


## Article

# Heritage Keepers: The Perils in Textile Conservation

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**Abstract:** One of the most frequent professional afflictions in Conservators-Restorers is the onset of work-related musculoskeletal disorders (WMSDs). The conservation of textiles is recognizably vulnerable to these problems. However, the assessments of the ergonomic conditions for these workers are rare or even non-existing. The present study focuses on a group of conservators-restorers of textiles and relies on the use of a Nordic Questionnaire for musculoskeletal disorders coupled with a Quick Exposure Check for the task of consolidation on a horizontal table to determine the severity and exposure levels to WMSDs. All surveyed workers reported numbness, pain or discomfort in the last 12 months for the neck region, while 67% reported the same afflictions for the back, shoulders/arms and hands/wrist. In the same time period, half of the workers used pain relievers in order to maintain their professional activity. For the textile consolidation task, the neck and back areas showed high and very high levels of exposure, respectively, and the results place these workers at a high-risk for WMSDs due to cumulative stress. Mitigation strategies are proposed but these should be paired with professional counseling. Although preliminary, this study is the first of its kind to assess the ergonomic impact of the profession in Portugal and presents a methodology that can be used to perform similar evaluations in other workplaces and/or other specialties in the Conservation and Restoration sphere, both nationally and internationally.

**Keywords:** textile; conservation-restoration; ergonomics; work-related musculoskeletal disorders; occupational health



**Citation:** Pinheiro, A.C.; Ramos, A. Heritage Keepers: The Perils in Textile Conservation. *Heritage* **2021**, *4*, 4716–4725. <https://doi.org/10.3390/heritage4040260>

Academic Editor:  
Francesco Soldovieri

Received: 27 October 2021

Accepted: 15 December 2021

Published: 20 December 2021

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## 1. Introduction

Art professions can be considered as hazardous occupations due to the materials used [1,2] but external factors such as irregular work schedules and long hours, solitary activities, inadequate preparation on health prevention measures and a general economic instability (especially for freelancers) can also have an impact on the worker's well-being [3]. Conservators-Restorers (CRs) can be included in this group and these very often pay more attention to the artistic objects in front of them than to the harm that may come, in the long run, from restoring them [4,5].

Different risks may arise from different working settings. The work performed on ancient documents and books in archives will certainly bring risks posed by biological contamination, while falling will be much more likely from a scaffold while restoring built heritage. Regardless, the most common risk factors facing this professional group are inhalation and contact with chemical or biological agents, dust inhalation, falls and visual and physical strain [6]. Ergonomically, restorers are challenged by the very frequent need to maintain awkward positions for a long time, while still managing to devote total concentration to the work being performed. This attitude can be compromising to their own health. From a survey conducted on a group of 35 CRs (personal data, not published) physical injuries were the number one complaint, resulting even in hospital

attendance and relief from work. One of the most frequent professional afflictions is the occurrence of work-related musculoskeletal disorders (WMSDs). Generally speaking, this term encompasses lesions at the muscles, tendons, ligaments, joints, cartilage and intervertebral disks whenever these can be correlated to job-related tasks. These disorders can be classified as either traumatic or cumulative in nature [5,7]. In the conservation-restoration of textiles—the only area where one can find ergonomic-related articles [4,5]—incorrect/extreme postures, physical demands of certain tasks, motion repetition, task duration, when coupled with individual characteristics and psychosocial factors, can effectively have an impact on the development of WMSDs [8] and it tends to be cumulative. The occupational health issues and the long-term impact of their activities on their well-being is not a particularly well-studied topic in most countries and Portugal is no exception. The absence of data or studies has been recognized by Occupational Medicine [6,9]. No data could be found by the authors on the prevalence or severity of WMSDs on textile conservators or any other CR specialty in Portugal. The goal of this study was to perform a quantifiable preliminary assessment on the ergonomic challenges faced by conservator-restorers of textile artefacts in a sub-group presently working in Portugal. The results were presented in a report delivered to the institution along with proposed mitigation strategies.

