Musculoskeletal Disorders Investigation Among Workers that Operate with Brush Cutter in Vegetal Maintenance Tasks

Filipa Carvalho, Teresa Cotrim, and Rui B. Melo

Abstract Objective: The main objectives were to assess the real working conditions and the complaints reported by workers using brush cutters and characterize the tasks' risk of developing musculoskeletal disorders (MSDs), aiming at implementing preventive measures. Background: The main tasks accomplished by brush cutter operators may be liable for increasing of chronic pain syndromes. Estimating the prevalence of self-reported musculoskeletal complaints among brush cutter operators and identifying possible associations with their real working conditions were the purpose of this study. Therefore, an Ergonomic Work Analysis was performed to evaluate and assess the working conditions of brush cutter operators during vegetal maintenance tasks. Method: To quantify the risk associated to the development of MSDs, Quick Exposure Check-QEC and Rapid Entire Body Assessment-REBA were applied for two tasks. A questionnaire aiming at characterizing MSDs symptoms and individual and work characteristics was filled by nineteen workers. Results: The results showed that the highest percentage of complaints were present in lumbar spine, feet, dorsal spine, right-wrist/hand, cervical spine and right-thigh. The risk of developing WRMSD was present in all tasks. Conclusion: This study has shown that several occupational risk factors trigger the development of MSDs among these operators.

Keywords Ergonomic Work Analysis · Quick Exposure Check (QEC) · Work-related Musculoskeletal Disorders symptoms (WRMSDs) · Nordic Musculoskeletal Questionnaire (NMQ) · Rapid Entire Body Assessment (REBA)

F. Carvalho (✉) · T. Cotrim · R. B. Melo
CIAUD (Centro de Investigação em Arquitetura, Urbanismo e Design), Faculdade de Arquitetura, Universidade de Lisboa, Rua Sá Nogueira, 1349-055 Lisboa, Portugal
e-mail: fcarvalho@fmh.ulisboa.pt

T. Cotrim
e-mail: tcotrim@fmh.ulisboa.pt

R. B. Melo
e-mail: rmelo@fmh.ulisboa.pt

ErgoLAB - Laboratório de Ergonomia, Faculdade de Motricidade Humana, Universidade de Lisboa, Estrada da Costa, 1499-002 Cruz Quebrada, Portugal

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1 Introduction

The tasks performed by brush cutter operators can be compared to those of forestry occupations which are recognized as physically demanding (Toupin et al. 2007). In 2015, according to the 6th European Working Conditions Survey, nearly 25% of the workers in Europe reported that their work affects their health, and 32% out of these correspond of the Agricultural workers. Plus, back pain was reported by 43% of the European workers daily. As for the muscular pain, the situation is similar, as around 42% of the respondents considered that working conditions origin muscular pain (upper limbs or neck). This result is greater among workers in forestry sector with 57% and 55%, respectively (Eurofound 2017; Sabino et al. 2019).

Musculoskeletal disorders occur in all activities sectors in European Union being the most frequent work-related disease (Park et al. 2017). Vegetation managing tasks usually require the adoption of uncomfortable and difficult postures for long periods of time, which may weakness and strain associate tendons and muscles, inducing the development of Work-related Musculoskeletal Disorders Symptoms (WRMSDs) (Francisco 2019; Grzywiński et al. 2016; Sabino et al. 2019). Numerous studies exploring the workload within workers of the forestry and agriculture sector highlight that certain activities impose a high workload (Balimunsi et al. 2011; Çalişkan and Çağlar 2010; Sullman and Byers 2000). To evaluate and assess the working conditions amongst brush cutter operators during vegetation managing tasks, an Ergonomic Work Analysis (EWA) was done considering the following main objectives:

- to assess the real working conditions and the self-reported complaints by workers using brush cutters;
- to Characterize the WRMSD risk associated with tasks/subtasks;
- to propose some preventive measures.

