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MUSCULOSKELETAL DISCOMFORT IN PRODUCTION ASSEMBLY WORKERS

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ABSTRACT

The purpose of this study was to analyse subjective self-evaluation of musculoskeletal discomfort conducted by female production assembly workers. Thirty-seven female assembly workers aged 20–54 years participated in this study, whereas 35 of them were right-handed. Discomfort in neck, shoulder, upper back, upper arm, low back, forearm, wrist, hips, thigh, knees, lower legs and heels was subjectively evaluated by Cornell Musculoskeletal Discomfort Questionnaire. The results indicated that female assembly workers felt most work-related discomfort in the neck (44%), lower back (19.7%) and in the right wrist (15%). Discomfort was less pronounced in the right knee (0.01%), left upper arm (0.04%) and left hip buttocks (0.1%). In conclusion, this study indicated that subjective discomfort sensed by female production assembly workers was higher in the neck, lower back, right shoulder and the right wrist. According to the study results, further research is needed on the relationship between musculoskeletal discomfort and its influence on the quality of assembly work.

Keywords: *physical workload, discomfort, pain*

INTRODUCTION

Global competition in the manufacturing sector has created an environment for continuous improvement, resulting in developing methods to increase capacity while lowering costs. One way for attaining the latter is re-organizing the production by using more effective equipment together with established production practices, e.g. Lean manufacturing or different ISO management standards. Being competitive includes not only the re-organization of production but

also paying more attention to the workforce, more specifically the employees' state of health.

In the manufacturing industry the work movements are repetitive and work situations often cause pain in the neck-arm region. These repetitive movements can be pushing, pulling, drawing, reaching, turning, raising, gripping or hitting and most of all this concerns professions such as painter, decorator, riveter, pneumatic tools operator and user of desktop computer [7].

Many occupations require workers to stand for prolonged periods, which can cause both discomfort and pain. Analytical results have demonstrated that the floor type and the work time spent standing significantly affected subjective ratings for leg discomfort and circumferential shank measurements in both laboratory and field studies. Besides, having suitable footwear also significantly affected the employees' subjective ratings for leg discomfort. It can be concluded that footwear and floor conditions and prolonged standing influence workers' lower extremity discomfort. These analytical findings suggest that common ergonomic interventions, e.g. modifying the flooring on which workers stand might alleviate leg edema for workers standing for 4 h-shifts in laboratory and field settings. Nevertheless, prolonged standing for even 1 h without rest showed negative effects and should be avoided when possible [10].

The development of work-related musculoskeletal disorders does not involve only work situations and physical factors, the psychosocial factors are equally important. The work of Eatough et al. [2] supports the notion that psychosocial stressors in work environment have important links to employee health, especially work-related musculoskeletal disorder symptoms. Furthermore, Giuliano and Leonardo [5] described in their study that already Bernardino Ramazzini (1633–1714) recognized the need to undertake measures to prevent disorders from repetitive motions and manual lifting and anticipated the now widely accepted advice of moderation and recommendations of reduction of work duration for a number of hard jobs requiring a standing position or severe muscular effort. From his early writings it is evident that Ramazzini acknowledged the importance of assessing the ergonomic factors associated with the occurrence of work-related musculoskeletal disorders.

The purpose of this study was to analyse musculoskeletal discomfort in production workers at a manufacturing plant and to use these data in the risk assessment of the factory as a preventive action to maintain workers' working ability for a longer period of time.

MATERIALS AND METHODS

Subjects

Thirty-seven females, working as assembly workers, aged from 22 to 54 years (with mean±SE age: 36.4±10.4 years) participated in this study. The mean (±SE) height, body mass and body mass index of the subjects were 166.8±4.2 cm, 61.0±9.5 kg and 21.9±3.7 kg/m^2, respectively and their general employment stage as manufacturing worker was 7.35±5.5 years. Thirty-five workers were right-handed.

The subjects participated in the research voluntarily and the selection of manufacturing workers was random. In the chosen factory was implemented the Lean manufacturing production practice together with a number of ergonomically designed work places. The production process was organized in two shifts. During the 8-hour working day there were two short 10-min breaks for recovery and one 30-min break for lunch. The subjects were familiarized with the essence and the aims of the survey.

