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Obesity and physical loading during manual lifting

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ABSTRACT
Manual lifting greatly increases the risk of developing work-related musculoskeletal disorders (WRMSD). Muscle loading related to manual tasks may be significantly influenced by workers' body conditions, being obesity one of them. In the present study, different tasks of manual lifting were performed by 14 participants with different obesity levels, defined in terms of individuals' fat mass percentage. Surface electromyography (EMG) data were collected bilaterally from 3 muscles recruited during this type of tasks. EMG data normalization was based on the percentage of maximum contraction during each task (MCT). Furthermore, the participants reported physical loading by using the Rated Perceived Exertion scale (RPE). These techniques sought to analyze the physical loading during manual lifting tasks. The obtained results indicate that obesity level influenced the MCT percentage, which in turn increases the muscle loading during manual lifting tasks. However, obesity level does not seem to influence the RPE values. In this context, further studies based on biomechanical approaches are required to provide a more complete understanding of the obesity effects on musculoskeletal loading during manual lifting.

Keywords: obesity, physical loading, manual lifting, EMG, RPE

1. INTRODUCTION

Obesity is a serious health problem in developed countries. In Portugal, statistical data demonstrated that people with unhealthy weight are more than 50% of all population (Carmo, 2008). Therefore, currently obese subjects represent a growing fraction of the workforce. Moreover, obesity is associated with social, psychological and physical problems, including WRMSD, which can negatively affect the productivity and increase the absenteeism (Morris, 2007). Different studies have correlated obesity with back pain prevalence (Kostova & Koleva, 2001) and with decreased trunk muscle strength (Bayramoglu *et al*., 2001).

Manual materials handling (MMH) tasks, including lifting, are very common in a wide variety of workplaces and represent one of the principals WRMSD risk factors, mainly for the back (Yeung *et al*., 2002). From the biomechanical point of view, excessive body fat mass can negatively affect the muscles and spine behavior during MMH tasks, but the psychophysical data obtained pointed out that obesity does not seem to reduce the maximum acceptable weight (Singh *et al*., 2009). In this context, Xu *et al*. (2008) analyzed the lifting kinematics and kinetics in subjects with different body compositions. These authors tested the following hypothesis: heaviest people lift more slowly to minimize the musculoskeletal load. However, the obese subjects registered greater values for the kinematics trunk variables, than the normal weight subjects. Concerning obesity effects on postural maintenance, Park *et al.* (2009) developed a psychophysical research with obese and non-obese subjects, whose performed static box-holding tasks in different working postures. In the referred study, the obese group reported a higher perceived overload in all postures considered, demonstrating that obesity increases postural stress. Gilleard & Smith (2007) also demonstrated that a more flexed trunk posture, an increased hip joint moment and a hip-to-bench distance are showed by obese subjects during a simulated standing work task.

Although obesity has been intensively studied over the past years, the findings still involve some controversy and studies are required to provide a more complete understanding of obesity effects on work performance. It is also important to mention that in the previously developed works body mass index (BMI) was the principal indicator used for obesity assessment. BMI is only based on subjects' weight and height and does not distinguish body fat-free mass and fat mass, foreseeing the need to use obesity assessment methods more appropriate and comprehensive (Xu *et al.*, 2008). For these reasons, in this study, the obesity levels were based on subjects' body fat mass, determined by bioelectrical impedance technique. In order to analyze the muscle loading for each obesity level, EMG data were collected, because the principal role of this technique was the objective evaluation of muscle activity within any manual work tasks (Konrad, 2005). Additionally, to address the research topic the RPE scale was employed as a psychophysical measure of physical loading. Several ergonomic studies have applied this scale in the past and validity, sensitivity and reliability of the scale were well established (Park *et al*., 2009). A RPE value reflects an overall integration of perceptions, signals and experiences of the individuals' body while enduring physical work (Borg, 1990). Succinctly, the purpose of the current study was to examine the obesity effect on physical loading during manual lifting.

2. MATERIALS AND METHOD

Ten healthy men and four women, with no history of musculoskeletal disorders, volunteered to participate in this experimental study. After signing an informed consent, different anthropometric measures (weight, stature, waist circumference) were recorded. An OMRON BF306 Body Fat Monitor was used to determinate the individuals' obesity levels ("Normal" with 5, "High" with 4 and "Too high" with 5 subjects), based on their body fat mass percentage, age and gender (Deurenberg *et al*., 1998). The mean age, BMI, waist circumference and fat mass percentage of the subjects are, respectively: 29.2 (±10.5) yr, 25.2 (±5.5) kg/m^2, 88.1 (±16.6) cm, and 24.9 (±8.9) %.

