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Ergonomic Risk Factors for Cumulative Trauma Disorders in VDU Operators

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The objectives of this study were to investigate the rate of cumulative trauma disorders (CTDs) in the upper body and to describe the associations of such disorders with ergonomic parameters in a group of data entry operators. A total of 173 data entry operators volunteered to take part in the study. Questionnaires were used to investigate their medical history. Diagnoses of CTDs were made with clinical tests. A visual posture analysis of the workers and an ergonomic analysis of workstations and workload were used to reveal risk factors. Neck and shoulder pain, extensor tendonitis of the wrists and De Quervain's disease were common in the study population. An assessment of risk factors showed that leaning wrists on the keyboard, hard keystrokes, extreme wrist joint and thumb positions and working in poor ergonomic design were correlated to pain and development of CTDs.

VDU operators cumulative trauma disorders ergonomics posture

1. INTRODUCTION

In recent years, jobs requiring stereotyped movements of the arms, hands and fingers, and repetitive occupational tasks with short cycle times have become more and more frequent in modern technology; many of them are associated with increased rates of pain and musculoskeletal disorders. Occupational cumulative trauma is a form of overexertion; it occurs when workers are repeatedly exposed to forceful and prolonged activities in awkward postures or unsympathetic environments [1]. A data entry operator has to perform thousands of keystrokes in an hour and has to bear prolonged constrained postures in the neck and upper extremities. The neck and shoulders have been reported to be the main sites of discomfort in those operators [2, 3]. The present

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study investigated a group of data entry operators in their working environments and was aimed at (a) finding out the prevalence of cumulative trauma disorders (CTDs) in the upper body and (b) describing the relations of such disorders to ergonomic parameters such as working postures and workstation characteristics.

2. METHODS

2.1. Subjects

One hundred and seventy-three data entry operators (14 males and 159 females) with a mean age of 30.5 ± 2.5 (range: 25–39) years and with a mean time since onset of work of 9.4 ± 2.2 (range: 1–17) years, volunteered to take part in the study. Demographic data, weight and height, and drinking and smoking habits were recorded. Smoking four or more cigarettes a day and consuming alcohol drinks regularly every day were the criteria for defining those habits. The mean body mass index (BMI) of the study group was 21.7 ± 2.5 (range: 17.5–32.0). None of the workers were heavy alcohol consumers, 83 were cigarette smokers.

2.2. Questionnaire

The first part of the questionnaire investigated the medical history of traumas or surgical interventions, comorbid diseases and perceived psychological stress (workers were asked to grade their stress as *mild*, *moderate* or *severe*, according to how they dealt with working demands). Six workers had previous trauma to the upper extremities, one had diabetes mellitus, one had liver disease, one was hyperthyroid and two were pregnant.

The second part of the questionnaire assessed pain in the upper body (in the neck, shoulders, elbows, forearms, wrists and fingers). Pain in a particular area which persisted over 6 weeks within the previous year was regarded positive for perceived pain. Workers were asked to indicate their painful area/areas.

2.3. Clinical Evaluations

All the operators were evaluated one by one. One and the same physician blinded to the background of the employees examined each operator. The physical examination consisted of specific tests to investigate common CTDs. The testing battery included tests to diagnose ganglions, De Quervain's disease, extensor tenosynovitis, carpal tunnel syndrome (CTS), tennis elbow, golfer's elbow, bicipital tendonitis and thoracic outlet syndrome (TOS). Electrophysiological tests were also performed for cases suspected for CTS, which had numbness and a tingling sensation in the hand (worse at night), particularly in the distribution of the median nerve [4]. Percussion of the median nerve (Tinel's sign) and Phalen's maneuver worsening the symptoms was also investigated in this population.

The operators' working postures were observed. A list was prepared of all the possible awkward postures such as excessive ulnar deviation, hyperextension of the thumb, hard keystrokes, leaning wrists on the keyboard, anterior tilt of the head, round back and asymmetric neck postures [5]. The same physician examined the operators whilst they were working and checked them for the listed harmful postures.

The subjects were from workstations A and B, which were different from each other. From workstation A, 43 operators (3 males, 40 females) participated in the study. There, text messages appeared on the upper two thirds of the screen and the operators typed those texts into the computer using the lower third. Working hours were divided into two, 8:30–12:00 and 13:30–17:00. Each operator was responsible for entering 110 messages a day and was allowed to leave the office when the work was finished. The chairs and screens were adjustable.

