Musculoskeletal Disorders Survey and Simulation Evaluation of the Handmade Drinks Task: A Case Report

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Received 8 August 2017; Accepted 21 September 2017;
Publication 5 October 2017

Abstract

This study collected 60 Nordic Musculoskeletal Questionnaire (NMQ) data of workers from handmade drinks stores to understand their discomforts on various body sites. The NMQ results indicate that the overall prevalence of musculoskeletal disorders was 88.0% within 1-year. In terms of discomfort, 66.4% of the respondents experienced discomfort at hands/wrists, whereas those at other body sites were less than 42%. The discomfort at hands/wrists was extremely higher than that data collected from other body sites in this study, as well as the different tasks in the previous surveys. Logistic regression result showed that one of the risk factors in hands/wrists discomfort was gender (odds ratio, male:female = 1:3.67). This study further recruited 10 male and 10 female participants to perform the simulated handmade drinks tasks and to measure their wrist postures using a goniometer, under three handmade-drink methods (i.e., upward, curve, and downward shaking). Results showed that, when performing the downward shaking task, females' wrists revealed more server ulnar deviations (-21.8°) and radial deviation (15.4°) on the left

Journal of Industrial Engineering and Management Science, Vol. 1, 149–160.

doi: 10.13052/jiems2446-1822.2017.007

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and right wrists, respectively, than males'. Contrarily, the male participants adopted a relatively neutral wrist posture (deviations were less than 10°) during shaking. The findings of this study can be served as references for the prevention from the musculoskeletal disorders resulting from the drinks handmade task, especially for corrective shaking method and employee recruitment.

Keywords: Musculoskeletal disorders, NMQ questionnaire, Handmade-drink task.

1 Introduction

In recent years, work-related musculoskeletal disorders (WMSDs) affect the well-being of workers [1] and have therefore become a critical topic, especially regarding people who must perform the highly repetitive tasks in awkward postures [2]. Although extensive and in-depth studies on WMSDs have been conducted, a literature review revealed that no studies have addressed the handmade drinks task (i.e., shaking the drinks), which is a common task in beverage stores in Taiwan.

When workers are exposed to the highly repetitive tasks for a long time, they are most likely to cause musculoskeletal injuries. Previous studies had pointed out that, in the clinical surgical cases, the wrist injury accounted for about 20 to 25%, in addition, many on-site workers and computer operators are also prone to wrist injury, such as carpal tunnel syndrome (CTS) [3, 4]. Previous studies have also found that the proportion of CTS employees in food and beverage industry is relatively high [5] because of the task characteristics.

In recent years, the beverage market in Taiwan has been booming, especially for handmade drinks because of their convenience and diversification of taste. The handmade drinks stores are therefore all over the Taiwan. According to the statistical reports, Taiwanese totally consume handmade drinks approximately a total of 1.02 billion cups in 2015, and the corresponding commercial benefit of each year is around NT\$ 85 billion. In Taiwan, the estimated number of handmade drinks stores is 16,000, and approximately 60,000 people are employed in the stores. Handmade drinks are undoubtedly the need for manual operation, that is, the highly repetitive cup-shaking by hands, with a frequency about 2–3 times/s. Therefore, the wrists would have impacts. To our observation, there is no specific shaking way for workers in the stores. Three ways for shaking tasks were observed, namely upward

Figure 1 Three shaking ways are usually adopted by handmade drinks workers.

shaking, curve shaking, and downward shaking (Figure 1). This case study was therefore employed the Nordic Musculoskeletal Questionnaire (NMQ) to investigate the prevalence of body part discomfort and to determine the risk factors that may cause injury among handmade drinks workers in Taiwan. Furthermore, this study further recruited 10 male and 10 female participants to perform the simulated handmade-drink task and to examine the shakers' wrist postures using a goniometer, under three handmade-drink methods (i.e., upward, curve, and downward shaking).

