Psychophysical Responses of Waste Workers in Lifting Tasks at Two Different Levels

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ABSTRACT

Manual Material Handling (MMH) is one of the key problems related to musculoskeletal disorders at the occupational settings. It is essential to assess the risk related to these tasks. The psychophysical approach can be used to assess and redesign the MMH tasks. Following a psychophysical approach and bearing in mind the specific problem faced by waste workers in a Portuguese hospital, this work aimed to determine, the Maximum Acceptable Weight (MAW) for the tasks of BIOBOX's lifting. Two different levels of BIOBOX's were assessed based on workers' usual tasks. The subjects were instructed to lift the box from the height of 110 cm and 174 cm (handling height) up to the height of 84 cm, the same height of the truck. Each set of experiments was conducted for 10 minutes. The heart rate was continuously monitored. At the end of each task, the MAW was achieved and subjects were requested to assess the Index of Perceived Exertion (IPE). The MAW determined at 110 cm and 174 cm was, respectively, 10.0 kg and 6.8 kg. The regions of the shoulders, arms and back were identified as presenting more pain during the tasks. The results show that workers are at risk of musculoskeletal disorders. Therefore, a strategy to reduce the risk related to these tasks is needed.

Keywords: Index of Perceived Exertion; Maximum Acceptable Weight; Psychophysical; Transportation Manual of Loads.

INTRODUCTION

Manual Material Handling (MMH) is one of the key problems related to Musculoskeletal Disorders (MSDs) at the occupational settings, being recognized as one of the largest source of work-related injuries and illnesses, especially in the lumbar region (Wai *et al*., 2010). Therefore, it is essential to assess the risk related to occupational tasks that involve MMH, as well as to implement measures for its reduction in order to make this risk as low as reasonably possible, this way preventing the development of MSDs.

Unfortunately, the number of MSDs still remains high in Portugal in the different sectors of activity (Eurostat, 2012). The Portuguese health care services, particularly the hospitals, are not exception. In relation to the problem of MMH, a large number of tasks involving different professionals require the movement of weighty loads, as, e.g.,

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patients, medical materials, food and waste. Nurses, assistants, professionals from the storage, or even the workers that handle waste, are usually required to perform MMH tasks, for long periods. This problem is even higher when other risk factors are present, as awkward postures, repetitive movements, mechanical shock, grip strength, mechanical stress, vibration and extreme temperatures (Pheasant, 2003).

In order to reduce the risk of injury due to MMH tasks it is important to assess the risk, identifying the need of risk reduction measures and promoting insights to redesign the workplaces and the tasks. To this end, researchers have adopted different approaches in order to analyze the risk of MSDs development. The use of risk assessment methodologies, as the equation NIOSH'91 (Waters *et al*., 1994) and the Mital *et al*. (1997) method are the most popular ones. However other approaches can be used, particularly in tasks where the features of the box are unusual, the environment presents limitations to the tasks and the weight and the distribution of the load in the box is irregular. Furthermore, the workers' experience can also be an important factor, but is not always considered in the risk assessment methodologies (Oliveira *et al*., 2012). In those cases, psychophysical tests can be a good approach to overcome some limitations of the risk assessment methodologies.

The psychophysical approach aims to design/redesign tasks acceptable for most of the workers who perform them and are based on their perceived exhaustion level (Dempsey, 1998). Usually this methodology consists on tests where subjects determine forces or maximum weight that can be moved under a specific condition during an 8-hour shift per day, comfortably, and without becoming tired, weakened or fatigued. At the end of the test the Maximum Acceptable Weight (MAW) was determined (Ciriello *et al*, 2010). Therefore, this approach assumes that individuals are able to detect the physiological and biomechanical incentives in order to provide a subjective evaluation of physical exertion (Nussbaum & Lang, 2005).

The use of the psychophysical tests is not unusual (see e.g. Maitia & Ray, 2004; Nussbaum & Lang, 2005; Choi & Fredericks, 2007; Li *et al*., 2007; Wu & Chang, 2010) and its applicability has been emphasized in the last decades (Wu & Chen, 2003). It is considered a good approach to be applied in low and moderate frequencies tasks (Ciriello *et al*., 1990). However, its application is not so popular as the risk assessment methodologies, because they are based on the subjective judgments (Asfour *et al*., 1980), are not applied to all situations (Ciriello *et al*., 1990; Dempsey, 1998) and require more time to be applied. However, for some specific tasks not considered in the risk assessment methodologies they can be a good alternative. Furthermore, this approach can be used as a complement to the risk assessment methodologies in specific cases.