In the sagittal plane, 6 trials (3 loads x 2 styles) of lifting and replacing a test box, with loads of 5, 10 and 15 kg, in constrained (the box was placed behind a 60 cm high barrier simulating an industrial bin) and free situations, were performed. Subjects stood in front of a height platform adjusted to each subject's standing knees height. They used both hands to lift the box vertically until their shoulders height and replaced it in its original position in a slow movement. In order to simulate a realistic working situation, no specific foot-placing instructions were given. The movement was subdivided into 4 phases: standing up (rest position), reaching, lifting and replacing the box. However, data analyzed in this paper are related only to the lifting phase.

A portable surface electromyography system (PLUX wireless biosignals) was used to collect EMG data while the subjects performed the manual lifting tasks. EMG activity was collected using bipolar surface electrodes with 1 cm diameter and an inter-electrode distance of 2 cm. The electrodes were located at 3 muscles recruited during this type of tasks: right and left *Erector spinae* (*iliocostalis*) at L2 (RI, LI), right and left *Erector spinae* (*longissimus*) at L1 (RL, LL), right and left *Deltoideus Anterior* (RD, LD). The EMG electrodes were affixed to the subject's body using Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM, 2012) standard placement procedures. The areas of electrodes placement was shaved, abraded and cleansed with rubbing alcohol absorbed into cotton rounds to lower skin's electrical impedance (Konrad, 2005). After each lifting trial, the participants reported psychophysical loading using the RPE scale (Borg, 1990). With this purpose, the RPE scale was placed in the visual field of the subject so that he/she could quickly rate the perceived loading.

AcqKnowledge 3.9.0 software was used to process and to analyze the EMG data. The raw EMG signals were amplified, smoothed, rectified, high-pass filtered at 20 Hz and low-pass filtered at 500 Hz. The root mean square (RMS) amplitude and its SD, as well as the maximum amplitude, were calculated for each muscle and for each phase of the experimental trials. EMG data were normalized to peak value during each lifting, according to the following expression: MCT percentage = (Mean amplitude/Peak value)*100. This normalization procedure has been used in EMG tests with subjects presenting restrictions to perform maximum voluntary contractions, such us musculoskeletal pathologies or obesity (De Luca, 1997). Subsequently, for each task condition, the MCT percentages were averaged across the subjects belonging to the same obesity considered level. In this experimental design, the independent variables were the different box loads, lifting style, obesity level, and the dependent variables consisted of the MCT percentage and the RPE. Meanwhile, in this paper only the following hypothesis has been tested: greater MCT percentage and RPE values are observed in individuals with higher obesity levels.

3. RESULTS AND DISCUSSION

The mean MCT percentage, mean RPE and Standard deviation (SD) values for each independent variable is presented in Table 1. Comparing the values associated with the different obesity levels, the results showed that the mean MCT percentage is higher in the group "Too high" obese subjects. This difference is more evident in the lifting tasks involving more load handling (in this case, 10 and 15 kg). These results seem to demonstrate that the MCT percentage is associated with the obesity level, being greater in obese subjects. Wherefore, obesity seems to increase the muscle loading during manual lifting tasks and it is, most likely, an important contributor to WRMSD appearance.

Table 2 – EMG and psychophysics data across the different obesity levels for each lifting trial.