## 2. Materials and Methods

A group of CRs working at the same workshop of textiles' conservation was selected for the study. Demographic data were collected for every worker assessed. A standardized Nordic musculoskeletal questionnaire (adapted for Portuguese context) [8,10] was filled in and this enabled the identification of the worker's main complaints and the potential risk factors as perceived by the worker. In addition, each worker pointed out what they considered the two most strenuous tasks or sub-tasks. These were determinant for the next step in the evaluation, the administration of a Quick Exposure Check (QEC) per task. This observational tool was developed for Occupational Safety and Health (OSH) practitioners to assess exposure to risks for work-related musculoskeletal disorders providing a basis for future ergonomic interventions. Although this QEC was not specifically devised for this particular activity, the tool is based on epidemiological evidence and investigations of OSH practitioners' aptitudes for undertaking assessments [11]. The QEC used allows for four main body areas to be assessed, involving both practitioners and workers in the assessment. Psychosocial factors were also assessed [8,11]. The results from the QEC are presented as a final score which ranks the particular task for its exposure level and allows prioritization of corrective measures. The statistical analysis was performed with STATA/IC 16.1 for Mac (StataCorp 4905 Lakeway Drive, College Station, TX, USA). The confidence interval was determined using the Adjusted Wald interval. Comparisons were made using the N-1 two proportion Test or the two-sample *t*-test (on binary or continuous data, respectively). It was considered that  $p < 0.05$  was statistically significant.

## 3. Results and Discussion

### 3.1. Demographic and Nordic Questionnaires

The questionnaires were applied to six workers, all conservator-restorers specialized in textiles. Only two of them did not work exclusively at the location where the study was performed. The first questionnaire collected demographic data and the results are presented in Table 1.

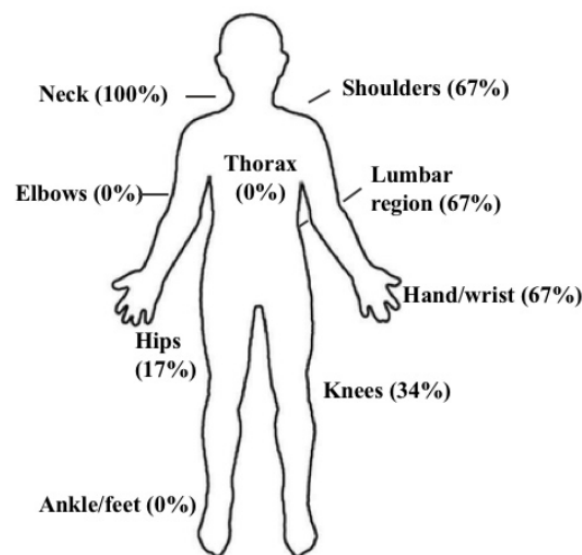
**Table 1.** Demographic data from six textile conservator-restorers.

Age (Years)	Height (Cm)	Weight (Kg)	Time Working as a CR (Years)	Physical Activity
39 to 62	155 to 174	60 to 80	12 to 40	One attends yoga classes daily; two go for daily walks; the remaining three do not practice any physical activity

The translated and validated Nordic questionnaire pointed out the regions of the body where the workers felt at least one episode of numbness, pain or discomfort in the last 12 months. Nine body areas were contemplated.

The neck region is the most mentioned by the workers and seems to be present irrespective of the time as a textile conservator. The shoulders, lumbar region and hands/wrists are the next most affected areas. Hands and wrists are most affected in the conservators who are seniors in this profession (22 to 40 years). Interestingly, this might be related to the needle type used since younger professionals tend to work with curved needles and older ones tend to work with straight ones, at least in this particular workshop. Straight needles usually require the aid of a plier that can place additional strain on the hand and wrist. Although insufficient to establish a statistically significant correlation, due to the small sample size, it poses a plausible causality link and an interesting technical evolution.