2 Methods

2.1 NMQ Survey

In this study, the NMQ survey was distributed to 60 handmade drinks workers in Northern Taiwan and was based on the pain experience of each body region over the past year. The NMQ is a general questionnaire that classifies musculoskeletal discomfort and disorders according to nine major symptom sites, enabling researchers to discriminate among sites of discomfort and injury and to closely examine symptoms specific to certain sites. The NMQ can be either general or specific and features a reliability ranging from 77% to 100% and a validity ranging from 80% to 100% [6]. In the study, informed consent was obtained from all respondents. This study was approved by the Chang Gung Memorial Hospital (Taiwan) Ethics Committee.

In addition to a general descriptive statistical analysis, a logistic regression analysis was conducted to explore possible risk factors causing the highest prevalence value of the symptom sites among all participants. The factors surveyed by the questionnaire covered the personal details and job demands. The odds ratio (OR) is used as the benchmark between different levels of the variable. The data collected from the questionnaires were analyzed using the

Statistical Package for the Social Sciences Version 19.0; the significance level α was set at .05.

2.2 The Simulated Handmade-Drink (Shaking) Task

Twenty participants [male: N = 10, mean (SD) age = 23.1 (1.5) years; female: N = 10, mean (SD) age = 23.0 (0.9) years] were recruited from the drink-handmade stores for the simulated shaking task. Their anthropometric data were collected and are listed in Table 1. All participants had no prior history of musculoskeletal disorder, volunteered for this study, provided informed consent, were paid, and were familiarized with the testing procedures.

In this study, participants were requested to perform the simulated handmade-drink task. The cup for the shaking task was made by stainless steel, which was extensively used by most handmade drink stores in Taiwan. Each participant was requested to shake the cup for 15 sec and to repeat 15 times for each shaking methods (upward, curve, and downward shakings). We used a goniometer (Biometrics, U.K.) to record changes in wrist postures, including palmar flexion (+), dorsiflexion (−), radial deviation (+), and ulnar deviation (−), for each participant during the shaking task. The sampling frequency was 16 Hz and the entire process was recorded. Figure 2 shows the goniometer used in this study, which contains two sensors connected to the signal collection device worn by participants. After attaching the goniometer to the participant's wrists, the electric potential of certain wrist postures

Table 1 Data of male and female participant groups in the simulation test of the study

Items	Males (N = 10)		Females (N = 10)	
	Mean	SD	Mean	SD
Age (years)	23.1	1.5	23.0	0.9
Stature (cm)	171.7	5.6	160.4	5.8
Body weight (kg)	83.6	16.0	55.2	8.8
<i>Left side</i>				
Wrist circumference (cm)	17.0	1.3	14.6	1.3
Hand width (cm)	8.5	0.8	7.2	0.4
Hand length (cm)	17.9	3.1	16.7	0.9
Grip strength (N)	411.6	71.5	204.8	53.9
<i>Right side</i>				
Wrist circumference (cm)	17.0	1.3	17.0	1.3
Hand width (cm)	8.6	0.8	7.2	0.4
Hand length (cm)	17.9	3.1	16.8	0.9
Grip strength (N)	420.4	62.7	201.9	43.1

Figure 2 A typical shaking test (*left*) and the goniometers attached on the hands (*right*).

measured by the goniometer were documented and set the calibration base. After familiarizing the experiment procedure, each participant performed the shaking tests. The participants were allowed a 20 sec break between each trial and were instructed to shaking using their usual postures and paces. Consequentially, the 15th shaking data were collected for further analysis. The testing protocol referred to the previous study [3]. In this study, the wrist postures were presented as the data of the 50 percentile within a 15 sec shaking period. This was used to avoid the inferences by fluctuations and outliers on data analyses.

During the wrist posture measurement, a randomized complete-block design was used for the experiment. Each participant was considered a block; he or she performed all 45 treatment combinations by three shaking methods and 15 repetitions. The wrist data were then analysed with a one-way repeated-measures analysis of variance (RMANOVA) for each shaking method, and the Duncan multiple-range test (MRT) was performed for *post hoc* comparisons. An alpha level of .05 was selected as the minimum level of significance.