	Surface EMG data – MCT (SD) %						Psychophysics data – RPE values
	5 kg Freestyle lifting						
	LI	**RI**	**LL**	**RL**	**LD**	**RD**	**RPE**
Normal	58.5 (6.0)	57.0 (5.5)	66.9 (4.3)	66.5 (4.1)	52.9 (7.4)	42.2 (21.9)	2.2 (0.4)
High	50.9 (5.7)	49.6 (15.9)	51.4 (21.3)	48.5 (15.6)	45.0 (8.5)	39.5 (8.3)	2.0 (0.0)
Too high	55.4 (6.3)	56.4 (5.8)	61.8 (4.5)	58.2 (8.3)	49.7 (6.8)	42.3 (3.4)	2.2 (0.4)
	5 kg Constrained lifting						
	LI	**RI**	**LL**	**RL**	**LD**	**RD**	**RPE**
Normal	59.3 (10.7)	52.0 (4.3)	59.2 (7.4)	61.3 (5.2)	45.7 (13.4)	49.8 (6.9)	2.4 (0.5)
High	48.3 (12.0)	50.6 (14.0)	49.0 (12.0)	50.3 (11.5)	42.2 (6.3)	42.0 (6.7)	2.3 (0.5)
Too high	48.0 (3.8)	56.5 (7.7)	63.8 (12.1)	58.0 (8.1)	55.3 (13.0)	49.5 (9.8)	2.8 (1.3)
	10 kg Freestyle lifting						
	LI	**RI**	**LL**	**RL**	**LD**	**RD**	**RPE**
Normal	52.7 (4.6)	55.1 (6.8)	59.1 (6.8)	61.5 (11.8)	46.6 (8.8)	48.0 (8.2)	4.8 (2.2)
High	53.2 (10.5)	57.2 (7.2)	58.9 (15.0)	52.1 (12.7)	55.9 (1.9)	44.7 (10.7)	4.0 (0.0)
Too high	58.6 (6.0)	58.1 (9.3)	65.1 (11.8)	61.9 (6.2)	56.1 (7.5)	56.3 (5.9)	4.0 (1.2)
	10 kg Constrained lifting						
	LI	**RI**	**LL**	**RL**	**LD**	**RD**	**RPE**
Normal	53.3 (8.3)	52.1 (4.6)	52.7 (9.8)	61.1 (4.1)	40.9 (7.2)	47.9 (10.2)	4.8 (2.2)
High	55.0 (8.1)	57.3 (7.6)	58.1 (7.1)	62.9 (4.1)	47.7 (4.6)	48.1 (7.0)	4.8 (0.5)
Too high	61.9 (5.3)	59.9 (4.7)	59.1 (12.1)	63.1 (6.2)	49.9 (8.3)	50.2 (11.3)	4.2 (1.5)
	15 kg Freestyle lifting						
	LI	**RI**	**LL**	**RL**	**LD**	**RD**	**RPE**
Normal	50.6 (3.6)	47.9 (10.1)	51.0 (6.7)	52.7 (9.5)	39.2 (8.1)	43.7 (6.0)	6.8 (2.6)
High	53.9 (9.5)	49.0 (7.0)	55.6 (5.5)	53.1 (8.7)	52.8 (4.1)	51.1 (6.1)	6.0 (0.8)
Too high	57.2 (10.3)	57.5 (7.6)	63.9 (17.2)	55.1 (4.6)	52.9 (9.4)	51.9 (8.9)	7.0 (1.4)
	15 kg Constrained lifting						
	LI	**RI**	**LL**	**RL**	**LD**	**RD**	**RPE**
Normal	52.2 (7.9)	49.4 (12.5)	55.3 (10.5)	52.2 (12.9)	40.4 (12.5)	44.3 (14.3)	8.0 (2.4)
High	56.6 (8.9)	54.0 (3.6)	57.4 (8.4)	62.1 (4.0)	40.6 (8.4)	42.3 (11.6)	6.5 (0.6)
Too high	59.8 (8.4)	54.2 (12.7)	62.9 (14.6)	65.0 (8.5)	47.2 (16.8)	54.4 (13.4)	7.0 (1.0)

In addition, many MMH tasks require workers to lift from industrial bins. These bins can constrain the knees flexion and can increase the trunk flexion during these tasks (McKean & Potvin, 2001). At the beginning of the current study, the authors had the expectation that the excessive body fat mass could negatively affect the posture adopted during these tasks, so in a constrained situation the muscle loading would be higher in this group of individuals. Nevertheless, "Normal" or non-obese, "High" and "Too high" obese subjects did not seem to differ in their MCT to the constraint for any lifting.

In this experimental study, the subjects also reported their perceptions about physical loading for each trial, using the RPE scale. However, obesity level did not seem to influence the psychophysical data, in contrast to the findings of Park *et al*., 2009. Similarly to Singh *et al*. (2009), this evidence can be related with the fact that obese subjects are continually exposed to higher physical loading than non-obese due to their larger body fat mass. They might be not so aware of the perceived physical loading and apply laxer criteria comparing with normal-weight subjects. Thus, psychophysical data may be less valid for obese workers as an ergonomic approach to prevent WRMSD. However, a more completed statistics analysis is needed with the aim of testing the dependences between the considered variables.

The study was also limited because of the fact that only a few muscles were monitored with EMG. However, this selection was influenced by the body position trying to avoid regions with more adiposity mass cumulated. Other EMG variables could be analyzed, such us the possibility to quantify changes in muscles activation time. Finally, most tasks in workplaces are not scaled in this study and it is possible that differences may exist for tasks with different constraints and loads for all obesity levels. Consequently, this area requires further study, which should be oriented to consider other type of data, such as kinematics data.

4. CONCLUSIONS

Obesity among the workforce is a growing problem and it is an individual risk factor for the appearance of chronic pathologies, such as WRMSD. The current study suggests that obesity increase the muscle loading, according to the obtained EMG data. On the other hand, perceived physical loading does not seem to be increased by higher obesity levels of the individuals. In the future, a kinematics study will be developed to achieve a better understanding of the obesity effects on individual lifting capability. Globally, these results may highlight the importance to consider the workers' anthropometric variability in workplaces, including those with obesity.

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