Physical Exertion and Prevalence Assessment of Musculoskeletal Disorders Among Brush Cutter Operators

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Abstract. An Ergonomic Work Analysis was done to assess and evaluate the working conditions among brush cutter operators during vegetation management tasks. The main objectives of this study were: to assess the actual working conditions and the complaints presented by workers that accomplish the task with brush cutters; to quantify the physical exertion during the use of the equipment and to characterize the musculoskeletal symptoms. Nineteen workers agreed to participate in the study answering the questionnaire, while only seven of these participated in the Physical workload assessment. The six body regions with the highest percentage of complaints were the lumbar spine, followed by feet, dorsal spine, right-wrist/hand, cervical spine and right-thigh. Considering physical exertion, the results showed that the workload in this study ranged from low to very high or extremely high.

Keywords: Musculoskeletal disorders (MSDs) · Nordic Musculoskeletal Questionnaire (NMQ) · Ergonomic Work Analysis · RHR · PHRI · Brush cutter

1 Introduction

Forestry occupations are known to be physically demanding [1]. According to the European Agency for Safety and Health at Work the employees of the forestry, farming and fishing sectors are among the occupational groups with particularly high Musculoskeletal disorders (MSD) risk. MSD are the most frequent diseases related with jobs, occurring in all activities sectors in European Union [2, 3].

Following the data published by Eurostat [4] more than 60% of employees in the whole EU (≈65% in Portugal (PT)) are exposed (at least 1/4 of work shift) to repetitive activities, about 43% (≈48% in PT) adopt painful or fatiguing positions and 32% (≈24% in PT) carry and lift heavy loads [4]. In some professions, there may occur long-term standing or walking (more than 70%), as well as exposure to vibration (25%). All above-mentioned occupational risk factors are the potential cause of the development of MSD.

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Despite these information does not specify that the MSD occur exclusively in forestry, most often concern the joint sector of agriculture, hunting and forestry.

Regarding the sixth European Working Conditions Survey (EWCS), in 2015, around 25% of the European workers considered that their work affects their health, corresponding to 32% of the Agricultural workers [4]. Globally, 43% of the European workers reported suffering from back pain. This result is higher among workers in agriculture/forestry sector (57%). The same source reported that the situation is quite similar for muscular pain, as about 42% of the respondents considered that their work causes them muscular pain (neck or upper limbs). Once again this rate was higher in the studied sector (55%) [2, 4].

Vegetation management tasks usually demand the adoption of awkward and uncomfortable postures for long periods of time, which may stress and fatigue supporting muscles and tendons, leading to the development of MSDs. In addition to the physical suffering of workers, MSDs cause an important economic impact for the society as a whole [2, 5].

Several studies that investigate the physiological workload among workers in the agriculture/forestry sector, show that some activities impose a high workload [1, 6–9].

An Ergonomic Work Analysis (EWA) was done to assess and evaluate the working conditions among brush cutter operators during vegetation management tasks. The main objectives of this study were:

- to assess the actual working conditions and the complaints presented by workers that accomplish the task with brush cutters;
- to quantify the physical exertion during the use of the equipment (brush cutter).

2 Method

2.1 Study Location and Sample

This study was carried out from Jul 2020 to Nov 2020, with the workers of a Private Portuguese Enterprise responsible for the operation and maintenance of road infrastructure.

Nineteen male workers, from 7 concessions, agreed to participate in the study answering a questionnaire. Out of these, seven participated in the physical workload assessment authorizing the recording of heart rate during the work. In both situations an informed written consent was previously obtained. The confidentiality of data was always guaranteed.

2.2 Questionnaire

Working conditions and the complaints reported by workers were assessed through a questionnaire specifically developed for this purpose, which was applied as an interview.

The questionnaire was based on the adapted version of the Nordic Musculoskeletal Questionnaire (NMQ) [10], similarly to other studies [2, 11], and information provided by the company. The questionnaire intended to identify key parameters for the workers'

characterization, evaluate their perception of the real working conditions, as well as to identify self-reported symptoms in terms of physical annoyance, discomfort or pain. The questionnaire comprises three sections (A, B and C).