One hundred and thirty operators (9 males, 121 females) were investigated at workstation B. There were two shifts: 7:30–13:30 and 13:30–19:30. The employees changed shifts every month. For each shift, there were two 15-min breaks. The operators were responsible for entering 100 texts a day but were not allowed to leave early. In this workstation the chairs and screens were not adjustable. The main task was

to read the text from a piece of paper and to enter it into the computer. The paper was placed on the desk and a copyholder was not used.

The questionnaires were answered by the workers themselves, and were delivered and collected by the physician on the first visit to the workplace. The questionnaires were assessed by a different physician. One and the same physician paid eight more visits to do the physical examinations, posture analysis and workplace analysis.

2.4. Statistical Analysis

Statistical significance between non-numerical data was evaluated with the chi-square test and between numerical data with Student's *t* test. *P* values smaller than .05 ($P < .05$) were regarded statistically significant. Logistic regression analysis was performed to assess the significance (odds ratio, OR) of risk factors. SPSS version 11.0 was used for statistical analysis.

2.5. Ethics

Volunteers were enrolled in the study. No invasive procedure was applied, apart from the electroneuromyography (ENMG) studies performed in cases suspected of CTS. For this procedure the visual display unit (VDU) operators were invited to the hospital and electrophysiological evaluations were done by another physician. The workplace was visited nine times. Apart from the physical examinations, all the assessments were performed by observing the workers in their ordinary circumstances.

3. RESULTS

Thirty-six percent of the workers had chronic pain in at least one region of the upper body. The mean number of characters typed per hour was 15774 ± 3420 (range: 7040–24200) and 20281 ± 5406 (range 5604–37092) in workstations A and B, respectively. The mean number of typed letters, mean age values, prevalence of CTDs and psychological stress did

TABLE 1. Rate (%) of Pain and Common Musculoskeletal Disorders in the Studied Visual Display Unit Operators and Associated Risk Factors

Disorder	%	Probable Risk Factor	*P*	OR	CI
Pain at least in one location	36.0	workstation B	.0043	4.54	1.60–12.84
		female	.0001	13.34	3.50–50.80
Pain in fingers	4.1	history of previous trauma	.0072	7.94	1.75–35.86
		typing with ulnar deviation	.0410	3.40	1.05–10.99
Pain in wrists	8.1	nonsmoker	.0081	1.47	1.11–1.96
Pain in forearm	7.5	nonsmoker	.0065	1.90	1.20–3.04
Pain in elbows	3.5	leaning wrists on keyboard	.0072	5.81	1.61–20.94
Pain in shoulders	16.2	hard keystrokes	.0116	5.44	1.46–20.28
Neck pain	22.0	female	.0073	18.2	2.18–151.79
		nonsmoker	.0143	1.37	1.06–1.76
Shoulder periarthritis	19.6				
Tennis elbow	19.6	workstation B	.0366	3.25	1.08–9.80
Thoracic outlet syndrome	21.9				
Ganglion	22.5	workstation B	.0419	2.84	1.04–7.77
		typing with ulnar deviation	.0049	3.12	1.41–6.90
		hard keystrokes	.0059	3.12	1.39–7.00
De Quervain's disease	35.3	excessive thumb extension	.0003	2.72	1.41–5.26
Carpal tunnel syndrome	9.3				
Extensor tenosynovitis	43.3	leaning wrists on keyboard	.0026	3.12	1.05–3.70

Notes. OR—odds ratio, CI—confidence interval.

not differ significantly between the employees at the two separate workstations ($P > .05$).

Results of postural analysis showed excessive neck flexion in 52.0% of the workers, round back postures in 52.6% and an anterior tilt of the head in 5.8% of the workers. The rate of excessive dorsiflexion of the wrists was 50.3%, ulnar deviation 56.1% and hyperextended thumbs 67.1%. Thirty-one point two percent of the workers leaned their wrists on the keyboard while typing. Table 1 shows the incidence of CTDs on physical examination and the rate of local pain experienced in the previous year, together with the possible risk factors causing them. The table includes statistically significant risk factors only. Neck pain was the most common of all (22.0%), followed by shoulder pain. Age, working years, BMI, comorbid conditions and perceived stress had no impact on any of the CTDs or on pain.