Two workers acknowledge having had some of the disorders displayed in Figure 1, in the last 7 days: one due to shoulder pain and the other to hand/wrist pain with the diagnosis of trigger finger. For both of them, the level of pain experienced reached an eight on a 1–10 scale. One worker had to cease or temporarily interrupt physical and domestic activity due to back and knee pain. In the last 12 months, half of the workers have taken medication to ease pain derived from WMSDs and two had to seek medical help to treat their symptoms.



**Figure 1.** Percentage of workers who have experienced numbness, pain or discomfort in the last 12 months for each of the body areas contemplated in the questionnaire.

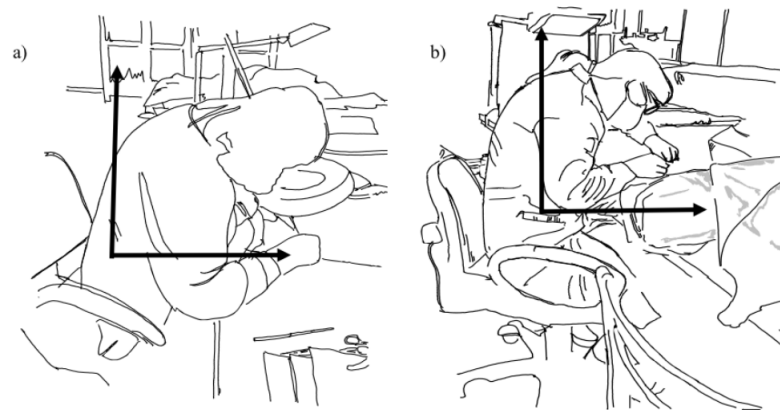
Finally, only one employee performs stretching exercises during short breaks, a practice inherited from attending regular yoga classes. No worker has received any training on mitigation strategies to alleviate symptoms from WMSDs but all recognize their importance and showed interest in receiving such training.

The small sample size represents a relevant limitation of this work, one that was clearly identified. The authors tried to overcome the paucity of data by using statistical instruments with the goal of amplifying the results and identifying statistically significant correlations, which, in none of the dimensions analyzed (Nordic questionnaire and QEC), were found. However, this is the first study to present the results of an ergonomic assessment with quantifiable data and presents possible recommendations for the most prominent issues encountered.

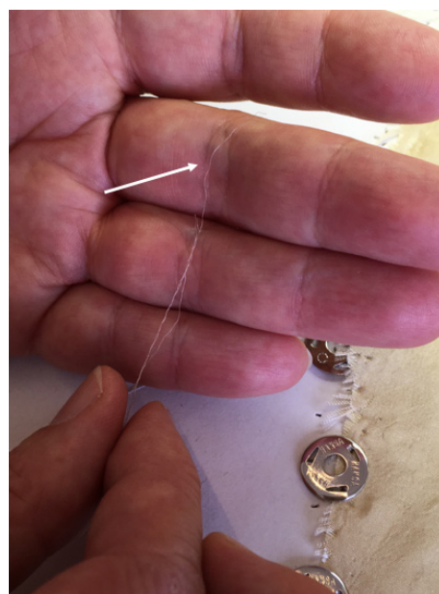
The questionnaires also asked the workers to point to the tasks or sub-tasks most likely to affect them. It is on the evaluation of these specific tasks that the Quick Exposure Check (QEC) is based on.

### 3.2. Quick Exposure Check (QEC)

The workers had some difficulty pointing to specific tasks with a higher impact. Washing textiles, sometimes of very large dimensions, was one of the tasks mentioned because the weight of the textile can increase impressively after being wet and also because the staff must reach the center of the piece, bending over to reach the most inaccessible spots. However, this is not a daily task and it was not possible to assess it in situ for the present study. The lining of tapestries was also mentioned. This involves spreading the textile on the floor and the conservator then alternates between standing and squatting positions for hours. This, however, is also an infrequent task. Most of the positions assumed for consolidation on a horizontal table, which can be considered the most frequent task, require postures that pose ergonomic risks (Figure 2). The task is made even more difficult when working with metallic thread (Figure 3), so thin and difficult to track that it increases the eye and concentration strain of this particular task. Because this line of work frequently involves very large textiles, the consolidation task is also ergonomically challenging when the worker has to bend over to reach the center of the textile.

