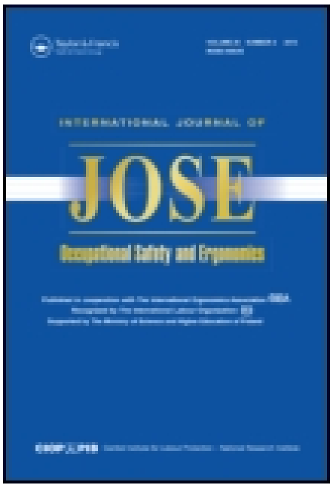


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# Manual Material Handling Assessment Among Workers of Iranian Casting Workshops

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# Manual Material Handling Assessment Among Workers of Iranian Casting Workshops

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*Manual material handling (MMH) tasks can be found in most workplaces and they may constitute a risk factor for work-related musculoskeletal disorders (WMSDs). This study was conducted to determine the prevalence of WMSDs and to compare MMH loads with the acceptable weight and force limits among Iranian casting workers. Data were collected from 50 workers of casting workshops who performed MMH tasks. The Nordic musculoskeletal disorders questionnaire and the Snook tables were used as tools for data collection. Hand/wrist symptoms were the most prevalent problems among the workers (84%). The results of the Snook tables showed that the loads in lifting (84%), lowering (86%), carrying (66%), pushing with initial (43%) and sustained force (59%), and pulling tasks with initial (48%) and sustained force (93%) exceeded recommended limits. WMSDs occurred in high rates among the workers and, thus, ergonomics interventions should focus on decreasing WMSDs and redesigning MMH tasks.*

musculoskeletal disorders    manual material handling    casting workers    Snook tables

## 1. INTRODUCTION

Manual material handling (MMH) includes lifting, lowering, pushing, pulling, carrying or moving a load with hands or body force. Properly designed MMH activities may enhance performance as well as reduce costs, incidents and accidents; while improperly designed MMH activities can lead to

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work-related musculoskeletal disorders (WMSDs) [1].

It is very complicated to estimate the costs of WMSDs but they are estimated to be ~171.7 million USD in developing countries, which is equivalent to 0.2% of the gross domestic product [2]. Despite current evidence indicating MMH activities as a susceptible risk factor for occupational low back pain, a series of review articles published in The Spine Journal in 2010 seem challenging [3, 4, 5, 6]. Nowadays, the main objective of ergonomics programmes is to prevent and control WMSDs, such as manual handling injuries [7].

Several analysis tools for evaluating, designing or redesigning MMH tasks are available. These tools include the NIOSH (National Institute for Occupational Safety and Health) lifting equation [8, 9]; American Conference of Governmental Industrial Hygienists' threshold limit values (TLV) [10]; manual handling assessment charts [11] and the Snook tables [12, 13]. In 1978, Ciriello and Snook collected data from industrial fields and, using the psychophysical approach, they established a database for designing MMH tasks [14]. This database includes maximum acceptable weights for lifting, lowering and carrying tasks, and maximum acceptable initial and sustained forces for pushing and pulling tasks [12, 13, 15]. According to the Social Security Organization of Iran, in 2008, 948 accidents were caused by carrying objects (~4% of the total number of accidents) [16]. Iranian casting workers are exposed to numerous ergonomics risk factors. In this industry, physical activities such as tasks in awkward postures; repetitive activities; MMH tasks (e.g., lifting, lowering, carrying, pushing and pulling) and force exertions are very common. In addition, these risk factors and other task-specific factors may cause unwanted situations for the workers. Therefore, this study was conducted with two purposes: (a) to investigate the prevalence rate of WMSDs among casting workers, (b) to assess MMH tasks with the Snook tables and (c) to compare MMH loads with the acceptable weight limits to identify the tasks, during which the exertions could exceed the operators' capabilities.

## 2. METHODS

This cross-sectional study was conducted among casting workers in Hamadan, in the west of Iran. For the purpose of this study, all occupational tasks were analysed. Performing all MMH tasks including lifting/lowering, carrying and pushing/pulling was the main criterion in selecting the workers. Hence, workers whose job did not meet the criteria were excluded. In total, 50 workers were chosen for the study. In the primary evaluation of the workplace, MMH tasks were shown to be the main ergonomics problem among the workers and some workers performed a combination of MMH tasks. In addition, by interviewing workers, we found that some of them had complained about WMSDs symptoms. The Nordic musculoskeletal questionnaire was used to study the prevalence of WMSDs [17]. This questionnaire has two sections: (a) personal details (including age, weight, height and job tenure) and (b) musculoskeletal disorders in body parts. The questionnaires were completed during the interviews.