In the *Section A* were integrated items to better characterize workers' gender, age, anthropometric data (height, weight), dominant upper limb; data that characterize the relationship with the organization (seniority, number of work hours worked per day/week, schedule type, practice of work breaks and second job,…); this section, also, included items, to better characterize the workers' health, sport and physical activities, smoking habits, and presence of chronic illnesses. In the *Section B* were integrated items to determine the presence of musculoskeletal symptoms. Subjects were asked about the musculoskeletal symptoms (annoyance, discomfort and physical pain) over the last 12 months and the last 7 days. To finalize this section, the workers were asked to identify possible relationship between MSD symptoms and characteristics of work; *Section C* integrates items to better characterize the workers' perception about Work Activity and Conditions of Realization in terms of organizational conditions (time available to perform the work, work schedule).

2.3 Physiological Measures - Heart Rate

Physical workload data were obtained through heart rate measurement. For this purpose, polar Vantage M brand pulse time meter and the compatible chest-belt was used.

The physical exertion was assessed by heart rate response considering both parameters: The Relative Heart Rate (RHR) and the percentage of heart rate increase (PHRI).

Heart rate was recorded for the entire working day, including during the main rest break at the middle of the day. Subsequently, the RHR and PHRI were determined for the effective working time (discounting the lunch period and the time spent traveling to the front of work).

RHR allows for the estimation of the relative physical work demands of workers during a work period, such that comparisons between workers and/or worksites are possible. The RHR and the PHRI were obtained by the application of Eq. 1 and Eq. 2, respectively:

$$\text{RHR}\ [\%] = \frac{\text{HR}_{\text{work}} - \text{HR}_{\text{rest}}}{\text{HR}_{\text{max}} - \text{HR}_{\text{rest}}} \times 100 \tag{1}$$

$$\text{PHRI}\ [\%] = \frac{\text{HR}_{\text{work}} - \text{HR}_{\text{rest}}}{\text{HR}_{\text{rest}}} \times 100 \tag{2}$$

Where:

HR_{work} is the heart rate (in beats/min) measured during work; HR_{rest} is the heart rate obtained from the value corresponding to the 1st percentile (P1) of the monitored period (in beats/min), and $\text{HR}_{\text{max}} = 220\text{-age}$ (in beats/min) [12].

Additionally, and in order to assess whether the work is being carried out within acceptable workload levels, we evaluated the maximum time allowed based on maximum

acceptable work time (MAWT) proposed by [13] using the Eq. 3.

$$\text{MAWT(h)} = 26.12 \times e^{-4,81 \times \text{RHR}} \quad (3)$$

Workloads were classified into very low, low, moderate, high, very high and extremely high according to Çalişkan and Çaglar [7] and Grandjean [14] (Table 1).

Table 1. Workload classification considering RHR and PHRI.

RHR [%] [7]	PHRI [%] [14]	Workload classification
10–20	0	Very low (resting)
20–30	]0–36[	Low
30–40	[36–78[	Moderate
40–50	[78–114[	High
50–60	[114–150[	Very High
>60	>150	Extremely High

Finally, MAWT (h) was related with the Work Time Duration (T_{work}) (h) obtaining the Exposure Dose (D) (Eq. 4). D > 1 is indicative that the work is being done outside acceptable load levels.

$$D = \frac{T_{work}(h)}{\text{MAWT (h)}} \quad (4)$$

where

T_{work} is the effective duration of the work (in hours); MAWT is the acceptable work time obtained by the application of the Eq. 3.

2.4 Data Analysis

For data processing the SPSS© software was used and descriptive analyses were performed using measures of location and dispersion. To assess associations between variables (demographic/work-related characteristics) and reported MSD symptoms, the Chi-square test and Cramer's V coefficient were used. A significance level of 0.05 was adopted as a criterion to reject the null hypothesis.

