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Musculoskeletal disorders among operators of visual display terminals

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Using a visual display terminal (VDT) is today a common occupational task with both benefits and hazards. One of the hazards is the occurrence of musculoskeletal disorders. This paper examines the possible causes of such disorders and suggests some preventive strategies. The debate on the relationship between musculoskeletal disorders and VDT usage usually centers around occupational factors (eg, constrained posture, poor ergonomic design of the workplace, equipment design), work-related psychological factors (eg, perceived high job demands, mundane, boring and repetitive job activity, little control, poor support from colleagues and superiors), and psychosocial factors (eg, biodemographic characteristics such as age, previous musculoskeletal injuries, emotional stress, family burden, environmental factors). Improving the ergonomic design of VDT workstations, changing occupational legislation, and improving occupational health services have been suggested as means to decrease the incidence of musculoskeletal disorders among VDT workers. Much research with a multidisciplinary approach is still needed.

The use of a visual display terminal (VDT) is today a common feature in many workplaces and a full-time task for many office workers. The change to this new technology has brought with it enormous benefits both to work organization and to individual users. However, at the same time, some concern has arisen, particularly with respect to its adverse health effects. One of the most frequently observed adverse health effects is that of musculoskeletal disorders. This paper examines the possible causes of such disorders and suggests some preventive strategies.

Work-related musculoskeletal disorders

Occupational disorders of the musculoskeletal system are not new. A description of disorders resembling musculoskeletal complaints of today among craftsmen, tradesmen, scribes and notaries can be found in Ramazzini's *Treatise on the Diseases of Workers* published in 1780. The 1893 edition of *Gray's Anatomy* described a "sausage-shaped swelling" of the hand that was characterized as "washer woman's sprain." The first report of musculoskeletal discomfort among office workers using a VDT came from Hultgren & Knave (1). It was found that VDT users, who remained sitting in the same posi-

tion for long periods of time and paid attention to a specific task, were more prone to feeling tired. In addition, symptoms of pain, stiffness, fatigue, cramps, numbness, and tremor were also reported and observed to be associated with high daily keystroke rates (2).

In the 1980s a significant increase in the number of musculoskeletal disorders among VDT users was reported in Australia and the term repetitive strain injuries (RSI) was coined. RSI was used to describe "pain and discomfort in the hands, arms, shoulders and neck of workers involved in repetitive, unvaried work and who were forced by their work and the workplace to maintain awkward, fixed postures for long periods during the working day [p 26]" (3). A musculoskeletal disorder of this nature has long been the subject of debate. The use of the term RSI implies a cause and pathology. However, the reported symptoms of VDT operators usually revolve not around discrete clinical entities like tenosynovitis and carpal tunnel syndrome, but around a class of chronic conditions, often involving pain at multiple sites without any sufficiently clear clinical or pathological sign.

Statistics in the United States have indicated an increased incidence of a similar condition among users of the VDT in recent years, and this condition is referred to

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as cumulative trauma disorders (CTD). Operators in occupations related to information and data processing were observed as having the highest incidence. Among some, the condition was so severe that surgical intervention was warranted. The true incidence of musculoskeletal disorders among VDT operators is unknown. Nevertheless, recent data have shown that claims for CTD suffered by keyboard operators have increased remarkably. It now accounts for more than half of all work-related illnesses (4). The disorders lead to losses in productivity and higher workmen compensations, as well as law suits against computer vendors. This situation reflects the fact that technological changes could lead to loss in productivity and higher health costs.

In contrast RSI, or CTD, is relatively unknown outside Australia, the United Kingdom, and the United States. It could be that the problems exist, but there is no epidemic of RSI or CTD. Nevertheless, it is important to point out that perceptions and interpretations of the nature of musculoskeletal complaints may depend on the processes of social negotiation. What is considered an illness is not given solely by nature, but is also tied to current medical and social practice, prevalent theoretical frameworks about health and disease, and so forth.

Possible causes of musculoskeletal disorders

The etiology of work-related musculoskeletal problems among VDT operators is not clear. It is generally acknowledged that the disorders are difficult to study epidemiologically. Apart from the inherent difficulties, such as establishing a cause-effect relationship, there are the problems of determining the contribution made by occupational and nonoccupational factors (5).

The debate on the relationship between musculoskeletal disorders and VDT usage usually centers around occupational factors, work-related psychological factors, and psychosocial factors.

Occupational factors

The high prevalence of musculoskeletal symptoms among VDT operators has been associated with task-related factors such as constrained posture, poor ergonomic design of the workplace, and equipment design. It has been suggested that workplace ergonomics could be dealt with satisfactorily (6). Several recent investigations have shown that ergonomic intervention could help minimize the musculoskeletal problem. However, even if the environment and the workstations are optimal, VDT operators still have musculoskeletal complaints (7, 8).

