders. Pearson's correlation and regression coefficients were applied for establishing the relationships among the variables measured. Automatic Linier modeling was used for choosing the best variables for a mathematical model to

predict back strength. Data was analyzed using SPSS (Statistical Package for Social Science) version 21.0. A $p<0.05$ was used to indicate statistical significance.

4. RESULTS AND DISCUSSION

Descriptive statistics of anthropometric variables are shown in Table 1. Mean values of the women back strength were (444.5 N ±143.3 N) and (906.7 N ±207.3 N) for men. Across all variables, males had significantly ($p < .005$-0.000) higher mean values than females (figure 1).

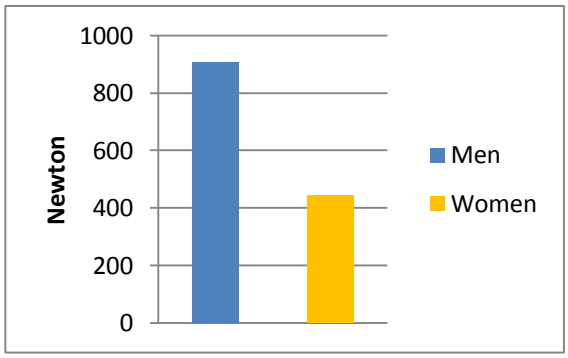

Figure 1. The comparison men and women back strength

Based on the result, female participants had strength that was about half mean value for back strength of the male respondents. It was shown in previous study by Kumar (1988) that this figure is about 51%-63%, but another study by Rasch (1990) noted that strength of the females can be as low as two third of strength of the males.
Key pinch strength was also significantly different between men and women ($p=0.000$). There was also the difference of strength between right and left hand (figure 2). In addition, in table 2 there was the a positive correlation between back strength and key pinch on right and left hand.

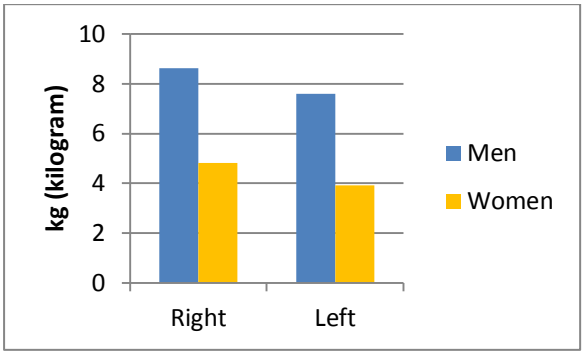

Figure 2. The comparison men and women strength of key pinch on right and left hand

Table 2. Correlation between back strength and key pinch strength

		BS	KPSR	KPSL
BS	Pearson Correlation	1	.700**	.715**
	Sig. (2-tailed)		.000	.000
	N	121	121	121
KPSR	Pearson Correlation	.700**	1	.865**
	Sig. (2-tailed)	.000		.000
	N	121	121	121
KPSL	Pearson Correlation	.715**	.865**	1
	Sig. (2-tailed)	.000	.000	
	N	121	121	121

**. Correlation is significant at the 0.01 level (2-tailed).

In this study, the best model to predict back strength by some anthropometric data and pinch strength was developed. There were four variables that were included in the model - gender, weight, age and key pinch strength for right hand (KPSR).

This mathematical model had adjusted R^2 value of 0.79, and the equation was significant ($p < 0.005$) with an R value of 0.848, indicating positive correlation. The regression analysis resulted in the following equation:

BS= 187.418-(285.090 G) + (4.048 W) +
(23.602 A) + (27.030 KPSR)
BS = Back strength (Newton)
G = Gender (1=male, 2=female)
W = Weight (kg)
A = Age (year)
KPSR = Key pinch Strength right hand (kg)

It should be noted that the anatomical and biomechanical structures of the back are extremely complex and, consequently, the accurate measuring of back muscle strength could be problematic outside of a research setting. If a relationship exists

between back strength and easily obtainable anthropometric or strength measurements, the back strength could be estimated reliably using simple methods in the field (Koley et al., 2010).

This model could be used to predict back strength. However, it is limited only for Indonesian young adults with age ranging from 18-28 years. This is due to the fact that muscle strength is closely related with age. Generally, muscle strength will decline slowly after age of 30 years old (Asmussen and Nielsen, 1962).

It is worth to mention that this study involved static measurement. This could be in contrast with activities in real work settings, where handling tasks are very often dynamic. Therefore, static muscle strength measurement data may not be used directly in the application associated with the dynamic activities. Kumar and Chaffin (1988) noted that static strength is generally greater than the dynamic strength of both men and women.

The mathematical model developed here is a way that can be used to predict maximum acceptable amount of lift. In previous study such as Ayoub et al. (1980), a model was used to estimate and predict the maximum acceptable amount of lift. Variables employed included task variables such as mass of the load, frequency and height of the lift and container characteristics. The worker variables include physiological factors such as aerobic and anaerobic capacity, endurance, and physical factors such as sex, age, anthropometric and strength measurements. The previous studies have used static strength to predict lifting capacity. However, since most manual material handling tasks consist of dynamic efforts rather than static efforts, it is logical to assume that an individual's performance on a dynamic task such as lifting can be better predicted from a dynamic measurement' than from a static measurement (Aghazadeh and ayoub, 1985). Nevertheless, static measurement data can still be used as rough estimates of one's physical capability in the design of manual handling tasks.