2 Materials and Methods

2.1 Stage of the Study, Location and Participants

Data collection was done from July to November 2020, in a Private Portuguese Enterprise, which workers are responsible for road infrastructures' operation and maintenance. Nineteen male workers, from six concessions, accepted to participate and fulfilled the questionnaire. However, only seven (being part of the vegetal maintenance teams) out of these, belonging to the two concessions visited, participated in the WRMSD development risk assessment, authorizing image recording during the work activity, for further postural analysis. In both situations, an informed and written consent was given. Data confidentiality was ensured. The study was developed in three stages:

(1) Characterizing the Work Situations;
(2) Characterizing WRMSD development risk associated with tasks/subtasks;
(3) Risk Controlling.

In the First Stage, the prevalence of musculoskeletal complaints was obtained from a questionnaire, in which self-reported symptoms were organized by body regions. In the Second Stage, two observational methods—Quick Exposure Check (QEC) and Rapid Entire Body Assessment (REBA)—were applied, aiming at characterizing the risk for the development of WRMSD, in the tasks and subtasks, previously selected. Finally, in the Third Stage, some preventive measures (technical and organizational) were proposed.

2.2 *Tasks/Subtasks' Sample*

This study comprised two main tasks: Control of Vegetation Growth (T1) and Cleaning of Drainage Systems (T2). Each task was further divided in Subtasks (Fig. 1).

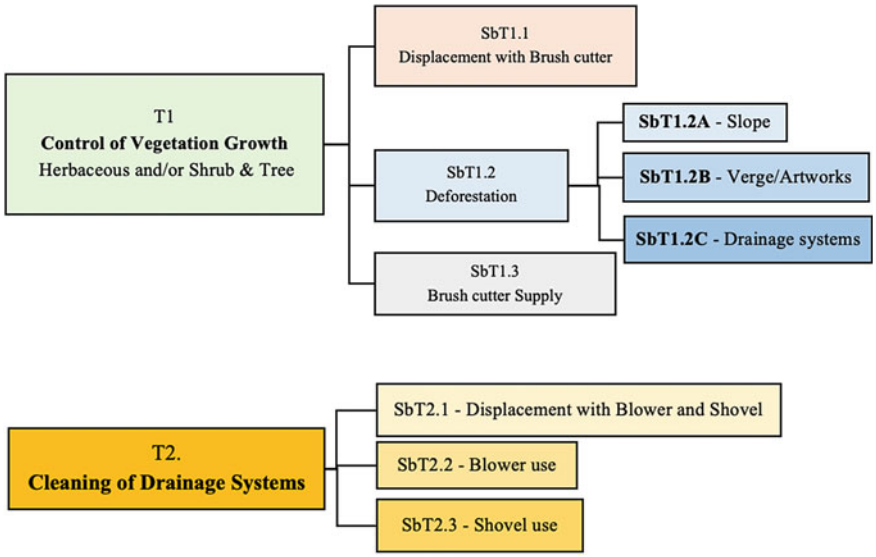

Fig. 1 Tasks and Subtasks assessed in the study

2.3 Data Collection and Procedures

For data collection diverse tools and methods were used: observations (free/systematized), non-structured interviews with workers, video/image recording and a Questionnaire (specifically developed for this purpose).

The questionnaire was created from the modified version of the Nordic Musculoskeletal Questionnaire (NMQ) (Kuorinka et al. 1987), used in previous studies (Francisco 2019; Sabino et al. 2019), and information collected in the company. The questionnaire, which was applied as an interview, aimed to identify important parameters for the workers' characterization, evaluate their perception of the real working conditions, and to identify self-reported symptoms related to discomfort, physical fatigue, or pain.

The questionnaire is organized in four sections. Section A included the workers' age, gender, anthropometric data (weight, height), dominant upper limb; organizational data (schedule type, number of hours worked per day/week, practice of work breaks, second job, seniority,…); the workers' health, smoking, alcoholic and caffeine habits, sport and physical activities, and the presence of chronic diseases. Section B incorporated items related to the occurrence of musculoskeletal symptoms, over the last 12 months and the last seven days. At the end of this section, the workers were inquired to identify possible relationships between characteristics of work and aforementioned WRMSDs. Section C included items to characterize the workers' perception about Work Activity and Conditions of Realization. This section also integrates the characterization of the general fatigue perception of workers. At the end, workers were asked to propose modifications to optimize their working conditions. Section D integrates QEC-Worker's Assessment Checklist, for further application of the method. The working postures were recorded with a Go Pro Hero 8 Black digital camera (with 12 megapixel and 1080 × 1920 HD/30 fps resolution).