To measure initial and sustained forces in pushing and pulling tasks, a force gauge was used. To assess acceptable weights in MMH tasks, a concise version of the Snook tables was used [13]. The Snook tables are a scientific way of finding safe weights and forces for MMH tasks. The Snook tables use collected data on weights and forces chosen by workers to determine the maximum acceptable limits for lifting, lowering, pushing, pulling and carrying. The tables provide values of maximum acceptable limits as judged by industrial workers for 10%, 25%, 50%, 75% and 90% of the worker population.

For each worker, MMH tasks were assessed with the Snook tables and an acceptable limit was determined. In addition, the workload imposed on the workers was determined. The data were then imported into a computer and statistical analyses were done with SPSS version 16. A *t* test was used to verify the differences between the lifted/lowered/carried weights, pushed/pulled and the acceptable limits.

## 3. RESULTS

Table 1 summarizes the means and standard deviations for personal details of the participating workers.

**TABLE 1. Demographic Characteristics of Workers (*n* = 50)**

| Characteristic | *M* (*SD*) | Range |
|---|---|---|
| Age (years) | 32.66 (4.46) | 24–42 |
| Weight (kg) | 73.06 (4.74) | 60–82 |
| Stature (cm) | 170.40 (5.23) | 160–182 |
| Job tenure (years) | 6.82 (3.10) | 2–15 |

Table 2 presents prevalence rates of WMSD symptoms in different body regions of the workers during the past 12 months and 1 week prior to the study. Table 2 shows that in the past 12 months, the wrist/hand, low back and neck were most commonly affected, whereas 1 week prior to the study, the wrist/hand, low back and back.

Table 3 compares lifting/lowering tasks. Overall, in the lifting tasks, 84% of the weights lifted by the workers exceeded acceptable weights. There were significant differences between lifted and acceptable weights in the tasks involving taking melted material out of the furnace and taking parts out of the cast. In those tasks, lifted weights exceeded acceptable ones by as much as 93% and 90%, respectively. As the results show, 86% of the weights lowered by the workers exceeded acceptable weights for lowering tasks and 86% of the ones lowered by the workers exceeded acceptable ones in the task of pouring the melted material into the cast; the differences were significant.

**TABLE 2. Frequency of Reported Work-Related Musculoskeletal Disorders Symptoms in Workers' Body Regions in the Past 12 Months and 1 Week Prior to the Study (*n* = 50)**

| | Symptoms Prior to Study (%) | |
|---|---|---|
| Body Region | 12 Months | 1 Week |
| Neck | 36 (72) | 7 (14) |
| Shoulders | 24 (48) | 3 (6) |
| Elbows | 10 (20) | 4 (8) |
| Hands/wrist | 42 (84) | 24 (48) |
| Back | 20 (40) | 15 (30) |
| Low back | 37 (74) | 24 (48) |
| Thighs | 2 (4) | 5 (10) |
| Knees | 15 (30) | 3 (6) |
| Legs/feet | 0 (0) | 2 (4) |

Table 4 compares carrying tasks; 66% of the weights carried by the workers exceeded acceptable ones. However, the differences between actual and acceptable weights were not significant.

Table 5 shows data for pulling/pushing tasks. In the pulling tasks, 48% of initial forces and 93% of sustained forces pulled by the workers exceeded acceptable ones. The force in pulling a loaded cart exceeded acceptable force in all tasks.