Tabel 1. Descriptive statistic back strength and anthropometric data

	Minimum		Maximum		Mean		Std. Deviation		P5		P10		P50		P90		P95	
	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W
Weight (kg)	45.0	39.6	120.7	93.1	64.7	54.7	14.2	13.4	49.6	40.9	45.0	41.0	62.0	50.5	81.6	70.5	90.5	83.6
Height (cm)	153.0	147.0	187.0	172.0	170.0	158.0	6.3	5.6	160.0	150.1	161.8	152.0	170.0	158.0	177.0	165.0	179.0	168.0
Age	17	18	28	28	21	20	2.8	1.9	18	18	18	18	21	20	25	22	27	23
KPSR (kg)	4.0	3.0	18.0	7.0	8.6	4.8	2.3	1.1	5.0	3.0	6.0	3.0	9.0	5.0	11.0	6.0	12.0	6.0
KPSL (kg)	4.00	2.00	12.00	6.00	7.58	3.92	1.95	0.967	5.00	2.00	5.00	3.00	8.00	4.00	10.20	5.00	11.00	5.0
BS (Newton)	400.8	234.2	1371.0	841.8	906.7	444.5	217.3	143.3	610.5	263.6	665.4	274.4	881.0	440.0	1204.4	625.2	1269.1	645.8
Body Fat (%)	12.2	9.0	50.0	46.5	28.7	21.9	10.4	8.9	15.6	10.8	17.2	11.4	27.5	20.2	43.2	36.5	49.3	39.0

M : men
W : women
KPSR : key pinch strength on right hand
KPSL : key pinch strength on left hand
BS : back Strength

In ergonomics, there are two ways for manual handling design. First, when the worker's ability of lifting is already known, manual-handling task can be designed so that the workload is within lifting capability. Otherwise, when the task cannot be redesigned, a worker's strength should be determined that is suitable for the tasks. A model can also be used for this purpose, in that the model will provide strength estimates and we can determine if the estimates match the physical requirements during handling tasks.

5. CONCLUSION

This study was aimed at determining back strength among samples of young adults, and describing strength differences between

genders. It was found that back strength for males was about 907N, while the strength for females was roughly 445N. In addition, this study sought to find if a model could be developed that predicts back strength. The model employed a number of variables, including genders, weight, age, and pinch grip (of the right hand). Findings of the present study can be helpful in predicting strength and in designing manual handling task. Further studies could compare strength differences between groups of workers and students. Moreover, studies of dynamic (as opposed to static) strength can help in providing a model which can be used in the design of manual handling tasks.

6. REFERENCES

(a) Aghazadeh, F., & Ayoub, M.M. (1985). A Comparison of Dynamic and Static Strength Models for Prediction of Lifting Capacity. Ergonomics, 28(10), 1409-1417
(b) Asmussen, E., Nielsen, H.K. (1962). Isometric muscle strength in relation to age in men and women, Ergonomics, 5(1), 167-169
(c) Astrand, P.O., Rodahl, K., (1986). Textbook of Work Physiological, 3rd ed, McGraw-Hili: New York.
(d) Australian Safety and Compensation Council, (2007). National Standard For Manual Tasks.
(e) Ayoub, M.M., Dempsey, P.G., (1999). The Psychophysical Approach to Manual Materials Handling Task Design, Ergonomics, 42:1, 17-31.
(f) Ayoub, M.M., Mital, A., Bakken, G.M., Asfour, S.S., Bethea, N.J. (1980). Development of Strength and Capacity Norms for Manual Material Handling Activities: The State of The Art. The Journal of The Human Factors and Ergonomics Society, 22: 271
(g) Chaffin, D.B., (1975). Ergonomics Guide for The Assessment of Human Static Strength, American Industrial Hygiene Association Journal, 36:7, 505-511
(h) Chaffin, D.B., (2005). Primary Prevention of Low Back Pain Through the Application of Biomechanics in Manual Materials Handling Tasks. University of Michigan, Ann Arbor, USA, 27:1, 40-50
(i) Chaffin, D.B., Andersson, G.B.J., Martin, B.J., (1999). Occupational Biomechanics, 3rd ed. New York: John Wiley & Sons, Inc.
(j) Chou R., (2007). Diagnosis and Treatment of Low Back Pain: A Joint Clinical Practice Guideline from the American College of Physicians and the American Pain Society. 147: 478-291.
(k) European Foundation for the Improvement of Living and Working Conditions, (2005).
(l) Garg, A., Mital, A., Asfour, S.S. (1980). A Comparison of Isometric Strength and Dynamic Lifting Capability. Ergonomics, 23:1, 13-27
(m) Koley, S., Kalsi, R., Sandhu, J. S., (2012). Estimation of back strength and its association with selected anthropometric variables in school going children of Amritsar, Punjab. Antropologist, 14(4), 339-346
(n) Shivers, C.L., Mirka, G.A., Kaber, D.B., (2002). Effect of grip span on lateral pinch grip strength, Human Factors 44(4), 569-577.

AUTHOR BIOGRAPHIES

Anisah H is a lecturer's assistant in Department of Industrial Engineering, Engineering Department, Mercu Buana University, Jakarta. She received bachelor degree of Industrial Engineering from Mercu Buana University in 2012 and now she'll complete master degree in this year. Her research interests are in ergonomic and supply chain management. She is a member of the ergonomic laboratory, as a coordinator assistant laboratory. Her email address is <just.nazha@gmail.com>

Hardianto Iridiastadi is an associate professor in the Faculty of Industrial Technology, Institut Teknologi Bandung. His research areas include occupational biomechanics, fatigue, human error, and lean manufacturing. He can be reached at hiridias@vt.edu.

Zulfa Fitri Ikatrinasari is an assistant professor in the Industrial Engineering Department, Universitas Mercu Buana. Her areas of research include operations

management, and research pertaining agroindustry. Her email address is zulfafi@gmail.com.