Electromyographic studies to evaluate the musculoskeletal load on the trapezius muscle in VDT operators have shown that the mean maximum voluntary contraction (MVC) required by mechanical and electrical typewriters is significantly higher than that required of computer keyboards (table 1). A typical electromyogram of an operator using an electric typewriter and an electronic keyboard is shown in figures 1 a and 1 b, respectively. It can be seen that the difference in the %MVC is about twofold (figure 1 and table 1), and the time taken to complete a similar task is longer when an electric typewriter is used (figure 1). These findings raise the question as to why keyboard operators, having less muscle tension than typewriter operators, have a greater incidence of musculoskeletal disorders.

These observations, together with the results of earlier field studies, suggest the possibility that musculoskeletal disorders may not be solely related to the physical characteristics of the display terminals or the layout of the workplace, but rather to the overall nature of the work of keyboard operators.

Work-related psychological factors

Several recent studies have indicated that musculoskeletal disorders among VDT users usually arise from muscle overuse due to repetitive motions, superimposed over localized muscle tension from heavy work demands (8). Tasks involving repetitive motion with few pauses ag-

Table 1. Mean percent of the maximum voluntary contraction (%MVC) at cumulative distributions of P = 0.1 to 0.9 for the left and right trapezius muscles.

Cumulative distribution	Electronic key boards ^a		Electric typewriter		Mechanical typewriter	
	Mean	SD	Mean	SD	Mean	SD
<i>Left trapezius muscle</i>						
P = 0.1	4.04	0.59	12.59	2.01	18.24	2.86
P = 0.5	6.83	0.50	16.92	2.34	24.68	3.49
P = 0.9	13.32	0.54	25.01	2.69	32.48	5.84
<i>Right trapezius muscle</i>						
P = 0.1	3.51	0.42	12.47	1.58	19.68	2.48
P = 0.5	6.55	0.50	16.68	2.23	27.24	3.44
P = 0.9	10.87	0.64	23.73	2.47	30.58	6.38

^a Four different types of standard 101-key style keyboard were used.

Figure 1. Electromyogram of the right trapezius muscle of a VDT operator using an electric typewriter (a) and an electronic keyboard (b).

gravated by administrative demands of VDT operations are common features in computerized offices; their effects on musculoskeletal disorder should not be ignored.

It has to be recognized that work stress can produce both physical and emotional complaints. Job demands, physical and psychological, influence the severity and frequency of VDT operators' health complaints. The expression of these complaints, and perhaps the actual incidence of musculoskeletal disorders, may be exacerbated by perceived high job demands, mundane, boring and repetitive job activity, little control, and poor support from colleagues and superiors. Some support for this view has been provided by several major studies on VDT operators (9). The evidence as to whether VDT operators have greater job demands than other occupations is mixed. In most cases, it is confounded by other factors, as well as by a lack of appropriate study design. However, it has been shown that, when VDT operators have little control over tasks, 70% complain of monotony, while, with greater control, only 10% complain of monotony (10). Evaluations by the National Institute for Occupational Safety and Health (NIOSH) in the United States have also indicated that clerical VDT operators report less work involvement, job autonomy, self-esteem, supervisor support, and peer cohesion and greater work pressure than professional VDT staff (11). This finding suggests that the lower social group may feel higher job stress. The results also showed that job stress was highly predictive of health complaints.

It appears that task design, primarily highly paced work, lack of control, and pressure for deadlines are more prevalent among VDT operators. Recent findings from NIOSH also show the importance of psychological factors in the etiology of musculoskeletal problems among VDT operators. The studies showed that the risk factors among VDT operators include heavy work pressure, concerns over job security, and a lack of social

support (12). In addition, routine repetitive work and heavy information processing demands were also common predictors of musculoskeletal disorders.

Perception of limited control or responsibility is also likely to give rise to stress, especially if combined with heavy work loads. Epidemiologic and work stress studies have demonstrated that rigid, time-scheduled, machine-paced tasks that do not allow adjustment lead to boredom, job dissatisfaction, and somatic complaints (13). Such conditions of unsatisfactory work pattern, having too little task variation and too high a work rate for long periods, are commonly seen in workplaces. Poor job design has also been shown to be related to health complaints; primarily high-paced work and pressures of having to meet deadlines are more prevalent among VDT operators (14). Thus the problem among VDT operators is not purely the mechanics of VDT operation, but also the nature of the work being undertaken.