Measures

Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) was used in this study. The CMDQ is a 54-item questionnaire containing a body mapdiagram and questions about the prevalence of musculoskeletal ache, pain or discomfort in 18 regions of the body during the previous week (Figure 1). Test-retest reliability for CMDQ at a 3-week interval found a 7% difference in responses for upper body parts and a 1% difference for lower body parts [6]. Respondents indicated the frequency of discomfort on an ordinal scale from 0 (none) to 4 (daily) and severity of discomfort from 1 (slightly uncomfortable) to 3 (very uncomfortable). A pain level of at least "moderately uncomfortable" was selected as a severity threshold for determining prevalence and frequency. The level at which the discomfort interferred with work was scored from 0 (no interference) to 2 (substantial interference). Total discomfort score was calculated by using the following formula: frequency × discomfort × interference = discomfort score.

The questionnaires were filled in at the workplace. The subjects wrote the values of height and body weight themselves and the body mass index (kg/m^2) was calculated.

For the most part of the workday assembly workers sit on a chair or stand behind their working desk, driving screws into the aluminium plate with pneumatic screwdriver (Figure 2). It is important to emphasize that the torque level of pneumatic screwdriver was not recorded.

The diagram below shows the approximate position of the body parts referred to in the questionnaire. Please answer by marking the appropriate box.		During the last work week how often did you experience ache, pain, discomfort in:					If you experienced ache, pain, discomfort, how uncomfortable was this?			If you experienced ache, pain, discomfort, did this interfere with your ability to work?		
		Never	1-2 times last week	3–4 times last week	Once every day	Several times every day	Slightly uncomfortable	Moderately uncomfortable	Very uncomfortable	Not at all	Slightly interfered	Substantially interfered
Neck		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Shoulder	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Upper Back		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Upper Arm	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lower Back		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Forearm	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Wrist	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hip/Buttocks		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Thigh	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Knee	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lower Leg	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Foot	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 1. Cornell musculoskeletal discomfort questionnaire, female version. (Reproduced with permission from the Human Factors and Ergonomics Laboratory at Cornell University). (http://ergo.human.cornell.edu/ahmsquest.html).

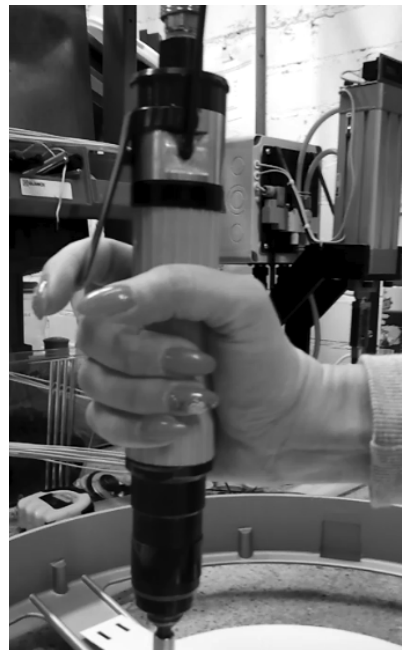

Figure 2. Pneumatic screwdriver

Statistical analyses

When processing the data, the standard statistical methods were used for calculating the mean and the standard error (±SE).

RESULTS

Seventy-three percent of the subjects experienced discomfort at or above the moderate severity level in at least one body region in the 7 days prior to questionnaire completion (Table 1). According to the total discomfort score of CMDQ (Table 2), it was concluded that female assembly workers felt discomfort mostly in the neck (44%), lower back (19.7%) and the right wrist (15%), while it was less pronounced in the right knee (0.01%), left upper arm (0,04%) and left hip buttocks (0.1%).

More specifically, the results indicated that 21 (56.7%) workers sensed discomfort in the neck 1–2 times per week or more and 14 of them assessed that this discomfort had a minor effect on their ability to work. Seventeen (46%) workers assessed low back discomfort 1–2 times per week or more and because of this discomfort, 10 (27%) workers estimated that this had a minor effect on their ability to work. The right wrist of production assembly workers was more loaded than other body regions; 14 (37.8%) workers felt discomfort there 1–2 times per week or more and 10 of them sensed that this had a minor effect on their work performance.

Table 1. Subjects' variations of estimating the feeling of discomfort by using CMDQ