3 Results and Discussion

3.1 Survey Sample Data of NMQ

For NMQ survey, one-on-one interview were conducted, and a total of 60 valid questionnaires were collected in this study. Among the 60 respondents,

twenty-one were male and 39 were female, with an average (SD) age of 23.2 (4.1) years, stature of 165.7 (6.7) cm and body weight of 55.5 (11.6) kg. Of the 60 respondents, 33.2% never exercised, 51.5% occasionally exercised, only 14.9% regularly exercised. 26.6% and 38.2% of the respondents were smoking and consuming alcohol. In addition, the respondents were all right-handed. A proportion of the 60 respondents had previously been diagnosed with wrist (10.0%), hand (5.0%), shoulder (16.7%), upper back (5.0%), lower back (15.0%) injuries, and 6.7% of these respondents had not recovered by the time of the interview. On average, the respondents had worked 2.4 ± 0.9 years at their current job. The daily work hour was approximately 7.4 ± 1.9 hours, and among all, 56.7% never arranged the rest time within a workday. The average weekly workdays were 5 days. All respondents responded that they almost kept the standing posture during the whole workday.

3.2 NMQ Result

Among the 60 drink-handmade employees in the survey, the overall prevalence of musculoskeletal disorders was 88.0% within 1 year. The overall prevalence value was higher than that of other tasks investigated by previous studies (e.g., taxi drivers: 51.0% [7]; beverage bottling workers: 60.0% [8]; nurses: 80.8% [9]). The results of the NMQ for each body part are shown in Table 2. The table also shows that the NMQ results in comparison with a previous study [10], which investigated the WMSD of Taiwanese labors from manufacturing and service industry samples. As shown in the table, the prevalence value of the hands/wrists discomfort were extremely higher than that of the results investigated by the Institute of Labor and Occupational Safety and Health, Taiwan (ILOSH). In the ILOSH study, the prevalence of the hands/wrists

Table 2 NMQ result and compared with a previous study

Body Sites	ILOSH [10]		This Study
	Manufacturing	Service	
Neck	57.0%	59.2%	10.0%
Shoulders	69.6%	58.3%	36.5%
Upper back	39.8%	34.5%	10.0%
Elbows	37.5%	32.7%	26.6%
Lower back/waist	53.0%	50.3%	41.5%
Hands/wrists	47.0%	39.4%	66.4%
Legs	24.1%	33.5%	11.6%
Knees	30.9%	34.7%	38.2%
Feet/ankles	27.4%	23.0%	31.5%

discomfort was 47.0% and 39.4% in manufacturing and service industries, respectively. This may be attributed to the job characteristics regarding the drinks shaking task.

In the analyses, as expected, the hands/wrists were the body part with the highest prevalence of discomfort (66.4%) among the 60 respondents, followed by the lower back/waist (41.5%) and knees (38.2%). In addition, the prevalence of shoulders discomfort was 36.5%, followed by feet and ankles (31.5%), and elbows (26.6%) discomfort. The main symptom was aching pain that slightly influenced operation abilities and all respondents reported that it occurred almost daily. However, most respondents neglected the discomfort. The primary treatment, if sought, was massage (approximately 1/3). A high proportion of the respondents considered the discomfort to have been caused completely or partially by work (e.g., hands/wrists discomfort: 85%; lower back and waist discomfort: 70%), indicating that most respondents deemed their discomfort to be the result of handmade drinks shaking.

To clarify the risk factors affecting each investigated symptom site, a logistic regression analysis was performed. The results indicated that, in addition to exposure dose (i.e., weekly workdays), gender factor substantially influenced hands/wrists discomfort (male/female, odds ratio = 1/3.67). This implied that the job demand may variedly match the individual characteristics and can be served as references for employee screening to the prevention from the musculoskeletal discomforts and even injuries. Females' wrist discomfort was significantly higher than that males', which may be reasonably attributed to difference in muscle strengths between genders. However, the hand size may be another crucial factor. An objective assessment to examine the gender effect on the shaking behaviour needs further investigation.

3.3 Wrist Posture Analyses

Because the hands/wrists discomfort was affected by gender, a simulated shaking test was then scheduled and performed by 10 male and 10 female participants. Table 3 shows the ANOVA results for the wrist postures between genders for the simulated shaking tasks. As shown in the table, there was no significant difference existed between genders in palmar flexion and dorsiflexion for both left and right hands/wrists under all shaking method conditions (all $p > .05$). However, when performing the downward shaking, significant differences in wrist postures (i.e., Radial/ulnar deviation) were found between male and female participants (all $p < .001$).