**TABLE 3. Comparison of Mean (*SD*) Weights Lifted/Lowered by Workers (Actual) and Acceptable Weights According to Snook Tables [13, 14, 15] (*n* = 50)**

| | Weight (kg) | | | |
|---|---|---|---|---|
| Task | Actual | Acceptable | PIWW < AW (%) | *p* |
| Placing bars in cart | 11.90 (2.99) | 11.10 (1.92) | 70 | .486 |
| Lifting and placing bars in furnace | 13.80 (3.68) | 12.30 (3.60) | 80 | .960 |
| Taking melted material out of furnace | 17.13 (5.20) | 10.94 (2.80) | 93 | .034** |
| Taking parts out of cast | 14.30 (3.90) | 10.60 (1.58) | 90 | .059 |
| Placing parts in cart | 8.10 (8.11) | 6.90 (1.82) | 80 | .549 |
| total | 38.40 (3.00) | 11.04 (2.57) | 84 | |
| Taking bars out of cart | 11.08 (3.20) | 9.47 (2.10) | 86 | .167 |
| Pouring melted material into cast | 13.87 (3.95) | 10.33 (1.88) | 93 | .027** |
| Taking part out of cast | 12.15 (2.65) | 10.15 (2.68) | 80 | .880 |
| total | 34.12 (3.36) | 10.00 (2.27) | 86 | |

*Notes.* ***p* < .05, *t* independent test; PIWW = percentage of weights imposed on workers, AW = acceptable weight.

**TABLE 4. Comparison of Mean (*SD*) Weights Carried by Workers (Actual) and Acceptable Weights (*n* = 50)**

| | Weight (kg) | | | |
|---|---|---|---|---|
| Task | Actual | Acceptable | PIWW < AW (%) | *p* |
| Carrying bars | 17.97 (5.27) | 12.90 (4.23) | 90 | .122 |
| Carrying melted materials with ladle | 16.27 (4.75) | 15.87 (4.39) | 46 | .353 |
| Carrying parts | 16.47 (4.24) | 16.33 (5.53) | 53 | .104 |
| total | 17.00 (4.80) | 14.82 (4.27) | 66 | |

*Notes.* PIWW = percentage of weights imposed on workers, AW = acceptable weights. None of the results are statistically significant, *t* independent test.

**TABLE 5. Comparison of Forces Pushed/Pulled by Workers (Actual) and Acceptable Forces (*n* = 50)**

| | Actual Force (N) | | Acceptable Force (N) | |
|---|---|---|---|---|
| Task | Initial | Sustained | Initial | Sustained |
| Pushing half-loaded cart | 19.84 (3.42) | 11.64 (3.70) | 11.64 (3.00) | 13.56 (3.96) |
| Pushing loaded cart | 21.00 (5.48) | 16.08 (11.30) | 13.20 (4.09) | 12.72 (9.27) |
| total | 20.42 (4.56) | 17.92 (8.54) | 12.42 (3.60) | 13.14 (7.06) |
| Pulling half-loaded cart | 20.60 (2.24) | 10.75 (2.99) | 16.30 (3.91) | 13.45 (1.99) |
| Pulling loaded cart | 22.40 (2.33) | 18.80 (9.89) | 15.00 (4.63) | 13.40 (4.63) |
| total | 19.00 (4.25) | 18.15 (6.36) | 13.84 (5.93) | 11.60 (4.07) |

| | PIFW < AF (%) | | *p* | |
|---|---|---|---|---|
| Task | in Initial Force | in Sustained Force | Initial Force | Sustained Force |
| Pushing half-loaded cart | 36 | 66 | .403 | .361 |
| Pushing loaded cart | 52 | 52 | <.001** | <.001** |
| total | 43 | 59 | | |
| Pulling half-loaded cart | 45 | 100 | .057 | .003** |
| Pulling loaded cart | 46 | 80 | .002** | .037** |
| total | 48 | 93 | | |

*Notes.* ***p* < .05, *t* independent test; PIFW = percentage of forces imposed on workers, AF = acceptable forces.



There were significant differences between initial and sustained forces pulled by the workers and acceptable ones. The results showed that 80% of the forces in pulling a half-loaded cart task were above acceptable ones; the difference was significant.

The forces in 52% of pushing loaded carts exceeded acceptable ones; there was a significant difference between the initial and sustained forces pushed by the workers, on the one hand, and acceptable forces, on the other hand.

