ORIGINAL ARTICLE

A PROPOSED RECOMMENDED WEIGHT LIMIT FOR LIFTING ACTIVITIES AMONG YOUNG ASIAN ADULTS

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ABSTRACT

OBJECTIVE: This study aims to develop a recommended permissible weight standard for different types of lifting, horizontal distances, gender and body mass index (BMI) among Asian population. **METHODOLOGY:** This cross-sectional experimental study recruited 72 young adults using criteria of gender and BMI (underweight, normal and overweight). Two sessions were used 1) first session is to determine maximum lifting strength (MLS), 2) second session is to determine the maximum acceptable weight to lift (MAWL). Both sessions need the respondents of two-handed exertions in four lifting types (back lifting, upper-body lifting, arm lifting and shoulder lifting) across two horizontal distances (toes aligned with and posterior to the exerted handle). Total of 8 lifting tasks were performed by each of respondent in each session. Wilcoxon sign test was used to compare between MLS and MAWL and Kruskal-Wallis test to compare MLS and MAWL between 3 different BMI. **RESULT:** For all different types of lifting and horizontal distances shows that there is a significantly higher MLS compared to MAWL ($p<0.05$). Male respondent had a significantly higher ($p<0.05$) MLS and MAWL compared to female for all types of lifting and horizontal distances. Respondent with higher BMI had significantly higher ($p<0.05$) MLS and MAWL compared to underweight and normal. The study showed that the maximum weight lifted and acceptable weight for lifting is at upper-body compared to back, arm and shoulder lifting types. The recommended acceptable weight to lift for male upper-body is 17.8 ± 3.5 kg and for female is 11.3 ± 4.0 kg. **CONCLUSION:** Recommended that lifting use acceptable weight limit compared to maximum weight limit. Permissible weight standard should consider gender, BMI, horizontal distances and lifting types.

Keywords: maximum lifting strength, maximum acceptable weight, lifting, lifting types, horizontal distances

INTRODUCTION

Manual handling or forceful exertion is one of the ergonomics risk factor. Manual handling is not just involves lifting or carrying of weight. According to Western Australian on Occupational Safety and Health Regulation (1996), manual handling means any activity requiring the use of force exerted by a person to lift, lower, push, pull, carry or otherwise move, hold or restrain a person, animal or thing. Manual handling can also exist in sustained postures which place excessive force on joints and overload the muscle and tendons. Most manual task risk factors that present during works include:

- Handling heavy or bulky load
- Holding loads with arms away from trunk
- Twisting back, neck or upper body
- Reaching and load handling at low levels or above shoulder height
- Repetitive movement
- Strenuous lifting, lowering, carrying, pushing and pulling
- Load handling on one side
- Sustained and repetitive gripping
- Inadequate task variety or breaks
- Postural or movement constraints due to working in narrow or obstructed work areas

According to Malaysian's Factories and Machinery Act (1967): Section 12 stated that no person shall be employed to lift, carry or move any load so heavy as to be likely to cause bodily injury to him. However, the statement of "load so heavy" was too general. Besides, there is no any standard for acceptable weight to lift in Malaysia that all workers need to comply with.

Manual handling is one of the main causes of musculoskeletal injuries in the workplace. Based on Malaysian's Social Security Organisation (Socso) Annual Report (2014), numbers of cases of occupational diseases were increase from 2005 with 194 cases until 2014 had reached 3002 cases. Apart from that, 675 cases in 2014 were related to occupational musculoskeletal diseases.

Currently, there is no Malaysian standard for manual handling. Therefore, there is a need to consider a standard for good technical practices to be used by the industry in reducing injuries related to manual handling (Raemy, 2015). A standard should consist of maximum acceptable weight for lifting, lowering, pushing, pulling and carrying activities that should be comply among Malaysian industrial population.

Thus, this study aims to develop a recommended permissible weight standard for different types of lifting, horizontal distances, gender and body mass index (BMI) among young adults.

METHODS

Subjects

A total of 72 respondents were recruited from Faculty of Medicine and Health Sciences to represent as young adult ages by using purposive sampling. There is no drop out respondents (100% response rate) in this study as all respondents had been chosen first by the inclusion criteria which are Malaysian, age ranging between 19 to 25 years old and no injury or medical records on orthopaedic and cardiovascular problems. From 72 respondents, 34 male and 38 female undergraduate students participated in this study. The demographic of the respondents are shown in Table 1.

