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ORIGINAL ARTICLE

Effect of the Gender and Personal Characteristics Impact on One-Handed Isometric Push-Pull Exertions

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ABSTRACT

Pushing/pulling activities are known as usual and high frequent tasks in industrial sectors, especially in developing countries. Nearly, half of all manual material handling tasks is comprised of push/pull exertions, so it is essential to determine the maximum value of push/pull force exertions by Iranian workers to design the workplace optimally. A total number of 31 volunteer students (19 males and 12 females) were participated in a one-handed maximum push/pull force measurement test in standing posture. The results were measured using the Isometric Push-Pull Dynamometer. Height and weight were also recorded through interviews. Data analysis showed that the pull/push forces of women were 72% and 52% of men, but the data variation for men was higher than women. Using linear regression and Pearson correlation coefficient, it was found that there were only two strong correlations between the push force of women with body mass index (R-Sq = 75.55%) and weight (R-Sq = 74.8%) and men's pull strength was almost independent of individual characteristics. The results of maximum push/pull can be used for improvement in workstations and push/pull tools' design in production and services industries, in which occupational health promotion will be achieved.

KEYWORDS: *One-Handed Exertion, Push/Pull Force, BMI, Weight*

INTRODUCTION

Work-related musculoskeletal disorders like injuries rate are one of the main sources of concern in workplaces [1]. Manual Material Handling (MMH) tasks included lifting, lowering, pushing, pulling, and carrying which has been noted as one of the important risk factor for work-related low back disorders. Among MMH tasks, pushing and pulling has received relatively less attention (i.e., vs. lifting/lowering) [2] while push/pull activities are increasing prevalence in industrial workplaces [3] and nearly half of all manual material handling tasks are comprised of push/pull exertions [4-5].

Pushing means as a force exertion in which the resultant force is aimed horizontally and away from the body and pulling as one where the resultant force is aimed towards the body [6]. Recent epidemiologic studies showed that push/pull activities

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increases shoulder and low back complaints [7-9] and have been identified as musculoskeletally problematic exertions [10]. The National Institute for Occupational Safety and Health (NIOSH) reported that 20% of the injury claims for low back pain were associated with pushing and pulling [11].

Different studies have pointed that males' muscle strength is higher than females' muscle strength in two-handed push/pull force [5-11-13], one-handed push/pull force [5-14], handgrip force [13-15], and women's two-handed pull/push forces were about 72% and 79% of men's, respectively [11].

Studies regarding push/pull force are often divided into isometric (static) and isokinetic (dynamic) categories. Generally, to design material handling equipment some factors such as design characteristics, load characteristics, operating conditions, user characteristics, performance aspects, and environmental conditions are effective [16]. There have also been numerous studies on equipment used in dynamic push/pull forces like manual carts [17], wheeled cages [12] and two-wheeled containers [18] and results showed that factors such as surface type, wheels width, wheels diameter, and wheels direction which have distinct impact on dynamic push/pull forces [17-18]. Since the main subject of the present study was to investigate one-handed push/ pull forces, so the research background in this area only will briefly be reviewed.

One-handed exertions are commonly used in industries such as telecommunications, warehouses, distribution centers, construction, and air transportation. However, only a few studies have examined the issues related to one-handed force exertion [19]. Although the Advanced Ergonomics Manual stated that the recommended value of one-handed push/pull force in standing posture, is 24 and 22 lbs for a frequency of less than once per minute, and 16.5 and 15 lbs for a frequency of more than once per minute, respectively [20]. Nevertheless, the research necessity and update in this field, especially for the Iranian workers' condition, cannot be ignored since understanding the strength capability of one-handed exertions can translate to improved guidelines for designing tools, equipment, and workplaces [21].

About one-handed isometric pull force, two studies with different postures in a standing position were performed in the United States (86 subjects) [19], and China (100 subjects) [14]. The result showed that the strength of the American sample was higher than the Chinese sample. Gender, pull height, race, body mass, and men's handgrip force were also associated with pull strength. So, these factors should be considered to develop of one-handed pulling activities in the above countries [14-19].

In the previous studies, different results have been obtained regarding the relationship between push/pull forces and individual characteristics such as height, weight, and body mass index. It was found in 1974 that height and weight had a significant impact on the maximum two-handed isometric push/pull strength applied [22]. However, in another study in the same year, the results indicated that bodyweight alone or in combination with other anthropometric characteristics were not useful for predicting maximum isometric horizontal push strength [23].

This study was aimed to investigate the effect of gender and individual characteristics (height, weight, and body mass index) on Iranian students' one-handed isometric push/pull forces in standing posture.