Body parts	During the last work week how often did you experience ache, pain, discomfort in:					If you experience ache, pain, discomfort, how uncomfortable was this?			If you experience ache, pain, discomfort, did this interfere with your ability to work?		
	Never	1–2 times last week	3–4 times last week	Once every day	Several times per day	Sightly uncom-fortable	Moderately uncom-fortable	Very uncom-fortable	Not at all	Slightly interefered	Substantially interefered
Neck	14	18	2	1	2	14	8	2	9	14	0
Shoulder_R	26	7	4	0	0	7	3	2	3	9	0
Sholder_L	29	6	2	0	0	6	3	1	2	7	0
Upper Back	29	6	1	0	1	1	6	3	1	8	1
Wrist_R	33	4	0	0	0	3	1	0	1	3	0
Wrist_L	34	3	0	0	0	3	0	0	1	2	0
Lower Back	20	11	5	1	0	7	7	3	5	10	1
Forearm_R	31	3	1	1	1	3	3	0	2	4	0
Forearm_L	34	2	0	1	0	2	0	1	1	1	1
Wrist_R	23	8	2	2	2	9	3	2	4	7	3
Wrist_L	30	3	2	1	1	5	2	0	2	5	0
Hip/Buttocks_R	33	3	1	0	0	3	1	0	3	1	0
Hip/Buttocks_L	33	4	0	0	0	3	1	0	2	2	0
Thigh_R	34	2	0	0	1	2	0	1	2	1	0
Thigh_L	34	2	0	0	1	2	0	1	2	1	0
Knee_R	35	2	0	0	0	1	1	0	1	1	0
Knee_L	32	4	0	1	0	2	3	0	2	3	0
Lower Leg_R	32	3	1	1	1	3	3	0	1	4	1
Lower Leg_L	29	5	1	1	1	3	5	0	1	6	1
Foot_R	34	2	0	0	1	2	0	1	1	2	0
Foot_L	34	2	0	0	1	2	0	1	1	2	0

Table 2. Total discomfort score

Body parts referred to in the questionnaire	Frequency	Discomfort	Interference	Discomfort score	%
Neck	59	36	38	80712	43.89
Lower Back	44.5	29	28	36134	19.65
Wrist_R	48.5	21	27	27500	14.95
Upper Back	22.5	22	20	9900	5.38
Shoulder_R	24.5	19	20	9310	5.06
Lower Leg_L	26	13	16	5408	2.94
Shoulder_L	16	15	16	3840	2.09
Forearm_R	23	15	11	3795	2.06
Lower Leg_R	23	9	12	2484	1.35
Wrist_L	16.5	9	12	1782	0.97
Knee_L	11	8	8	704	0.38
Forearm_L	13	6	6	468	0.25
Foot_R	13	5	5	325	0.18
Foot_L	13	5	5	325	0.18
Thigh_R	13	5	4	260	0.14
Thigh_L	13	5	4	260	0.14
Upper Arm_R	6	5	7	210	0.11
Hip/Buttocks_R	8	5	5	200	0.11
Hip/Buttocks_L	6	5	6	180	0.10
Upper Arm_L	4.5	3	5	68	0.04
Knee_R	3	3	3	27	0.01

DISCUSSION

Several studies have shown similar results to the present study. For example, the physical assessment of 146 female workers in highly repetitive jobs found 54% to have musculoskeletal disorders in the upper limb that were potentially work-related [8]. Many workers had multiple problems, and/or were affected bilaterally (33% of workers). Muscle pain and tenderness was the largest problem, both in the neck/shoulder area (31%) as expected and in the forearm/hand musculature (23%), a previously unreported site [8].

In the study where relationships between a number of ergonomic conditions and product quality in car assembly plant were examined, the results showed that quality deficiencies were three times as common for the work tasks with ergonomics problems, compared with other tasks and an increased

risk of quality deficiencies was established for all three categories of ergonomic problems investigated [3]. Direct causes of quality deficiencies were identified, such as discomfort from strained parts of the body, organizational factors and time pressure. The analysis pointed to certain types of tasks that were more likely than others to cause quality problems. The results also showed that an important factor for job satisfaction for the workers was the possibility to perform their tasks with high quality. The study therefore confirms close relationships between ergonomics and quality [3]. Singh et al. [9] found in their study that ergonomically designed equipment reduced physiological and economic costs over others. In another study Dianat et al. [1] investigated the effects of wearing typical industrial gloves on hand performance capabilities (muscle activity, wrist position, touch sensitivity, hand grip and forearm torque strength) and subjective assessments for an extended duration of performing a common assembly task – wire tying with pliers – requiring a combination of manipulation and force exertion. The results showed that wearing gloves significantly increased muscle activity, wrist deviation, and discomfort whilst reducing hand grip strength, forearm torque strength and touch sensitivity.

The causes of cumulative trauma disorders are complex in nature and usually no single factor or simple reason can be determined during work evaluation. Cumulative trauma disorders, also called repetitive strain injuries, have been found to be a major source of occupational disability; their causes and contributing events need to be carefully studied [4].

In conclusion, this study indicated that the feeling of discomfort, subjectively felt by female production assembly workers was higher in the neck, lower back, right shoulder and the right wrist. Further research is needed on the relationship between musculoskeletal discomfort and its influence on the quality of assembly work.

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