WRMSD risk assessment relied on two observational methods: REBA (McAtamney and Hignett 2005) and QEC (David et al. 2008). The most harmful postures for the worker (such as: posture known to cause discomfort; the most frequently repeated posture; unstable, extreme, or awkward posture, especially when force is exerted; posture requiring the higher muscular activity or the greatest force) were always selected, as suggested by the authors of the methods.

Both methods were applied according to Sabino et al. (2019). Therefore, the videos were observed, and the worst posture was selected for assessment with QEC. For the application of REBA, several frames were selected from each video for further assessment. One single researcher analyzed 1378 postures with REBA and 129 postures with QEC.

As a reference, in both methods (REBA and QEC) low Scores represent acceptable work posture, whereas higher scores require an action. As both methods incorporate different Score level scales, REBA Scores were modified (the 2 first levels were merged in one) to simplify the association between both results. The QEC/REBA Risk Level and respective Action Level are shown in Table 1.

Table 1 Correspondence between QEC/REBA Risk level and action level

Risk level	Action level
1 - Low (or color green)	Acceptable
2 - Moderate (or color yellow)	Investigate further
3 - High (or color orange)	Investigate further and change soon
4 - Very high (or color red)	Investigate and change immediately

Source Adapted from Sabino et al. (2019)

3 Data Analysis

The Statistical Package for the Social Sciences (SPSS ©) software was used (version 26), for data processing.

To summarize socio-demographic data, job characteristics, prevalence of complaints and Risk Level obtained by each method descriptive analyses were performed using dispersion (standard deviation and ranges) and location (Frequency, Percentiles, Mean and Median) parameters. The non-parametric Wilcoxon test was used to compare the results obtained with both methods (REBA and QEC) whereas subtasks' Risk Levels were compared using the non-parametric Kruskal–Wallis test. In both cases the median value was considered. To make the comparison process feasible, the number of REBA analyzes was previously adjusted to the number of QEC analyzes (N = 129).

As criterion to reject the null hypothesis, a significance level of 0.05, was considered, in all cases.

Action Level two was considered the first one involving risk for WRMSD development according to both methods (REBA and QEC). Posture Score A and Posture Score B were additionally contemplated, for REBA method. Posture Score A evaluates the biomechanical load considering the use of "neck+trunk+legs" set and Posture Score B evaluates the biomechanical load considering how much the "upper arm+lower arm+wrist" segment set is involved in the task. As for the QEC method, the Risk level for each body region (QECNeck, QECBack, QECShoulder, QECWrist/Hand) was also considered. The working postures and the working conditions (frequency, held loads and movements' amplitude) were contemplated in the analysis.

4 Results and Discussion

Table 2 summarizes the principal socio-demographic data of the participants. Fifty-eight percent of the operators were over-weighted. Thirty-eight percent out of the 32% of the chronic health problems were related to musculoskeletal disorders. High school level was accomplished by 53% of the participants. Regarding Job, the majority of

Table 2 Main characteristics of the participants (N=19)

Variables	Average	Sd	Min.	Max.	Variables	Yes (%)	No (%)
Age (years)	35.8	8.45	24	53	Right-handed	95	5
Seniority (years)	3.3	3.93	0.58	15	Medical history of chronic illnesses	32	68
Height (cm)	174	6	160	187	Regular physical activity	53	47
Weight (Kg)	80.89	12.27	55	100	Smoking Habits	53	47
BMI (Kg/m2)	26.88	4.72	20.02	35.94	Caffeine daily habits	89	11
					Second Job	89	11

the workers were conservation assistants (84.2%) and the rest were conservation officers (15.8%).

Regarding working time organization: workers should complete eight hours daily; 95% of them stated that normally they took between one to six rest breaks (5–10 min each) per day. Only two participants were involved workplace accidents, in the last two years.