3 Results and Discussion

Considering the socio-demographic data the age of participants ranged from 24 to 53 years (mean = 35.8 years; SD = 8.45 years). In general, the participants had: an average weight of 80.89 kg (SD = 12.27 kg; range: 55–100 kg); an average height of 174 cm (SD = 6 cm; range: 160–187 cm); and an average BMI of 26.88 kg/m^2 (SD =

4.72 kg/m^2, range: 20.02–35.94 kg/m^2) where, at least 58% of the operators were Overweighted. In terms of Seniority ≈50% of the workers had more than 3-years' experience in the functions assessed. 47% of the operators reported that they were not involved in regular physical activities or sports. 53% of the participants were smokers and ≈90% of workers consumed caffeine daily. Thirty-two percent of the workers had chronic health problems of which 38% related to MSD. The majority of the workers (95%) were right-handed. Fifty-three percent of the participants had a regular education level. In terms of Job, 84.2% of the workers were conservation assistants and 15.8% were conservation officers.

In terms of working time organization: all workers should complete 8 h daily; 95% of the workers reported that usually took rest breaks (5–10 min) varying between 1 to 6 times throughout the day. Only 2 of the respondents had suffered an accident at work, in the last 2 years.

3.1 Self-reported Symptoms

The body regions with the highest percentage of complaints were the lumbar spine (95%), followed by feet-right (79%) and left (74%) and, with the same ratio, the dorsal spine and right-wrist/hand (58%), and the cervical spine and right-thigh (53%) (Fig. 1). These results are similar to those of other studies [11, 15, 16] where lumbar spine is reported as the region with higher prevalence of complaints. The presence of complaints in the knees and feet is also common among workers who operate on sloped surfaces [17, 18].

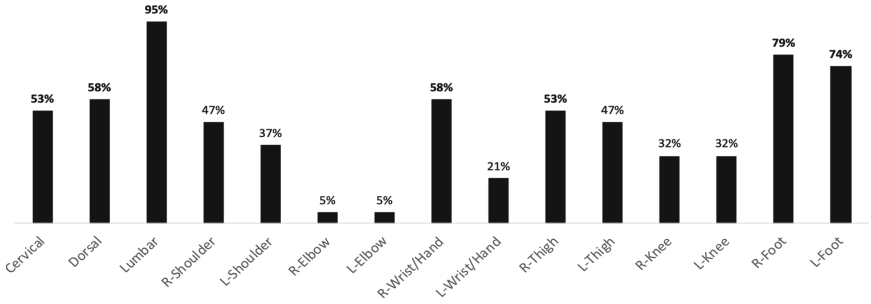

Fig. 1. MS Symptoms (prevalence of physical complaints - annoyance, discomfort or pain) registered per corporal region.

Regarding the intensity of complaints, it was found that the highest level of the scale (very high) is present in the 6 most affected regions in a proportion that varies between 7 to 36%. It is also noteworthy that there were regions, such as the knees and the left hand/wrist, which despite not showing a prevalence of complaint as high as the other regions (<50%), presenting very high intensity (with records ≥ 50% of cases). All regions presented at least more than 4 complaints/year in a proportion ≥ 50%. Figure 2 shows the comparison between self-reported symptoms in the last 12 months and in the last 7 days. It should be noted that most of the complaints, in the lumbar region, thighs

and feet, were related to the work on the *Talude* (sloped surface). Therefore, the low percentage (≤50%) of the complaints reported in the last 7 days for the aforementioned regions could be related with the fact that the workers were not doing work of this nature in the past few weeks. The workers associated their pain level with the working conditions in particular with: sloped surfaces, the repetition of movements of hands/fingers and arms, the standing posture and the rotation and inclination of the trunk.