Table 3 ANOVA result for wrist postures between genders for three shaking methods

Wrist Postures	Methods	DF	SS	MS	F	<i>p</i>	Power
Left wrist	US	1	23	23	0.1	0.700	0.067
palmar flexion/ dorsiflexion	CS	1	75	75	0.8	0.385	0.139
	DS	1	232	232	1.2	0.279	0.190
Left wrist	US	1	162	162	1.0	0.310	0.173
Radial/ ulnar deviation	CS	1	1	1	0.0	0.898	0.052
	DS	1	2359	2359	16.5	$p < 0.001$	0.981
Right wrist	US	1	164	164	1.2	0.276	0.192
palmar flexion/ dorsiflexion	CS	1	134	134	1.7	0.200	0.248
	DS	1	1	1	0.0	0.912	0.051
Right wrist	US	1	15	15	0.2	0.663	0.072
Radial/ ulnar deviation	CS	1	124	124	1.6	0.216	0.013
	DS	1	1424	1424	14.8	$p < 0.001$	0.968

US: upward shaking; CS: curve shaking; DS: downward shaking.

Duncan MRT test further revealed that male participants presented a relatively small wrist deviation (deviations at 3.9° and 6.2° for left and right wrists, respectively), whereas female participants more flexed their wrists (left wrist: ulnar deviation at 21.8° , right wrist: radial deviation at 15.4°), indicating that female participants were exposed to a worse wrist posture condition (Table 4). This may be explained by the differences between genders in nature, that is, muscle strength and hand size. It is well-known that females are two-thirds as strong as, or less than males [11, 12]. In this study, the grip strength of the female participants was approximately 50% lower than that of the male participants, as shown in Table 1. Moreover, the hand size of the female participants was also substantially smaller than that of the male participants (Table 1). The relatively weak and small hands of the female participants would cause the more difficult in holding the shaker

Table 4 Means (SD) of ulnar/radial deviations of hands between genders when performing downward shaking and Duncan's MRT Results (unit in degrees)

Radial/Ulnar Deviations	Genders	N	Mean	SD	Duncan Groups
Left wrist	Male	10	3.9	5.0	A
	Female	10	15.4	12.7	B
Right wrist	Male	10	6.2	6.4	A
	Female	10	-21.8	10.8	B

Note: + radial deviation, - ulnar deviation.

Figure 3 Changes in left and right wrist postures of two representative and comparable participants (one female (F) and one male (M)) when performing a downward shaking.

than male participants, therefore the females may have to change their holding methods (i.e., changing the hand posture) to steadily hold the cup and shake it, therefore avoid the cup slipping or falling from the hands.

Ryu et al. [13] found that the largest range of motion (ROM) of human wrists is 59.3° for dorsiflexion, 79.1° for palmar flexion, 37.7° for ulnar deviation, and 21.1° for radial deviation. For the handmade drinks shaking analyzed in that study, the largest radial deviation of the female left wrist (approximately 15.4°) was near the maximum ROM suggested in previous studies. The female ulnar deviation of the right wrist also showed a similar phenomenon. This may cause the difference in hands/wrists discomfort between genders, which was found by the logistic regression. Figure 3 shows the changes in wrist postures of two representative and comparable participants (one male and one female) when performing the 15-sec downward shaking task. It was apparent to find that the inherent difference in wrist postures between genders.

4 Conclusion

This study collected discomfort data of 60 workers from handmade drinks stores to understand their discomforts on various body sites. The NMQ results indicate that the overall prevalence of musculoskeletal disorders was 88.0%

within 1-year. Apart from 66.4% of the respondents experienced discomfort at hands/wrists, other body sites responded were all less than 42%. Further logistic regression result also showed that one of the risk factors in hands/wrists discomforts was the gender factor, therefore the simulated handmade drinks test was performed. The finding of this study revealed that, the relatively weak and small hands of the female participants would cause the more difficult in holding drink cup than male participants, therefore the females may have to change their wrist postures to steadily hold and shake the cup to avoid the cup slipping or falling from the hands. This would cause the more uncomfortable in females' hands/wrists than males'.

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