Table 1: Demographic data of respondents

Demographic	Frequency (%)
Gender	
Male	34 (47.2)
female	38 (52.8)
Body mass index	
Underweight	20 (27.8)
Normal	28 (38.9)
Overweight	24 (33.3)

Experimental Design and Apparatus

The procedures to determine the maximum lifting strength have already been developed by previous study (Caldwell et al., 1974; Chaffin, 1975; Mital & Kumar, 1998; Lee, 2004; Shamsul & Tan, 2011). An arm, back and leg dynamometer was used to measure the strength of the back, legs and arms by recording the maximum reading in kilogram (kg). This dynamometer provides a base for footing, a large and easy-to-read LCD screen and adjustable hand grip chain to accommodate height differences. Two handed handle bar is use for exertion in this study. The diameter for the two handed handle bar is approximately 3.5cm. A steel chain is use to connect the handle bar with the load cell and adjust the handle bar at the different lifting types.

The horizontal distance in this study was different in distance from the toes to the vertical plane of the handle bar which namely as align with (near) and posterior to (far). Horizontal distances near and far refer to participants' toes being align with and posterior to the vertical plane of the handle bar respectively. The one-forth foot length for male and female participants is set according to the respondents' mean anthropometrical data.

The four lifting types were set and assessed according to the respondents' height. Back lifting was characterized with two hands approximately at knee height and in stoop posture. Upper-body lifting was characterized with respondents stood erect with back, legs and elbow straight and placed two hands in front of the body at knuckle height. Arm lifting was characterized with respondents stood erect with back and legs straight and kept forearms horizontal. Shoulder lifting was characterized with respondents stood erect with back and legs straight and two elbows fully flexed in front of the body.

For the second session was to determine the maximum acceptable weight for lifting. Basically the experimental was quite similar with the first session which is still considering four types of lifting with two horizontal distances. But the different in this second session was determined based on the "self-adjustment of weight method" used by Ciriello and Snook (1983). Instruments used were a box filled with loads by respondents until the weight was maximum for them can handle for 8 hours per day without perceiving any strain, overexertion, discomfort, tiredness, weakness or breathlessness (Snook & Ciriello, 1991). The summary of the procedure for the whole this study is shown in Figure 1.

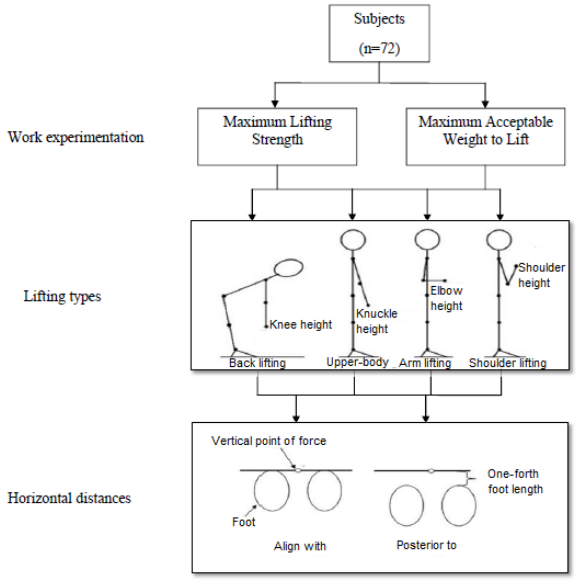

Figure 1: Procedure summary

Statistical analysis

SPSS version 22 was used to analyse all the result in this study. Since the data was not in normal distribution, non-parametric test was used in this study. Wilcoxon signed rank test was used to compare between maximum lifting strength and maximum acceptable weight to lift. Mann Whitney-U test was used to compare between male and female in lifting strength and acceptable weight to lift. Kruskal-Wallis test was used to compare maximum lifting strength and maximum acceptable weight to lift between

underweight (<18.5 kg/m^2), normal (18.5 – 24.9 kg/m^2) and overweight (>25 kg/m^2). All tests were significant at $p < 0.05$.

RESULTS

The result in Table 2 shows that all maximum lifting strength in four lifting types across two horizontal distances are significantly higher than maximum acceptable weight to lift ($p < 0.001$). However, recommended that lifting use acceptable weight limit compared to maximum weight limit.

The results showed in Table 3 indicate that there is significant higher among male respondents compared to female respondents ($p < 0.001$) and respondents with higher body mass index (BMI) in all lifting types across two horizontal distances ($p < 0.05$).

For maximum acceptable weight to lift, upper-body lifting type give the highest weight can be lifted followed by back, arm and shoulder lifting and near horizontal distance (align with) are higher than far horizontal distance (posterior to) as in Table 4.

