Investigation of work-related Musculoskeletal Disorders (MSDs) in warehouse workers in Saudi Arabia

Abdulrahman M Basahel*

Department of Industrial Engineering, King Abdulaziz University, Jeddah, Saudi Arabia

Abstract

In many field organizations, such as those in the industrial and service sectors, poor working posture is a common issue that can lead to various human body problems, particularly musculoskeletal disorders (MSDs) and physiological stress. Numerous tasks in the workplace, particularly in the industrial sector (i.e., manual material handling tasks), require an individual to perform in poor working conditions to meet task demands. The purpose of the current study was to evaluate musculoskeletal disorders and identify ergonomic factors related to lower back, shoulder and lower arm pain in two types of manual tasks: lifting and pulling objects in supermarket warehouses. A total of 92 male workers (ages 26–38) participated; 45 workers performed lifting tasks (first posture) and 47 workers performed a task that involved pulling heavy objects (second posture). Rapid Upper Limb Assessment (RULA) and a pain self-report chart were used. The heart rate (HR) was continuously recorded to evaluate the physiological stresses of each task posture. The results showed that lifting task highly significantly impacted low back pain among all participants. In addition, the results found a significant correlation existed between trunk, upper arm and lower arm scores and all self-report charts of pain and discomfort in the lower back, upper arm and lower arm region for all participants. Also, the pulling heavy object task posture significantly affected the lower arm score and reflected a highest prevalence of MSDs on wrist body part. The results presented a significant association existed between lower arm and wrist scores and all self-report charts of pain and discomfort in the lower arm and wrist body parts of all participants. The higher HR value was associated with the lifting task posture. There was a significant difference between both task postures overall. The results of the study proved that the RULA method was a useful tool to assess the MSDs on body regions in manual lifting and pulling tasks.

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* Corresponding author. Tel.: +966126400000 (Ext. 72398)
E-mail address: ambasahel@kau.edu.sa
1. Introduction

Some of the most common factors of ergonomics that lead to injuries, in particular musculoskeletal disorders (MSDs), are awkward postures and a heavy exertion workload. In fact, manual material handling is considered a common type of task that increases ergonomics hazards such as low back problems [1]. In developing countries such as Saudi Arabia the occupational health and safety hazards and illness are perceived less attention in particular, the MSDs issues [2]. Numerous research has found that heavy physical demand and improper posture while performing a task can cause musculoskeletal disorders: in particular, tasks that need lifting activity and pulling or pushing tasks in various sectors such as manufacturing and warehouses [3]. Poor working conditions such as repetitive back bending while lifting objects, and twisting and pulling or pushing of heavy objects, are all kinds of poor posture conditions that can lead to a significant impact on performance as well as postural stresses [4]. The correlation between over-exertion, poor working postures and musculoskeletal disorders such as back pain and arm problems are significant [5,6]. Some tasks, such as stocking work in warehouses, require a worker to perform an activity in poor working conditions in addition to the physical load such as lifting an object [7]. Researchers have stated that workers who perform handling tasks (i.e., lifting, pulling and pushing tasks) such as stock workers are more likely to claim lower back injuries and other types of MSDs than workers (i.e., department supervisors) who have less exposure to handling tasks [7]. In fact, the number of research studies that have evaluated the effect of poor working posture and physical task demands in manual material handling tasks on worker performance and musculoskeletal disorders in Saudi Arabia is too rare [8]. In addition, numerous workers in Saudi Arabia in different occupational sectors, in particular warehouses in factories and superstores, are exposed to an improper working posture and to heavy physical workload jobs, since most of these sectors depend on manual work rather than on automatic systems. Therefore, it seems that an evaluation of the effect of manual material handling tasks, such as lifting and pulling tasks, is necessary to demonstrate the significant contribution of awkward posture with physical demand in these types of tasks.