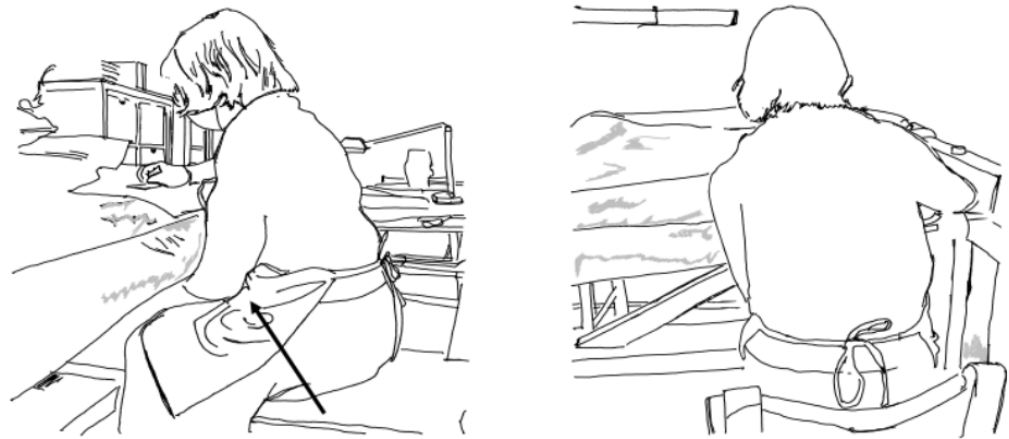


**Figure 2.** Both (a,b) show consolidation work being performed by conservators on horizontal sectional tables. The positions shown here are kept for long periods of time and the focus is permanent. On the left image (a) a magnifying lens is being used to ease the detection of a metallic thread. Both (a,b) show the angles adopted by the workers during working hours [12].



**Figure 3.** The metallic thread used to sow is extremely thin and very difficult to keep track of while sewing. Some of the workers use a magnifying lens with or without additional illumination.

There is, of course, equipment that makes this task easier by keeping the textile as a roll but even in these conditions the body has to adopt non-natural positions to perform the job (Figure 4).



**Figure 4.** At the tapestry loom. The left hand goes below the rolled textile to reach its back while the right hand, in a dexterous person, stays on the front. In this particular case the roll was not too large but when the area to be treated is in the middle of a very large tapestry then the position assumed is much more tilted to the left than the one seen above right.

At the tapestry looms, staff must accommodate to the presence of a sometimes very large roll blocking their access to the back of the textile. Because tapestry requires a motion to retrieve the needle on the other side, the conservator is forced to a tilted position in order to reach both sides of the piece. An angle can, however, be introduced in these looms, reducing the neck strain and providing a more upright position. Tapestry loom-work was mentioned as a strenuous activity but its frequency at this conservation workshop somewhat diminishes its importance overall. No one was performing any activity at the tapestry loom at the time of the visit.

Some of the workers did not mention any particular task, just the fact that in most (if not all) of the frequent tasks and sub-tasks, the sustained bending over the piece either just using the neck or the back and lumbar region had the most impact on their well-being. In fact, this particular static position can be maintained for hours, days and even weeks since the type of work is highly detailed and time-demanding and weak textiles are kept flat for safety reasons. Thus, even if it is possible to invest in alternative working positions, the safekeeping of the cultural heritage items is paramount and no sound options may be available. Even if a better position was to be devised, maintaining it for long periods of time would always bear the risk of injury [5]. Consolidation work is one of the tasks where this static, bending position is held and because all of the staff were performing it on a horizontal table at the time of this study, this was the task assessed using the QEC. Exposure assessment has concentrated on the back, shoulders, upper limbs and neck since these are the areas where most work-related injuries are reported [11]. The QEC, as mentioned, involves both the worker and the practitioner and for each of the areas assessed (neck, shoulder/arm, wrist/hand and back) the position and duration of the activity are recorded. It has a scoring system, and exposure levels have been proposed to guide priorities for intervention (Table 2).