DISCUSSION

Comparison of Lifting Strength and Acceptable Weight

All maximum lifting strength in four lifting types across two horizontal distances are significantly higher than maximum acceptable weight to lift ($p < 0.001$). However, recommended that lifting use acceptable weight limit compared to maximum weight limit. Through the observation, none of the respondents could be lifted weight even nearly to their maximum strength.

According to Mital, Kilbom and Kumar (2000), the low correlation between strength and lifting capability of individual did not permit the development of reliable and accurate lifting capability prediction model. The main reason and has been discussed that the static strengths are failed to take into account for inertial forces resulting from the movement of the object and body segment.

Table 2: Comparison of MLS and MAWL

Lifting Type - Horizontal Distance	Median (IQR)	
	Maximum Strength (N = 72)	Maximum Acceptable (N = 72)
Back – Align with	51.25 (42.25)	14.25 (7.50)
Back - Posterior to	42.50 (30.25)	11.50 (6.25)
Upper-body - Align with	53.50 (39.63)	14.50 (8.50)
Upper-body - Posterior to	48.25 (28.63)	10.50 (6.19)
Arm – Align with	31.00 (23.63)	12.50 (6.81)
Arm - Posterior to	28.25 (14.00)	8.75 (6.94)
Shoulder – Align with	34.00 (15.25)	11.25 (6.38)
Shoulder – Posterior to	30.00 (14.88)	7.13 (5.00)

Table 3 – Gender and Body Mass Index (BMI) in Acceptable Weight to Lift

Lifting Types	Horizontal Distances	Median (IQR)				
		Gender		Body Mass Index (BMI)		
		Male (N = 34)	Female (N = 38)	Underweight (N = 20)	Normal (N = 28)	Overweight (N = 24)
Back	Align with	17.50 (13.50)	11.75 (19.75)	11.50 (10.00)	15.00 (17.25)	17.50 (19.75)
	Posterior to	14.50 (14.25)	8.88 (13.50)	9.25 (12.25)	11.25 (13.75)	14.88 (18.50)
Upper-body	Align with	18.50 (15.50)	10.63 (16.25)	10.63 (13.50)	15.00 (15.75)	16.63 (19.25)
	Posterior to	13.75 (17.50)	7.50 (10.75)	7.50 (12.50)	10.00 (11.25)	12.88 (18.75)
Arm	Align with	15.00 (10.50)	8.75 (11.25)	8.75 (11.25)	12.50 (16.25)	15.00 (14.75)
	Posterior to	12.38 (11.25)	5.50 (7.50)	5.88 (8.50)	8.50 (13.25)	10.25 (14.00)
Shoulder	Align with	13.50 (10.50)	7.38 (8.25)	7.50 (7.50)	10.88 (13.25)	12.50 (12.00)
	Posterior to	10.00 (10.00)	5.00 (7.50)	5.00 (7.50)	6.25 (10.25)	9.88 (11.50)

Gender and Acceptable Weight to Lift

Many previous studies had similar result with this study. According to Lemmer, Martel, Hurlbut and Hurley (2007), gender effect showed both men and women increased strength with the 24 weeks of training. In other study, gender was found to be statistically significant with male participants reported larger maximum acceptable weight to lift (MAWL) than the female participants. The mean MAWL of the male and female participants were 22.2 kg and 15.9 kg respectively (Singh, Park and Levy, 2009). Similar study in static lifting strength by Shamsul and Tan (2011) also showed a significant difference in men's and women's lifting strength in all lifting condition. They reported that range of static lifting strength ratio for females to males were able to exert are about 56% to 72%.

The reason of higher strength of male lifting could be explained by previous finding on human muscle properties. Generally, males' muscles are known to have a higher capacity for anaerobic metabolism and generate a higher maximum power output than female muscles (Hakkinen, 1993; Linnamo et al., 1998; Fulco et al., 1999; Singh, Park & Levy, 2009). Study by Miller et al. (1993) explained that strength in male was due primarily to larger muscle fibers. The greater gender difference in upper body strength can attribute the fact that women tend to have lower proportion of lean tissue distributed in the upper body.

Body Mass Index (BMI) and Acceptable Weight to Lift

There are discrepancies in studies between body mass index (BMI) with strength. According to Hulen et al., (2001) revealed that there was a low positive correlation between BMI and fat mass with strength measures but Apovian et al., (2002) reported that seems BMI did not have any association with levels of coordination or strength. However, there also have studies that in line with this study finding. According to Singh, Park and Levy (2009) study, the mean maximum acceptable weight to lift (MAWL) of moderate and extremely obesity were not significantly different but still had significantly larger than non-obese group. The comparison between lifting strength with normal and abnormal BMI respondents showed significant difference in all lifting types and horizontal distances (Shamsul and Tan, 2011).