The physical examination of the subjects revealed that extensor tendonitis ranked first on the list of CTDs, with an incidence of 43.3%, followed by De Quervain's disease, ganglion and TOS. Forty-eight percent were suspected for and 16 of them (9.3%) were diagnosed as CTS after electrophysiological tests.

An assessment of risk factors showed that leaning wrists on the keyboard while typing was associated with elbow pain and extensor tenosynovitis of the wrists, whereas performing hard keystrokes was related to shoulder pain and ganglion formation. Excessive thumb extension was responsible for De Quervain's disease and typing with ulnar deviation was associated with ganglion formation and finger pain. Working in workstation B was a risk factor for tennis elbow, ganglion formation and chronic pain (Table 1). Female workers experienced more chronic pain in the previous year, but the number of male workers was too small to generalize.

4. DISCUSSION

In 1992, Kroemer developed a list of conditions that were frequently identified with CTDs. The list consisted of many painful syndromes that were caused by nerve and/or blood vessel compression (CTS, TOS), muscle tenderness (neck tension) and tendon inflammations (De Quervain's disease, ganglion, extensor tendonitis, shoulder periarthritis, epicondylitis). The list also included descriptions and outlines of the typical job activities carried out by persons with such disorders. Typing was among the jobs cited as a risk factor associated with the development of CTS, neck tension and TOS [6]. Many studies reported increased prevalence of neck and shoulder pain in VDU workers [2, 3]. Yu and Wong reported 31.4% of neck pain and 16.5% of shoulder pain in frequent users of VDUs and related those problems to unfavorable working postures [2]. The present study revealed that prevalence of pain (36.0%) was high among data entry operators, the neck (22.0%) and shoulders (16.2%) being the most common sites. The rate of perceived psychological stress among employees was very high as well. Only 5.2% of the workers described their stress as *mild*. VDU operators had to carry out a stressful task, requiring high speed and accuracy [7].

Semple claimed that tenosynovitis, enthesopathies and compartment syndromes were all well-described and understood clinical conditions, whereas CTDs, repetitive strain injury and overuse syndrome were not, as numerous vague and indistinct pathological concepts have been suggested by these terms [8]. These words reflect the scepticism of a clinician. On the other hand, many studies, investigated painful muscles without any distinctive pathology and found electrophysiological and morphological changes indicating muscular fatigue and pain [9, 10]. To relieve uncertainty about the terms, we not only used the questionnaires to localize painful areas but performed special clinical tests as well, to diagnose musculoskeletal disorders in the assessment of associated risk factors. Awkward postures of the wrists and fingers were the primary risk factor (Table 1). From the environmental point of view, workstation B was ergonomically poor in design. The workers were more frequently exposed to forceful exertions and rotated postures of the neck and back. Working in workstation B was associated with chronic pain and a couple of CTDs. Konarska, Wolska, Widerszal-Bazyl, et al. reported high rates of neck

and shoulder pain as well as psychological issues among the VDU operators working in improper working conditions such as inadequate lighting, uncomfortable chairs and lack of forearm and wrist support [11]. Another unfavorable condition in workstation B was the strict break. In a highly repetitive task like data entry, letting the workers have their own breaks whenever they are needed would perhaps be a better work policy. In Aarås, Horgen, Ro, et al.'s study a data entry group reported significantly more symptoms and signs of musculoskeletal illness when they were compared to a data dialogue group, as they had longer periods in front of the VDU without a break [12]. Although it was obvious that smoking did not have a direct or favorable influence on pain, being a nonsmoker appeared as a weak (OR: 1.37–1.90) risk factor for neck and wrist pain in this study. This was so because smokers had longer or more frequent breaks during which they could rest. The small sample size for males made it difficult to comment on gender differences. Gender differences in perceiving less pain favoring the male gender were reported frequently in previous literature [13, 14].

5. CONCLUSION

More than half of the workers reported severe stress and also displayed awkward postures while working. Neck and shoulder pain was very common in VDU operators. Leaning wrists on the keyboard, hard keystrokes, excessive thumb extension and ulnar deviation were the awkward postures that gave rise to the occurrence of certain CTDs. Extensor tendonitis, De Quervain's disease, ganglion and TOS were the most common CTDs. Organizing the workstations and providing staff with correct techniques based on ergonomic principles deserve more emphases in preventing musculoskeletal symptoms in VDU operators [11, 12, 15].

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