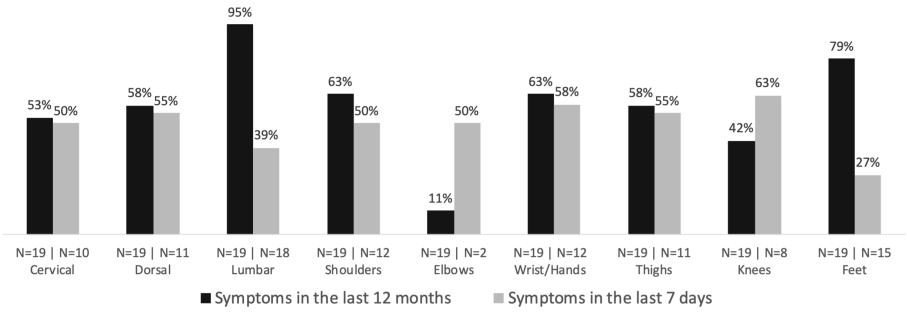

Fig. 2. Comparison between self-reported symptoms, in the last 12 months and in the last 7 days.

3.2 Associations Between Demographic/Work-Related Characteristics and MSDs Symptoms Reported by Body Region

In general, there were no statistically significant associations between the MSD symptoms and the variables (demographic/work related characteristics) ($p > 0.05$). The only three associations found were in the shoulder and in cervical region. It is important to highlight that in majority of the cases Cramer's V test revealed moderate and strong associations (>0.60). From the analysis made, it is possible to draw the following conclusions: a) for the shoulder region there was a positive association with clinical history (χ^2 (1) = 5.115; p = 0.044) and BMI (χ^2 (3) = 9.330; p = 0.014). Thus, we can conclude that the presence of some type of disease seems to be associated with the complaints revealed in this body region; on the other hand, complaints are more prominent among operators who fall outside the normal body weight category; b) the complaints presented on the neck seem to be associated with the quality of sleep revealed by the participants (χ^2 (1) = 9.972; p = 0.021). However, from the analysis of the data it is not possible to define a clear pattern.

3.3 Workload Assessment

The results obtained in this study showed that the RHR ranged from 24% to 75% and the PHRI ranged between 24% and 131%, which means that the workload ranged from low to very high based on the physical workload classification. Figure 3 shows the proportion of the workload obtained according to the Workload Classification obtained by each evaluated parameter: RHR [%] and PHRI [%].

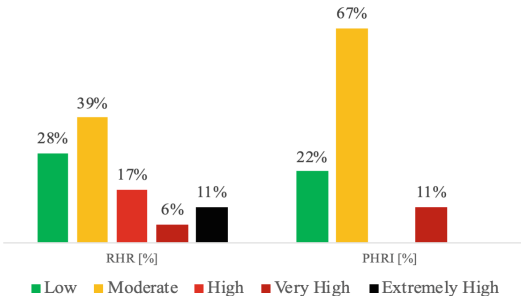

Fig. 3. Proportion of the workload obtained according to the Workload Classification obtained by each evaluated parameter: RHR [%] and PHRI [%].

These results are a consequence of the nature of the work performed in each day and the individual characteristics of each operator. The climatic conditions may also have had an influence on the results. Additionally, the tool used can also explain the differences found since the lowest (heart rate) records were found in workers who handled, or when handling light tools. These results suggest that further investigations should be made to better characterize the situation, allowing future improvements in the working conditions.

Considering de Exposure Dose (D) parameter, 44% of the evaluations performed are above 1 suggesting that the work is being done outside acceptable load levels.

4 Conclusion

This cross-sectional study was conducted in a Private Portuguese Enterprise responsible for operation and maintenance of road infrastructure. The intensity of MSDs symptoms (in all regions) among the operators was assessed as high or very high, emphasizing the need of ergonomic interventions for improving the working conditions. These results are similar to those of other studies [11, 15–18].

All regions assessed presented at least more than 4 complaints/year in a proportion $\geq 50\%$. The results also showed that the majority of the participants did not experience MSDs symptoms over the last 7 days in the lumbar spine, thighs and feet; which could be related with the fact that workers were not doing work on the *Talude* (sloped surface), in the past few weeks.

Considering the physical exertion, the results showed that workload ranged from low to very high. In 44% of the evaluations, the work was being done outside acceptable load levels. These results are similar to those obtained by [1, 6–8]. This study revealed that the work done by these workers entails risks factors, which may be responsible for the development of musculoskeletal disorders. As a limitation of this study, we can highlight the sample dimension, which can explain some of the results.

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