In general, there are number of measures that are used to measure posture stress. The measures are divided into two types: firstly, objective measures such as heart rate, electromyography (EMG) and pressure distribution [9]. Secondly, subjective measures such as the Ovako Working Posture Analysis System (OWAS) and Rapid Upper Limb Assessment (RULA). The RULA technique is a subjective measure has been widely used to assess postural effect on individual body parts [10]. Objective measures such as heart rate (HR), blood pressure (BP) and electromyography (EMG) have been used extensively to assess the impact of postural stress in addition to heavy exertion during task performance [11]. Therefore, the tasks, which require a heavy load such as manual material handling tasks, might have a negative influence on body parts in addition to the poor working conditions that may be required to perform these types of tasks. The aim of this study is to examine the effects of two manual tasks (lifting and pulling tasks) on MSDs.

2. Methods

2.1. Descriptions of the tasks and warehouses

This study investigated the impacts of two types of tasks—lifting tasks (16-20 kg) and pulling heavy object tasks (35-40 kg)—on MSDs and physiological stress. The current study aimed to identify the ergonomics hazards, in particular MSD hazards, that can be associated with both these tasks. These tasks were selected because workers need to have poor working postures and heavy manual physical loads to perform both of the tasks.

The supermarket stores examined in this study particularly dealt with various types of electronic devices such as microwaves, televisions and computers. The stores receive a large number of products per day. The stores include around 26 sections of store areas with different layouts, and the major lifting tasks and pulling tasks in electronic sections depend on manual activities and handling with poor types of manual tools and equipment used in lifting and pulling products in the store racks of the warehouses. The work shift is from 7:30 am to 3:30 pm, 40 hours/week in this type of tasks. The workers are given two break periods and one hour for lunch.

The worker in a lifting task needs to lift different received products, weighing from 16 kg to 20 kg, to arrange these products. A worker in a pulling product must pull the products, which weigh from 35 to 40 kg, manually.
different locations in the warehouse. However, the workers need to make awkward postures (i.e., bending their backs) while lifting the products from low-level surfaces. On the other side, besides the heavy physical load in the pulling products task with the pallet truck, workers perform this task with poor working postures that can negatively impact their arms and lower back as well as their legs. As a result of that, the current study aims to evaluate the effect of these both tasks on body parts and the physiological stress of the workers during the shift.

2.2. Output measures

Dependent variables were included, namely: physiological measure (heart rate (HR)) and subjective assessments of MSDs (observed by using the RULA method and pain self-report) [12].

2.3. Output measures

In total, there were 92 skilled male workers aged 26–38 (mean = 30.23; s.d. = 3.51). The participants were divided into two groups, with 45 participants for the lifting task and 47 for the pulling task. Descriptive statistics for the group that performed the lifting and pulling tasks are illustrated in Table 1. In addition, all of the workers completed health questionnaires prior to participation and they were healthy. Informed consent was submitted to all workers, and workers were not paid for their participation other than their usual salary. Furthermore, participants were informed that their performance would not be judged and that the findings would not affect their job or salary. The study was approved by the supermarket management.

| Task               | N   | Age     | Height (cm) | Weight (kg) | HR-rest (beats/min) |
|--------------------|-----|---------|-------------|-------------|---------------------|
| Lifting Products   | 45  | 32.3±3.42 | 171.6±5.80 | 82.42±9.2   | 82.1±6.2            |
| Pulling Products   | 47  | 33.4±3.72 | 173.2±4.62 | 79.68±7.4   | 79.3±5.8            |

2.4. Procedures

At the beginning, the participants were given a short introduction to the aim of the study. The participants were then asked to affix the chest electrodes for the heart rate monitor on their chests so we could record the HR at baseline (rest) and measure the HR continuously during the task performance.

Two postures were evaluated: the first posture was the lifting task, in which the workers lifted a product from floor level with both hands and a bent back (the products weighed 16-20 kg) to put them in a specific location. The second posture was pulling numbers of heavy products via a manual pallet truck with stretched hands, bent knees and a bent back (average product weight was 35-40 kg).