From biomechanical and physiological point of view found that obesity does not reduce MAWL. This is because obesity would most likely increase biomechanical and physiological stresses during lifting motions or manual activities because of the extra fat mass in the obese body. Other study found that muscle strength of obese person was higher than non-obese (Miyatake et al., 2000). Besides, there was a decrease in aerobic fitness and increase in maximal static lifting strength among adolescents and may due to increased body weight and BMI (Westersahl et al., 2003).

Four Lifting Types across Two Horizontal Distances in Acceptable Weight to Lift

From the findings, maximum acceptable weight to lift in four lifting types from highest to lowest order were upper-body lifting, back lifting, arm lifting and shoulder lifting. Lifting types significantly determined the vertical location of the hand and lifting strength. The vertical location of the hand is one of the main factors in NIOSH lifting equation in which a height of 75cm (upper-body lifting) suggested to be the highest lifting strength. According to Lee (2004), even though his study recognized 45cm (back lifting) as the highest strength, he recommended that hand should place at higher position to lessen the lumbar strain.

The order for horizontal distances for acceptable weight were near horizontal distance (align with) and far horizontal distance (posterior to). This finding was in agreement with Ciriello (2003) reported that maximum acceptable weight to lift was decrease with extended horizontal reach compared to lifting close to the body. As shown by NIOSH lifting equation (1994), horizontal distance also as one of the main factors in estimating the relative risk of lifting heavy load. Lifting with near horizontal distance (align with) will give more strength because the body's centre of gravity will be closer and thus lesser the shoulder angle in upper extremities (Cheng and Lee, 2005).

Table 4: Comparison of MAWL in Four Different Lifting Types across Two Horizontal Distances

Horizontal Distance	Lifting Types	Median (IQR)	Mean Rank	x^{2F} (df)	*p*-value*
Align with	Back	14.25 (7.50)	3.05	93.28 (3)	<0.001
	Upper-body	14.50 (8.50)	3.22		
	Arm	12.50 (6.81)	2.34		
	Shoulder	11.25 (6.38)	1.40		
Posterior to	Back	11.50 (6.25)	3.44	143.34 (3)	<0.001
	Upper-body	10.50 (6.19)	3.20		
	Arm	8.75 (6.94)	2.13		
	Shoulder	7.13 (5.00)	1.22		

*p-value significant at 0.05 level

CONCLUSION

This study had shown that the maximum lifting strength is higher than maximum acceptable weight to lift in all lifting types across two horizontal distances. However, recommended that lifting should use acceptable weight limit compared to maximum weight limit.

The result in this study revealed that gender had given significant difference. Male gender and people with higher body mass index (BMI) had higher lifting strength and acceptable weight to lift. The study showed that the maximum weight lifted and acceptable weight for lifting is at upper-body compared to back, arm and shoulder lifting with the near horizontal distance (toes align with). Therefore, the recommended standard for acceptable weight for lifting activities among young adults is shown in Figure 2.

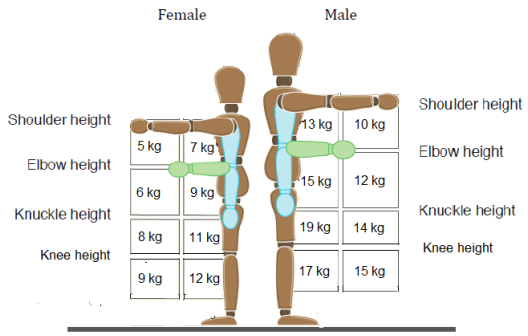

Figure 2: Recommended Standard for Lifting Activities

Limitations and Recommendations for Future Study

This cross-sectional experimental study was done only at Universiti Putra Malaysia. It cannot be generalised towards all young adults in Malaysia. Therefore, further study need to be conducted at any other various places to get more significant standard for acceptable weight for lifting activities that can be use throughout this country.

This study performed only took variables such as gender, body mass index (BMI), lifting types and horizontal distances. There are still some other variables that need to be in further consideration such as the frequencies of lifting, size and handling position of the box that to be lifted. The discrepancy between in this study and other studies also should need further discussed and explored.

ETHICS

This study has received an ethical clearance from Ethics Committee for Research involving Human Subjects (JKEUPM), Universiti Putra Malaysia.

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