METHODS

Research Methodology:

In this cross-sectional study, the main objective was to obtain the related data about push/pull tasks among Iranian blue-collar workers. In this study, two parts of laboratory work and result analysis were included. Moreover, there had been a cross-sectional plus laboratory work, in which volunteers' anthropometric data were recorded through interviews. In the current study, the dependent variable was the one-handed isometric push/pull forces in standing posture, and independent variables of the study were gender, height (cm), weight (kg), and body mass index.

Sample size:

In the present study, 31 volunteer students of Iran University of Science and Technology (IUST) comprised of 19 males and 12 females were participated, and the experiments were conducted in the Advanced Ergonomics Lab in the School of Architecture and Urban Development at IUST. The conditions and purposes of the experiments were explained to the volunteers thoroughly.

Volunteers' mean height was 171.548 cm (SD = 8.951 cm), with a standard deviation of 8.951 cm. Volunteers' mean weight was 71.378 kg (SD = 18.027 kg), and volunteers' mean age was 21.355 years (SD = 1.279 years).

Procedure:

In the current study, a digital isometric push-pull dynamometer (made in Iranian Danesh Salar Company) was used. The volunteers in standing position, handle grip, exert pull force, and the maximum applied to pull force were recorded by dynamometer (Figure 1). After a rest-time for a few minutes, the same test was repeated but with push force and the maximum applied push force.

For data analysis, Pearson correlation coefficient and univariate linear regression were used to examine the relationship between independent and dependent variables. Paired t-test was applied to compare the push/pull force results among subjects. The confidence level of 0.95 was also considered for all methods. Minitab software version 16 and Microsoft Excel 2016 were used to analyze experiment's data.

RESULTS

The results showed that the men's push/pull strength was higher than women's, while women's push/pull strength variation was less than men's (see Figure 2). The push/pull forces of men and women was significantly correlated (P-Value=0.000). The push strength of both gender were higher than their pull strength (Figure 2).

The regression equations and Pearson correlation coefficients between the independent variables of the study, namely height, weight, and body mass index, with push/pull forces applied by men, women, and all volunteers have been presented in Table 1.

The results showed that there was no relationship between males' pull strength and individual characteristics. However, there was a strong significant relationship between females' push strength and body mass index as well as weight (refer to Table 1 and Figure 3).

Fig. 1. Procedure for experimental task

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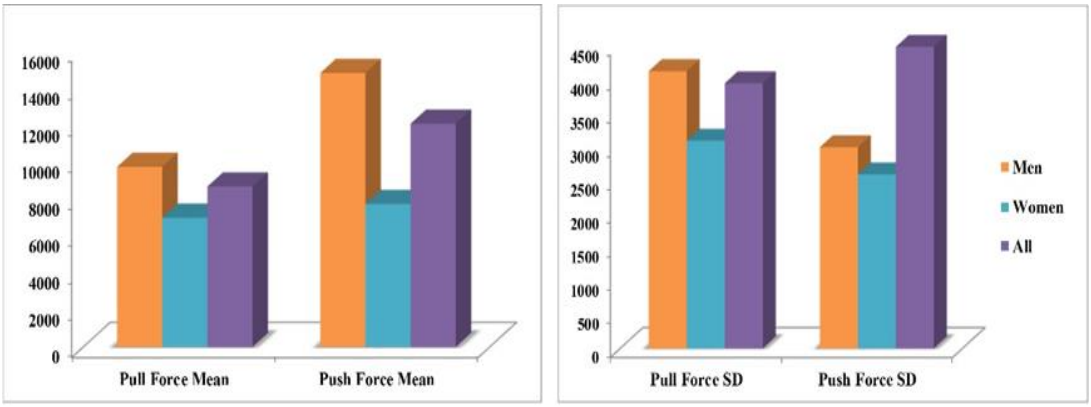

Gender	One-handed Pull Force (gf)		One-handed Push Force (gf)	
	Mean	SD	Mean	SD
Men	9764.21	4131.31	14850.00	2997.50
Women	7008.33	3093.82	7754.17	2593.13
Total	8697.42	3951.23	12103.20	4494.51

Fig. 2. Experimental test results and charts for one-handed push/pull forces including mean and standard deviation

Table 1. *Regression equations and Pearson correlation coefficients*

Independent Variable	Dependent Variable	Intercept	Regression Coefficient	R-Sq	Pearson Correlation Coefficient
		Male			
BMI	Pull	8822	25.75	% 1.2	0.108
Height	Pull	-7557	97.7	% 1.9	0.138
Weight	Pull	7042	34.45	% 2.1	0.145
BMI	Push	12158	73.56	% 18.0	0.424
Height	Push	6148	49.1	% 0.9	0.095
Weight	Push	8722	77.57	% 20.2	0.449
		Female			
BMI	Pull	3491	156.6	% 24.7	0.497
Height	Pull	-12766	121.8	% 1.8	0.136
Weight	Pull	-1414	142	% 28.4	0.533
BMI	Push	2597	229.6	% 75.5	0.869
Height	Push	22932	-93.5	% 1.5	-0.124
Weight	Push	-3706	193.2	% 74.8	0.865
		All			
BMI	Pull	6371	74.73	% 9.4	0.307
Height	Pull	-18442	158.2	% 12.8	0.358
Weight	Pull	2870	81.64	% 13.9	0.372
BMI	Push	6684	174.1	% 39.5	0.629
Height	Push	-45163	333.8	% 44.2	0.665
Weight	Push	-589	177.8	% 50.9	0.713