Bearing this in mind, and considering the specificity of the tasks performed by the waste workers in a particular Portuguese hospital, this work aimed to determine, following a psychophysical approach, the MAW for the tasks of BIOBOX’s lifting.

METHODOLOGY

Sample

Ten waste workers who perform the BIOBOX’s handling tasks and without any kind of MSDs were recruited from a Portuguese hospital. The workers’ physical condition was collected, including the anthropometric measurements and the estimated maximal aerobic capacity (VO_2max). Their age was in average 33.9 years old (SD = 9.8; interval range 22-48 years old), the average of weight was 80.65 kg (SD= 15.74; interval range 64-109.7 kg), and the average VO_2max was 40.97 (SD= 8.01; interval range 29.84-52.63 ml O_2/Kg/min).

Task analysis

In a first stage the real tasks performed by the workers were analyzed. Each task was identified, recorded and characterized. Data related to the type of tasks, postures, distance of transport and the important heights linked to the different tasks were collected. Furthermore, the time and frequency of the lift tasks, daily routines, BIOBOX features and truck features were analyzed.

Estimation of workers' maximal aerobic capacity

Workers' maximal aerobic capacity was estimated using the submaximal Åstrand Cycle Test (Åstrand and Rodahl, 2004) carried out on a Monark 928E cycle ergometer. The initial power was determined by using 1.65 W per kg of body weight and this value was adjusted at the third minute when necessary (Adams and Beam, 2008). The test finished at the sixth minute and subjects were allowed to recover at a low-intensity exercise level until their heart rate was 100 bpm or less.

Determination of the Index of Perceived Exertion (IPE)

The IEP was analyzed through a questionnaire previous developed in Portuguese language by Oliveira *et al*. (2012). The aim of this analysis was to assess the effort intensity that is perceived by the individuals. The questionnaire was divided into two parts. The first one aimed to analyze the feelings of pain or discomfort, through a diagram adapted from Coluci *et al*. (2009), and using an increasing scale with 5 degrees (0 = absent and 4 = unbearable) adapted from Silva *et al*. (2011). The second part was designed to analyze the perceived exertion for the wrists, arms, shoulders, back and legs through the Borg scale, using a scale of increased 15 degrees (6 = no effort and 20 = maximum effort) (Borg, 1990).

Psychophysical study

Test conditions

BIOBOX dimensions - A box with 32 cm length x 32 cm deep x 62 cm width was used. The box had handles at 48 cm from the base.

Handling height - Most commonly, in the task analysis, it was observed that workers put the boxes at three different levels: on the floor, at 62 cm and at 124 cm. In this study only the two superior levels were analyzed. The handling height considered was the correspondent to the height of the handle, i.e., 110 cm and 174 cm.

Environmental conditions - The environmental conditions were controlled with the indoor air quality monitor, IAQ Calc (model 8760, TSI, USA), in order to keep the temperature close to 25 °C and relative humidity at 60%.

Heart rate (HR): The HR was controlled with a Polar FT4 heart rate monitor during the entire task.

Procedure

The subjects were instructed to lift the BIOBOX from the predefined height (110 cm or 174 cm) to the height of 84 cm, the same height as the truck. Two levels were analyzed, each one corresponding to a handling height, i.e., 110 cm and 174 cm. The boxes were lifted with two hands, closely to the body, flexing the knees and using the box handles (at 48cm). The boxes had a false bottom, in which weights that accounted for a total of 2 kg were hidden. Initially workers were asked to select the weight that they could carry for 1 hour of work. Therefore, each individual was requested to put in the box the weight that they found suitable for the conditions proposed. This weight was considered the Initial Weight (IW). They were instructed and encouraged to make adjustments to the IW, by adding or removing weights, in accordance with their perceptions. Each experiment was conducted for 10 minutes. At the completion of each task, the MAW was achieved. The heart rate was continuously monitored. Afterwards the subjects were asked to determine the IEP, filling out the questionnaires.