A video recorder was used during the performing of both tasks in the shifts. A pain self-report for each participant was completed, as well as the RULA method sheet. As mentioned previously, the awkward postures in both tasks (lifting products and pulling products) were evaluated by the RULA method to assess the level of ergonomics risks and MSDs while the workers performed both tasks [12,13].

The current study used the RULA method, as mentioned previously, to assess the impacts of the tasks on MSDs. In assessing the neck, upper arms and back, scores ranging from 1 to 6 were used. Scores ranging from 1-4 were used for the lower arm and wrist, while leg scores ranged from 1 to 2 [1,14].

The muscles and force scores ranged from 18 to 25 kg for the lifting products task and from 35 to 40 kg for the pulling products task since the weight of the products in the lifting task ranged from 16-20 kg and for the pulling products task ranged from 35-40 kg. The RULA method was divided into four main scores: first, score posture A was obtained by adding upper arm, lower arm, wrist and wrist twist scores. Second, score posture B was determined
by adding neck, trunk and legs scores [13]. The third score, score C, was obtained by adding score A to force and muscle use scores. Finally, score D was determined by adding the force and muscles scores to the B score [13]. The total RULA score was obtained by adding scores C and D, and it ranges from 1 to 7. These scores reflect the MSDs associated with each worker. A total score of 1 or 2 means a low MSD load level, whereas a 7 score means too much MSD demand and impact.

The SPSS analysis showed that the appropriate inter-reliability was satisfied since the RULA score was assessed by two independent evaluators to satisfy the inter-rater reliability. The SPSS analysis showed that for the lifting products task the kappa was 0.93, 0.78, 0.90 and 0.67 for arm, wrist, back, and leg scores, respectively. For the pulling products task the kappa was 0.87, 0.85, 0.75 and 0.72 for arm, wrist, back, and leg scores, respectively.

3. Results

3.1. Heart rate (HR)

The ANOVA analysis showed that there was a significant effect of both lifting products and pulling products tasks on participants’ HR (F(1,44) = 487.28, p<0.01 and F(1,46) = 354.37, p<0.01, respectively). In addition, the analysis showed that the highest HR value was associated with the lifting task, and the Tukey post-hoc analysis showed that there was a significant difference between average HR values in the lifting products task and pulling products task (p=0.033) and that the differences between HR in the lifting product task and pulling product task versus rest level was significant (p=0.014) and (p=0.023), respectively, as illustrated in Fig. 1.

3.2. RULA method and pain self-report

Lifting products task: According to the RULA back score, 91.1% of participants scored greater than 2, and that was significantly associated ($\chi^2 = 19.2, p<0.01$) with pain self-report since 63.6% reported discomfort. In addition, the upper arm was greater than 2 in 86.7% of participants, and as the pain self-report showed that 91% of participants felt discomfort in upper arm, the association between both analyses was significant ($\chi^2 = 17.04, p<0.01$). However, the association between lower arm score (75.6% of participants scored greater than 2) and pain report (67.9% reported discomfort) ($\chi^2 = 11.9, p<0.01$). However, the association between wrist RULA score versus

![Fig. 1. The mean of HR for the both lifting and pulling products tasks and HR rest level.](image-url)
pain self-report was not significant \((p=0.081)\); this was also seen in the association between neck score and pain discomfort report \((p=0.11)\).

Pulling products task: The results showed that the lower arm and wrist RULA scores were greater than 2 for 87.2\% and 82.9\% of participants, respectively. The \(\chi^2\) test analysis illustrated that these results were significantly associated with pain reports for lower arm and wrist \((\chi^2 = 18.85, p<0.01)\) and \((\chi^2 = 13.13, p<0.01)\), respectively, since 87.4\% of participants reported discomfort and the wrist was observed in 85.1\% of participants in the pain self-report. On the other hand, the correlation between pain self-reports and back, upper arm and neck RULA scores was not significant \((p=0.013), (p=0.09)\) and \((p=0.24)\), respectively.