## 4. DISCUSSION

The results of this study showed that most casting workers had experienced musculoskeletal symptoms in the past 12 months (84%). This high rate of prevalence of WMSDs could be attributable to handling loads exceeding acceptable ones in MMH tasks, force exertion, awkward postures, repetitive works and inappropriate workstation design. In addition, the workers who performed five MMH tasks were exposed to some ergonomic risk factors measured in this study. The prevalence of WMSDs in casting workers according to this study was higher than the prevalence in other studies: in the Iranian rubber factory (73.6%) [18], in municipal solid waste workers (65%) [19] or in the Iranian zinc industry (77.6%) [20]; however, it was lower than the rate reported by Choobineh, Tabatabaee and Behzadi for an Iranian sugar-producing factory (87.1%) [21].

The hand/wrist, back and neck symptoms had the highest prevalence (Table 2). Armstrong, Marshall, Martin, et al. reported awkward postures of the neck and shoulders in foundry workers [22]. According to Choobineh et al., problems related to the neck had the second highest prevalence in body regions. It is worth mentioning that no association was found between age, weight, height, job tenure and WMSDs prevalence rate in casting workers [21].

In 84% of the lifting tasks, the weights lifted by the workers exceeded acceptable weights (Table 3). This could be attributable to different weights of aluminum bars for melting, heat stress caused by the furnace (leading to a situation when workers could not work near the furnace), using a ladle with a long handle for lifting melted material, a high frequency of tasks during the shift, the weight of the parts, placing the parts in the cart, awkward posture and force exertion. According to Chung and Kee's study on fire brick manufacturing processes, most lifting tasks exceeded the recommended weight limit [23]. Ciriello, whose study aimed at investigating maximum acceptable weights in lifting, showed that the frequency of lifting considerably affected maximum acceptable weights in the case of a big box [24]. Ciriello also showed that the high frequency of tasks during the shift was a main factor decreasing acceptable weights.

The results of the present study showed that in 86% of the cases of lowering tasks, the weights lowered by the workers exceeded acceptable weights (Table 3). This could be due to a long handle of the ladle, heat stress because of hot melted materials, attention in pouring the melted materials into the cylinder, high repetition of the task during the shift and the horizontal shift away from the body. The present study revealed that a decrease in weight affected horizontal distance more than a decrease in height, which is in step with Ciriello's results [24].

The weights in 66% of the carrying tasks exceeded acceptable weights (Table 4). Some of the possible reasons include high repetition of tasks during the shift, carrying weights for long distances and the position of the elbow (bent and straight). In Ciriello's study, the mean (*SD*) carried weight was 20.30 (5.30) kg [25], whereas in the present study it was 17.00 (4.80) kg.

The workers applied more initial force to move the part, and then applied sustained force to pull and lift it. The parts were taken out from the cast and placed horizontally on the surface. The workers had to shift them to a vertical position, lift them in an awkward posture and then push the half-loaded cart. Pushing the cart and the nonflat floor (resistance factor against moving the cart) could lead to high initial and sustained forces. In Haslam, Boocock, Lemon, et al.'s study, the mean acceptable load on a slip-resistant surface was 430 N [26]. In Ciriello's study, the mean (*SD*) initial and sustained forces were 314.7 (51.6) and 179.6 (24.7) N, respectively [25], which is different from the results obtained in the present study (Table 5).

In pulling tasks, the workers put parts into a cart, covered a distance and then put the parts in storage. The number of parts in the cart varied, which can be a criterion for dividing them into two types, loaded and half-loaded carts. This could be attributable to the heavy weight of parts, weight of the cart and the nonflat floor. In Haslam et al.'s study, the mean acceptable load in the slip-resistant surface/pulling was 435 N [26]. In Ciriello's study, the mean (*SD*) initial and sustained forces in the pulling tasks were 305.8 (61.5) and 190.2 (46) N, respectively [25]. The results of the present study are not in line with those results (Table 5). At some workstations, the floor had a slope, which facilitated moving the cart. In the case of loads over 15 kg, MMH tasks were performed as team work.

## 5. CONCLUSIONS

The results of this study indicate that the high prevalence rate of WMSDs requires ergonomic intervention. This study was conducted to assess MMH tasks and, thus, the results are applicable for redesigning the MMH tasks. Taking corrective actions to improve MMH tasks seems essential. The ergonomics intervention should focus on redesigning them. According to our findings, lifting and lowering tasks should be considered critical and prioritized in taking corrective actions.

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