Since it is the same task being assessed the results fall within the expected, with similar scores for all workers for the body areas being assessed. The majority of the scores obtained for the Back section of the body places the workers at a high level of exposure and the result reaches a very high level for one of the workers. The exposure for the shoulders/arms and wrist/hand is moderate for all workers. Due to their position and the visual strain posed by the type of work all workers experience the highest level of exposure on the neck region. They all scored an 18 at this task and for this body region. Time working

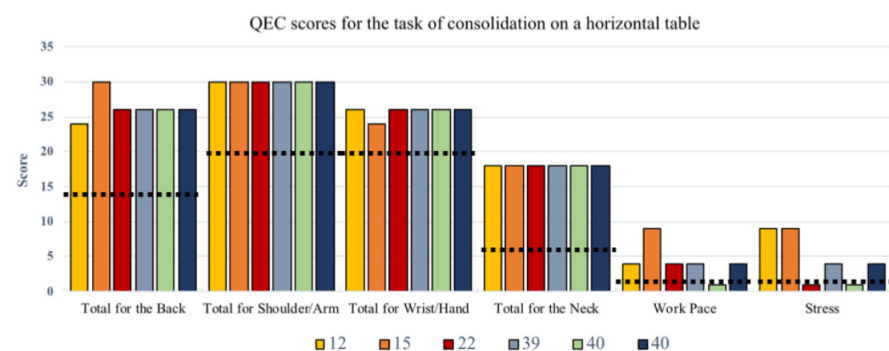


as a conservator does not seem to influence the obtained scores for the work pace, but it showed a correlation with the stress results. It is worth noting that the first two workers (12 and 15 years at the job) are freelancers and don't have a legal bond to the institution. They are called when the workload justifies it (and it normally does) but they don't enjoy the same stability as their co-workers. The work pace offers only a moderate exposure for most of the workers. Because the only case where this was high was on an external contributor, this can be related to the agenda of that particular worker. For most of the workers, the potentially negative impacts of pace and stress are counteracted by the job itself, which they find calming and soothing.

**Table 2.** Exposure levels for the areas mostly associated with work-related musculoskeletal disorders [8,11]. The back section was evaluated as static given the task assessed.

	Exposure Level			
	Low	Moderate	High	Very High
Back (static)	8–14	16–22	24–28	30–40
Back (moving)	10–20	22–30	32–40	42–56
Shoulder/Arm	10–20	22–30	32–40	42–56
Wrist/Hand	10–20	22–30	32–40	42–56
Neck	4–6	8–10	12–14	16–18
Work pace	1	4	9	-
Stress	1	4	9	16

The results obtained for each of the workers are presented in Figure 5:



**Figure 5.** Below the dotted line the exposure level is considered low. Each bar corresponds to a worker identified by how many years he/her has been performing this job [12].

### 3.3. Mitigation Strategies

Several results demanded the proposal of mitigation strategies:

- The majority of the workers have experienced pain, numbness or discomfort in the last 12 months and attribute these conditions to their line of work;
- Pain relievers and medical assistance have been required to address these health issues;
- The workers are aware of the physical demands of their activities but don't have the notion of their real impact and don't have the tools to address the issues or easy access to professional assistance to mitigate them;
- For all workers, the level of exposure and risk to the development of WMSDs is maximum for the neck region and high or very high for the back region

So, despite the reduced number of professionals surveyed, the collected data point to the relevance of WMSDs in the textile's conservation and restoration with posture and repetition on the origin of the documented problems. Posture involves the body's muscles, tendons, ligaments and joints which can lead to mechanical stress which translates into

neck and shoulder pain along with other complaints [13]. There is a sense that these kind of injuries are common in museums and cultural activities [7] but no actual report on their frequency and their impact has been identified by the authors.