The current research study used the RULA assessment tool in order to measure the level of musculoskeletal risks while workers performed both the lifting products and pulling products tasks. Generally, the musculoskeletal risks in the lifting product task were greater than the pulling products task, since the total score of the lifting task \((5.76 \pm 1.4)\) was significantly higher than \((p<0.05)\) the score of the pulling task \((4.88 \pm 1.2)\). As presented in Table 2 for the lifting products task, the analysis showed that the body part with the most exposure to MSDs was the trunk, which had the highest score of 4.92 \((\pm 1.1)\). In addition, the posture of worker in this task impacted the upper arm at 4.12 \((\pm 0.8)\). On the other hand, in the pulling task posture, the wrist had the highest score of 4.78 \((\pm 0.5)\) and the lower arm had 4.16 \((\pm 0.7)\) as illustrated in Table 3. According to the t-test analysis, there was a significant difference between the lifting task and pulling task in total wrist and arm score \((p<0.05)\), since the lifting products task had the highest score 4.96 \((\pm 0.5)\). Also, the score of total neck, trunk and leg in the lifting task \((5.02 \pm 1.2)\) was significantly higher than the score in the pulling task \((p<0.05)\). However, in the pulling task posture assessment the lower arm \((4.16)\) and wrist \((4.78)\) scores were significantly greater than \((p<0.05)\) the scores of the lower arm \((3.62)\) and wrist \((2.08)\) in the lifting task.

Table 2. Details of RULA scores for the lifting products task.

| Participant body part N (%) | RULA score | Upper arms | Lower arms | wrists | Total Wrist & arm score | Neck | Trunk | Legs | Total Neck, trunk & leg score | Final RULA score |
|-----------------------------|------------|------------|------------|--------|-------------------------|------|-------|------|----------------------------|----------------|
| 1-2                         | 6 (13)     | 11 (24.4)  | 34 (75.6)  | 4 (8.9) | 38 (75.6)               | 4 (15.6) | 42 (93.3) | 3 (6.7) | 2 (4.4)                   |                |
| 3-4                         | 15 (33.3)  | 7 (15.6)   | 6 (13.3)   | 23 (55.6) | 4 (13.3)               | 17 (37.8) | 3 (6.7) | 12 (26.7) | 10 (22.2)                  |                |
| 5-6                         | 22 (48.9)  | 26 (57.8)  | 5 (11.1)   | 17 (33.3) | 3 (11.1)               | 21 (46.7) | -      | 23 (51.1) | 22 (48.9)                  |                |
| 7                           | 2 (4.4)    | 1 (2.2)    | -          | 1 (2.2) | -                       | 3 (6.7) | -      | 7 (15.6) | 11 (24.4)                  |                |
| Mean \(\text{SD}\)         | 4.12       | 3.62       | 2.08       | 4.96    | 2.38                    | 4.92 | 2.63   | 5.02 | 5.76                       |                |