The highest percentages of complaints were identified for six body regions: lumbar spine (95%), feet—right (79%) and left (74%), dorsal spine (58%), right-wrist/hand (58%), cervical spine (53%) and right-thigh (53%). These results are in accordance with other studies, that reported lumbar spine as the region presenting higher prevalence of complaints (Francisco 2019; Gallis 2006; Lachowski et al. 2017). Workers who operate on sloped surfaces also reported complaints in the knees and feet (Breloff et al. 2019; Choi 2008).

Considering the intensity of complaints, the highest level of the scale (very high) was marked in the most affected regions in a proportion that varied between seven to 36%. It is important to highlight that some regions, despite not showing high prevalence of complaints ($<50\%$), presented very high intensity (with records $\geq$ 50% of cases), such as the left hand/wrist and the knees.

For the thighs, feet and lumbar region, many of the complaints were related to working on the Slope. Therefore, the low percentage ($\leq 50\%$) of complaints reported in the last seven days, for the abovementioned regions, can explain the results, since the workers were not involved in these tasks in the past few weeks. The reported pain level was associated by the workers with some working conditions such as the rotation and flexion of the trunk, the repetition of hands/fingers and arms' movements, the standing posture, and the sloped surfaces.

Considering REBA and QEC results, the risk for the development of WRMSD (Risk Level $\geq$ 2) is present for 99% and 94% of the assessed postures and, for most of them, the risk level for the development of MSD is between High (39.9% and 34.9%) and Very High (37.8% and 45%) for both methods, respectively. These results indicate that further investigation and adjustments in the work situation are necessary.

Considering the Wilcoxon test, statistically significant differences were not found between the results obtained with both methods ($Z = -3.48$; $p = 0.728$). Only 33% of the postural rating obtained similar classification. Overestimation was registered in 36% and 31% of the cases (postures) assessed with QEC and REBA, respectively.

Considering the REBA results, the Biomechanical loading at the "neck + trunk + legs" segment set was the most contributing to the overall result of the Reba Risk Level (Posture Score A = 6), whereas according to QEC results, only the Neck region seems to be the region with higher contribution (QECNeck = 4).

Figure 2 shows the results by Task and Subtask when evaluated with REBA and QEC methods.

The results reveal that one Task (T2) and five out of eight Subtasks reveal different results, when assessed with both methods. The subtask Slope revealed to be the worst with both methods.

Additionally, considering the Kruskal–Wallis test, there were statistically significant differences between the results obtained by task when assessed with the same method (REBA or QEC) ($p < 0.05$). A careful analysis of the data suggests that the differences found are more related to the nature of the Subtasks in which each operator was evaluated. It should be noted that it was not possible to observe all operators performing all Subtasks. This disparity justifies the results found. Finally, the use of the Bruch cutter proved to be more demanding than the use of the Blower, with both methods.

4.1 Proposed Solutions

A few technical and organizational solutions were recommended to minimize the risk of developing WRMSD and the complaints presented by workers.

In terms of technical solutions, whenever new tools are purchased (Blowers, Brush cutters, etc.), special attention must be driven to the following characteristics: vibration levels; weight of the tool and adjustment possibilities; Equip each team with a "Green Climber" robot ensuring that they have the necessary means to reduce the effort associated with the use of the Brush cutter.

Concerning the organizational measures, increasing workers' awareness about their posture and the risk factors for the development of WRMSDs should be pursued. Whenever possible, pauses should be taken or rotation among tasks (such as: use of Bruch cutter vs use of Blower; Deforestation in Slope vs Verge/Artworks) should be promoted; Improve work planning before moving on to work fronts, ensuring that workers have the most appropriate tools and the right machines; Develop