RESULTS AND DISCUSSION

The first step of this study was the analysis of the tasks performed by the waste workers. It was identified the BIOBOX's lifting as the more critical task related to the risk of MSDs. The weights of the BIOBOX's daily handled by these workers generally ranged from 10 kg to 18 kg, the height lifting was considerably high and the workers posture was compromised. Accordingly, in order to define the risk reduction measures to be applied, this task was replied in the laboratory. A psychophysical study was performed in order to identify the maximum acceptable weight that an individual can, comfortably, carry out for 8 hours of intermittent work (Wu, 2006; Cheng & Lee, 2006; Wu & Chen, 2001).

The results obtained for the IW and MAW are presented in Table 1. The MAW determined at 110 cm was 10.00±2.45 kg and for the height of 174 cm was 6.40±1.71 kg. The obtained values are considerably lower than the actual weight of the BIOBOXs handled by workers, particularly at the height handling of 174 cm. These results indicate that workers are at risk of developing MSDs (Pheasant, 2003). Accordingly, it is important to redesign the BIOBOX's lifting tasks. Restrictions to the levels where the boxes are stacked outside of the hospital services and on the truck (only two levels are recommended) and a better control of the weight of the boxes are needed through the definition and implementation of specific procedures. However, these procedures cannot be only restricted to the waste services. All the hospital services need to control the amount of waste that they place in the boxes. In services like pathology/autopsy the use of boxes with small dimensions can be a better solution. On one hand, as the waste refer to anatomical parts, in general weighed, can be difficult to the professionals to set a limit of waste that can be put on the box. On the other hand, the waste workers are unaware of the boxes' weight, being difficult for them to know when two persons are necessary to lift the box. Therefore, a box with small dimensions, adapted to the type of waste, can be a better solution.

Table 1: Results of IW and MAW at different lifting levels

	IW		MAW	
Handling height (cm)	**Mean (kg)**	**Standard Deviation**	**Mean (kg)**	**Standard Deviation**
174	9.10	2.85	6.40	1.71
110	10.20	3.01	10.00	2.45

The results of Table 1 also present a considerable standard deviation for the obtained MAW. However, it is important to note that these values present the same magnitude as the values obtained in other studies (see e.g. Nussbaum & Lang, 2005; Oliveira et al., 2011). It is also interesting to note that the IW was similar for the both levels, despite the biggest standard deviation achieved comparing with the MAW values. These results indicate that waste workers cannot discriminate the risk of lifting a heavy box to a higher level.

The IPE values for the wrists, arms, shoulders, back and legs were obtained based on the application of a questionnaire at the end of each task and the results are presented in Table 2. The regions of the shoulders, arms and back were identified as presenting more pain during the tasks. Furthermore, the achieved IEP was higher for the third BIOBOX level analyzed (174 cm). Effectively, these are the body parts with higher demand in that type of tasks, with the effort being higher as the height of lifting increases.

Table 2: Results of IPE at different lifting levels

	174cm		110cm	
Body part	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**
Wrist	12.20	1.87	11.10	2.18
Arm	12.60	1.51	12.30	1.89
Shoulder	13.80	2.44	11.90	1.66
Back	12.50	0.97	12.10	1.45

Legs	9.90	1.97	10.20	1.81

The pain experienced by workers in the course of the tasks was also analyzed and the results are presented in Table 3. The higher sensation of pain was identified in the region of shoulders, particularly for the tasks with higher lift height (174 cm). However, it is important to keep in mind that, on all working days, these workers handle loads in the same conditions that those used in this study and that the pain felt by them can be related with the daily tasks.

Table 3: Values of pain/discomfort experienced by workers

Body part	174cm	110cm
Neck	1.1	1.0
Shoulders	2.7	2.0
Column	1.1	1.5
Elbows	1.1	1.3
Pulses	1.1	1.3
Lumbar	1.0	1.4
Buttocks	0.5	0.6
Knees	0.5	0.7
Feet	0.5	0.7

CONCLUSION

Overall, the results show that workers are at risk of musculoskeletal disorders, because the real weight handled by them in their daily tasks it is higher than the MAW determined in this study. Therefore, a strategy to reduce the risk related to these tasks is needed.

The psychophysical approach allowed the assessment of the risk of MSDs, as well as, to identify recommendations in order to provide acceptable working conditions for most of the subjects, in order to reduce/eliminate the appearance of MSDs. The psychophysical approach is more complex than the traditional risk assessment methodologies, but for specific tasks, they can provide better results, being in some cases also a complement to the risk assessment methodologies.

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