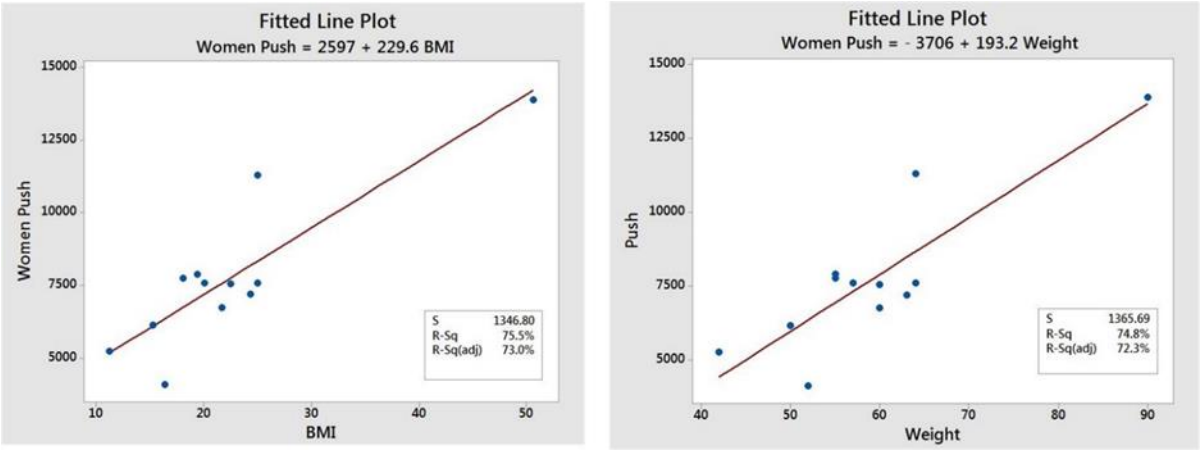

Fig. 3. Significant correlations between females' push strength with BMI and weight

DISCUSSION

According to the results in Figure 2, women's push/pull strength was less than men, which was confirmed by the results of previous studies [5-14]. In addition, the push/pull strength of women was about 72% and 52% of men's, respectively. Therefore, these results were confirmed previous studies' findings about pull strength, while about push strength; this percentage was much lower than 79% [11]. It seems that the difference was appeared due to one-handed or two-handed testing and push force reduction percentage in women compared to men was much higher when exerted with two hands. On the other hand, according to Figure 2, the variation of men's forces was greater than women's, and the dispersion was more pronounced in pull forces.

Based on the findings in Table 1, there was no virtually relationship between men's and all volunteers' pull strength with height, weight, and body mass index. However, there was a weakly significant relationship between females' pull strength and weight (R-Sq=28.4%).

According to Figure 3 and Table 1, There were two significant correlation between the push strength of women with body mass index and weight (R-Sq=74.8%, R-Sq=75.55%) which was consistent with. the results of the Or's et al study [14]. However, there was almost no correlation between the women's push force and height (R-Sq=1.5%). Generally, it seems that height was not a good predictor for push/pull forces because its R-Sq values range from 0.9% to 44.2% (Table 1).

However, the correlation between men's push strength with weight and body mass index was greater than men's pull forces, but it was not significant. On the contrary, for two-handed isometric push/pull force, Ayoub et al. found that there was not necessarily a significant relationship between one-handed isometric push/pull force with height and weight for Iranian students, and it depends on gender and the push or pull activity [22].

CONCLUSION

Males' one-handed isometric push/pull strength was significantly greater than females'. Also, in this study, females' pull/push force was about 72% and 52% of males' but men's push/pull variation was more than women's. The pull forces showed less significance against the personal characteristics than the push forces, and males' force showed less significance than females' force against individual characteristics. Only two significant correlations were

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found between push strength of women with weight, and body mass index and generally. It can be concluded that, for Iranian students, the correlation between push/pull forces with individual characteristics such as height, weight, and body mass index, was dependent on gender, and push or pull activity nature.

In the present study, a limited number of persons were participated in a standing position which is recommended to implicate this process in a broader sample size with other postures. Further researches can investigate one-handed push/pull exertion in different positions among a larger sample size of Iranian with a broader age range.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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