Posture and movements are frequently imposed by the task and the workplace environment. For all art conservators, however, the safety of the object is usually considered ahead of the ergonomic challenges posed [5] and risk control measures must comply with the obligation of assuring the safety of the object as stated in Article 5 from the ECCO Code of Ethics [14]. Keeping this in mind, it is still possible to increase the safety and improve the health of the workers by resorting to engineering and ergonomic interventions. The first type can include technology that allows the worker to automatically adjust the height or angle of the table so that less strain is placed on their body or the creation of modified equipment to work while lying down if needed [4,15]. These measures, however, generally demand professional counseling and some investment and are, therefore, often postponed. The ergonomic interventions, however, are more attainable and can focus on a better use of the available equipment and/or minor modifications to existing equipment. These also require professional counseling by an Occupational Health Physiotherapist/Ergonomist. In this particular workshop, each worker has their own workplace defined when the task can be done at a sectional table so each one has their own chair, desirably adapted to their height. All chairs have this adjusting property. Curiously, however, the chair all workers prefer and consider to be the most ergonomic is the one assigned to the loom (Figure 6).



**Figure 6.** The chair normally assigned to the loom was specially built for the task and provides back support where other more modern chairs seem to fail.

This wooden chair was made specifically for the textile department in the 1980s–1990s and the workers praise its back support which the modern and available chairs do not seem

to match. So, there are probably better choices in terms of chairs than can be exploited at the present moment or when new equipment is budgeted for acquisition. Professional advice should be sought at that moment and to help determine if the height and position chosen by the worker are actually the best suited for the work being done. Previous experiences support the need for these professionally-advised adjustments [5] that can also provide the workers with training in adjusting chairs.

Coming last in the ranking of risk control measures, after engineering and ergonomic measures, are the administrative ones [15]. They are important because even assuring better positioning with an adequate chair and adjustment does not change the fact that the work performed is static, meaning the same posture is maintained for long periods (eight hours per day, often four consecutive hours each day). Static positions require continuous muscle contraction which can reduce blood flow, muscle compression and lead to increased fatigue [13]. The only movement observed while the workers were performing the task assessed by the QEC was the repetitive motion of the hand, arm and shoulder (the right one, as all workers were dexterous). Repetitive motion activities are common in museums [7] and in conservation-restoration. The strain that results from these movements is a response to excessive demands of the body without adequate time for recovery and is also commonly referred to as cumulative trauma disorders, repetitive stress or strain injury and overuse injury [7]. Injuries most often associated with these include carpal tunnel syndrome, white finger, chronic back strain and even stress. Normally, both fatigue and repetitive motion trigger the need to relax and recover, introducing the need for short breaks at given intervals, but currently these are not yet embedded in the work schedule. Short breaks are an example of an administrative measure and these are the easiest ones to incorporate because they are aimed at changing the attitudes and behaviors of the CR and despite their low(er) impact they do have a role in this particular setting. According to an evaluation report performed in 2002 in the Hampton Court Palace Textile Conservation Studios [5] these breaks should be frequent and short in duration: a one or two minutes break to stretch the legs and perform relieving movements every 20 min is ideal and does not compromise the task or its completion. The type of break can depend on the conservator and personal preferences should be taken into account in an effort to facilitate their self-administration but it is also important to stress out that a longer break after 2 or 3 h of uninterrupted focus will not deliver the same positive results [5]. Besides promoting adherence to these breaks, other administrative control measures can involve preparation prior to the task (warming-up exercises and stretches included) [15,16], better positioning of the magnifying lamp and early interventions by a physiotherapist to monitor the CR and be on the lookout for potential problems [15]. Carpal-tunnel syndrome, diagnosed in one of the workers in the present study, is a hand/wrist injury that, when detected and intercepted in its early stages, can be reversed and trying to work in spite of pain makes the injury worse [16]. After a diagnosis, and in case no active treatment is pursued, the symptoms for this type of injury can improve if the causal factor is removed, but otherwise tend to become chronic [17]. Providing professional advice on aerobic and stretching exercises to be performed during the breaks [15] is an additional administrative measure. Time constraints, pressure and work overload can be strong barriers to the successful implementation of these administrative measures and should be addressed at the onset.