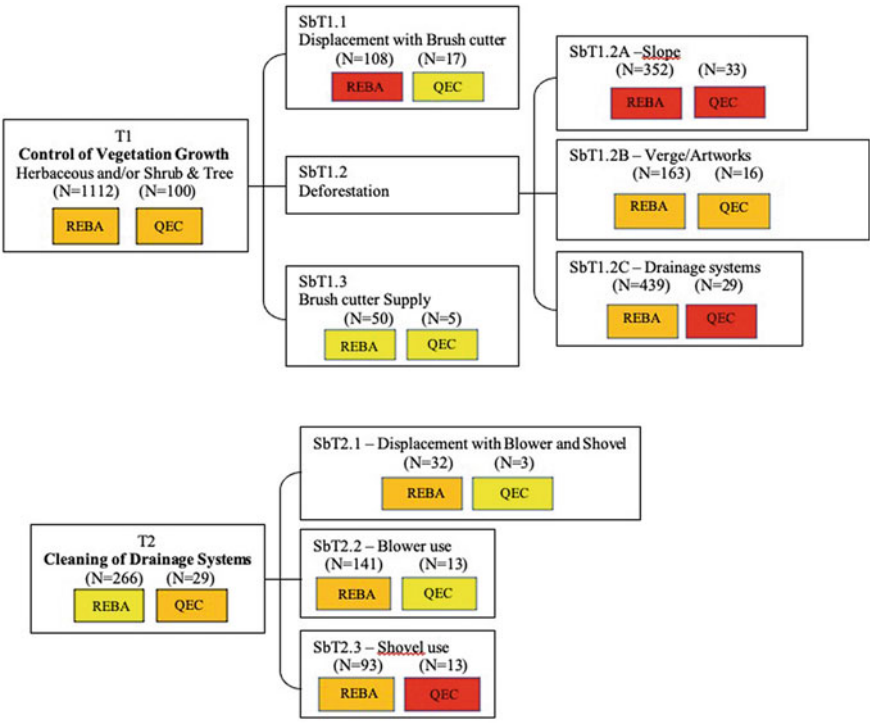

Fig. 2 Comparation between QEC Scores and REBA Scores results, by tasks and subtasks

the skills among the elements of the team, providing an effective rotation between control tasks (maneuvering machines) and execution tasks (use of hand tools such as Bruch cutter and Blowers); Bearing in mind the high prevalence of musculoskeletal symptoms among the respondents, and the risk of worsening due to the workers' aging, it is essential to reinforce the Health Promotion Program, already existing in the organization.

4.2 Limitations

The cross-sectional design of the study and the sample dimension may have influenced the results.

5 Conclusions

This study was carried out in a Private Portuguese Enterprise, who's main task is to ensure the operation and maintenance of road infrastructures. The intensity of WRMSDs was rated as high or very high, highlighting the need of ergonomic interventions for improving the working conditions. The obtained results agree with other studies (Breloff et al. 2019; Choi 2008; Francisco 2019; Gallis 2006; Lachowski et al. 2017). For all assessed regions, a minimum of four complaints/year in a proportion equal or higher then 50% were presented. It was also shown that most participants did not experience WRMSDs over the last seven days at the thighs, feet, and lumbar spine level, which could be due to the fact that workers did not work on the Slope in the previous weeks.

The QEC and REBA scores revealed that the risk for the development of WRMSD ($RL \leq 2$) is present in most evaluated postures, which requires further investigation and adjustments to be made in the work situation. The use of the Bruch cutter proved to be more demanding than the use of the Blower.

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Filipa Carvalho Universidade de Lisboa, Faculdade de Motricidade Humana, Laboratório de Ergonomia and Faculdade de Arquitectura, Centro de Investigação em Arquitectura, Urbanismo e Design, Ph.D. in Ergonomics (2013), Faculdade de Motricidade Humana, Universidade de Lisboa.

Teresa Cotrim Universidade de Lisboa, Faculdade de Motricidade Humana, Laboratório de Ergonomia and Faculdade de Arquitectura, Centro de Investigação em Arquitectura, Urbanismo e Design, Ph.D. in Ergonomics (2008), Faculdade de Motricidade Humana, Universidade de Lisboa.

Rui B. Melo Universidade de Lisboa, Faculdade de Motricidade Humana, Laboratório de Ergonomia and Faculdade de Arquitectura, Centro de Investigação em Arquitectura, Urbanismo e Design, PhD in Ergonomics (2006), Faculdade de Motricidade Humana, Universidade de Lisboa.