Table 3. Details of RULA scores for the pulling products task

| Participant body part N (%) | RULA score | Upper arms | Lower arms | wrists | Total Wrist & arm score | Neck | Trunk | Legs | Total Neck, trunk & leg score | Final RULA score |
|-----------------------------|------------|------------|------------|--------|-------------------------|------|-------|------|----------------------------|----------------|
| 1-2                         | 29 (61.7)  | 6 (12.8)   | 8 (17.0)   | 6 (12.8) | 41 (87.2)               | 16 (34.0) | 37 (78.9) | 11 (23.4) | 5 (10.6)                  |                |
| 3-4                         | 10 (21.3)  | 13 (27.7)  | 7 (14.9)   | 26 (55.3) | 6 (12.8)               | 19 (40.4) | 8 (17.0) | 21 (44.6) | 18 (38.3)                  |                |
| 5-6                         | 8 (17.0)   | 25 (53.2)  | 31 (65.9)  | 14 (29.8) | -                       | 11 (23.4) | 2 (4.3) | 12 (25.5) | 17 (36.1)                  |                |
| 7                           | -          | 3 (6.4)    | 1 (2.1)    | 1 (2.1) | -                       | 1 (2.1) | -      | 3 (6.4) | 7 (14.9)                   |                |
| Mean \(\text{SD}\)         | 2.71       | 4.16       | 4.78       | 4.21    | 2.08                    | 3.81 | 3.51   | 4.11 | 4.88                       |                |
4. Discussion

The current study investigates the potential ergonomics hazards of two types of manual material handling tasks (lifting and pulling products tasks) on physiological stress and MSDs on warehouse workers in Saudi Arabia. The findings of the study showed that the heart rate was significantly changed from rest level and HR during the performing the both lifting and pulling products tasks. The highest value of HR was associated with the lifting products task. There was a significant difference between the HR value of the lifting and pulling products tasks. That may be because the lifting task was more physically demanding on the physiological state of workers and the working posture in the lifting task was more stressful than in the pulling task, since in the lifting task the worker needed to bend his back to pick up the product from a low-level surface below his knee height. However, this was consistent with the results of a study that mentioned that the increasing level of physical lifting tasks in construction was associated with a highly significant increasing level of physiological heart rate, since the HR significantly increased while the frequency and level of loads increased [15,16]. As expected, the HR parameter was sensitive to changes in the tasks and posture stress since, as mentioned, the highest value of HR appeared under the lifting product task condition and the HR at rest level was significantly changed from the lifting and pulling products tasks.

In terms of the RULA method, in the lifting product task this study found that the highest score (4.92) among the region of MSDs appeared in the trunk. Following the trunk region, the upper arm had the next highest score (4.12) while the other MSD regions had scores lower than 4. The total neck, trunk and leg score in the lifting task was significantly greater than the total score in pulling. That was because the workers needed to bend their backs to lift products from a low ground level (i.e., below the knee level). This result was the same with previous research study which mentioned that the most hazards and injuries in term of MSDs are low back disorders due to lifting tasks [7]. On the other hand, the pulling task showed a greater total wrist and arm score than the lifting task; that may be due to the range of heavy loads in the pulling task. In the pulling task, the wrist pain score (4.78) was the highest among other body regions. Following the wrist pain score was the prevalence of lower arm disorders (4.16). According to the total score of the RULA method, the lifting product task was a greater ergonomic hazard than the pulling products task in term of MSDs as well as being more physically demanding, since the score of the lifting task (5.76) was significantly greater than the score of the pulling task (4.88) as illustrated in Tables 2 and 3.

The results of the pain self-report for the present study confirmed that lower back pain was a significant pain among warehouse workers. This was similar to the previous research finding that the major problem of MSDs among stockers and warehouse workers is in the lower back, due to lifting heavy objects [7]. In addition, other researchers have found that low back pain is considered a greater problem among Thailand rubber tapper workers, since they need to lift heavy objects and use a bending trunk posture [1]. In the pulling task, the current results proved that wrist pain was a greater MSD hazard among the workers. This was significantly associated with the RULA method.

5. Conclusion

This study concludes that the lifting products task in warehouses is more ergonomically hazardous for MSDs than the pulling products task. In addition, the lifting task is an occupational risk for MSDs, in particular lower back pain. The wrist had the most exposure to the MSDs hazard in the pulling products task. However, the working posture in the lifting task is more physically demanding and stressful than the pulling task, since the highest value of HR is associated with the lifting task. The study highly recommends implementing ergonomics interventions as ergonomics mechanics aids to support the workers and prevent MSDs hazards in tasks such as manual material handling in warehouses.

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