The European Union has issued guidelines on the need to address WMSDs as an emerging risk and their current impact. These were created to strengthen the enforcement of regulations (Framework Directive 89/391/EEC) governing ergonomic working conditions for more sustainable working environments [18]. These guidelines address issues already mentioned here and which are very characteristic of the assessed task: repetitive motion, sitting in the same position for long periods of time and adopting awkward positions. Although not mandatory, these guidelines should be consulted by stakeholders at this and other workshops. The results obtained by this preliminary study reinforce the need for action and for further studies, such as periodic assessments to check for improvements and specific assessments for the repetitive motion of the upper limbs (ART Tool) [18,19].



The mitigation strategies presented here were also included in the report delivered to the institution and a strategy to address this issue can now be implemented. The authors are also conducting efforts to establish the vital relationship between the institution, its staff and Occupational Health professionals in order to properly guide them through this process. It is also worth stressing the importance of publishing these and other related results in journals consulted by CRs for their professional benefit. As mentioned earlier, it is the “rule” for the CR to place the object above everything else and studies on the importance of tending for their own health while at work will go unnoticed if (only) published in the field of Occupational Health and Industrial Hygiene. High-quality conservation can only be achieved by fully functional and focused CRs and awareness is key for keeping them that way.

#### 4. Conclusions

Specific questionnaires to address the issue of WMSDs in the conservation-restoration of textiles are a valuable tool in assessing the risks posed to this particular group of CRs. It was possible to identify the neck, shoulders, lumbar region and hands/wrists as the most affected areas (for numbness, pain or discomfort) and present the results on an impact scale: exposure level was high or very high for the back section of the body and very high (maximum level of exposure) for the neck region. This means there is a strong possibility of developing WMSDs in these workers and, apart from the decrease in life quality for the worker, this can have an economic impact also with absence from work (lost income for the worker and additional costs for the institution). The work environment can be tailored to address the encountered issues and risk mitigation efforts can include more modern and ergonomic-oriented equipment. This involves an investment from the institution but is the most effective way of decreasing risk. Administrative measures are easier to implement and may also play an important role in preventing the onset of WMSDs. These include frequent breaks and executing specific exercises to release the accumulated tension in these areas. Only a small number of CRs were included in this particular study and only one task was assessed during the evaluation session. These are limitations acknowledged by the authors that will be mitigated in future evaluations as the authors aim to increase the number of CRs surveyed, and studied tasks. Presently, the data strongly suggest the need to improve the occupational settings for CRs in textiles. In addition, included in coming assessments will be the expansion to other specialties since data on this topic are very scarce internationally and, as happens in textiles, nonexistent in Portugal.

**Author Contributions:** Data curation, A.C.P.; Formal analysis, A.C.P. and A.R.; Investigation, A.C.P.; Methodology, A.C.P. and A.R.; Project administration, A.C.P.; Software, A.R.; Writing—original draft, A.C.P.; Writing—review & editing, A.C.P. and A.R. All authors have read and agreed to the published version of the manuscript.

**Funding:** Ana Catarina Pinheiro is under a researcher contract with the Hercules Laboratory, Évora University (CEECIND/02598/2017) supported by the Foundation for Science and Technology.

**Institutional Review Board Statement:** Ethical review and approval were waived for this study, due to absence of any manipulation or risk to any of the participants. The published results are all collected and non-identifiable data. Consent was given for publication in these terms by all participants and institutions enrolled.

**Informed Consent Statement:** Participant written consent was waived due to absence of any risks or manipulation from enrolling in this study. Furthermore, the participants are not identified in this study and authorization for publication in these terms was given by all participants and institutions enrolled.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflict of interest.

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