Psychosocial factors

Comparatively little attention has been paid to psychosocial factors in relation to musculoskeletal disorders among VDT users. The psychosocial environment surrounding the workplace and the users may contribute to musculoskeletal complaints and to eventual ill health. It is increasingly apparent that work methods and new technologies are important factors in contributing to health and well-being. It is common that staff in poorly managed work organizations tend to report higher levels of stress, boredom, and isolation and lower job satisfaction (15). Therefore psychosocial factors could play a role in the etiology of musculoskeletal disorders.

Recent studies also suggest that musculoskeletal disorders are related to biodemographic characteristics such as age, previous musculoskeletal injuries, emotional stress, family burden, and environmental factors. Working mothers have been noted to have more health prob-

lems as well as health complaints (16). It is probable that prenatal and postnatal stress affect the health of working mothers.

It was also observed that there was a significant difference in the frequency of musculoskeletal complaints among VDT operators in different ethnic groups in Singapore, Malay and Indian operators reporting a significantly higher prevalence than the Chinese ones (17). The differences are likely to reflect the different level of reporting pain among the different ethnic groups. Variations in sociocultural practices may account for this observation.

Although labor-intensive computing functions such as data entry are now being carried out on a relatively large scale in many industrially developing countries, RSI is relatively unknown in these places. The conscientiousness of employees in these countries is reported to be high, with the absenteeism and turnover rate extremely low (18). The high rate of unemployment in the industrially developing countries and the desire for jobs could also contribute towards the low incidence of musculoskeletal disorders. Workers may not complain because of fear of their employment being terminated. This situation indicates that either industrially developing countries have no problem with RSI or CTD or that the problem exists but is not reported.

A recent report from Finland showed that changes in occupational legislation and improvement in occupational health services could affect the incidence of musculoskeletal disorders (19). There was also an indication that during severe unemployment the number of musculoskeletal problems was significantly lower. This finding suggests that willingness to report musculoskeletal problems or file a claim is reduced. The authors believed that this reduction could be due to the fact that VDT operators are afraid of losing their jobs (19). The preceding observations suggest that social policy and economy could also affect the statistics of musculoskeletal disorders.

Research needs

There has been genuine concern expressed in the scientific and medical community on the health problems of VDT operators, and most countries have been, or are in the process of, issuing guidance, developing standards, or enacting legislation on actual or perceived VDT-related health issues. It has been increasingly recognized that both physical and psychological variables are important in the context of VDT use, both in terms of impact on users and associated health outcomes. Unfortunately, although a considerable amount of research exists, it has failed to provide a practical solution towards solving the problem.

To date, workplace intervention strategies that focus on addressing the risk factors for musculoskeletal disorders

have met with varying degrees of success (15). Worker selection and education have been attempted with a small degree of success, and they have been effective only to some extent.

From the point of view of ergonomics, the introduction of the VDT into offices has led to an integration of employees into a human-machine system associated with work loads due to constrained posture, eye strain, and psychological problems. A more comprehensive approach to this situation requires better insight into activities within the human components of the human-machine system. The functional components of the task, which is an important feature in the human-machine relationship, needs to be carefully researched. In order to reduce musculoskeletal strain, more attention should be paid to the nature of VDT activities.

Problems caused by the inappropriate design of work can be seen as part of the generic problem associated with the impact of new technologies, which are increasingly likely to confront occupational health specialists. More research focusing on the static and dynamic physiological load, and as to how it affects the performance and well-being of operators, is obviously required. Studies to examine this problem should include an examination of excessive muscle activity due to unnecessary tension, poor workplace design, and poor work posture. The assessment of musculoskeletal load and its effects would be of benefit in the long-term prevention of the health problems. Questions as to the acceptable load on the muscle during prolonged periods of work and the high frequency of key strokes require elucidation. Further issues which also require study include whether there is a threshold level for loads in various parts of the muscle involved with the keyboard task and whether there are different thresholds for operators of different ages.

In the prevention of VDT-related health problems, psychosocial factors are at least as important as the physical ergonomics of workstations and the work environment. Inappropriate computerization programs would lead to more machine control, tighter supervision, social isolation, and little freedom of movement, as well as probable de-skilling of some users. Lack of control at work may lead to the adoption of passive behavior patterns. A participative, interventional multidisciplinary team approach that incorporates work design analysis, environmental and equipment modifications to cater for specific local conditions, and realities are essential. This approach is expected to improve the well-being of the workers and the effectiveness of the work.

Although the introduction of new technology provides an opportunity to enhance job content significantly, in many instances appropriate principles have not been used in job design; thus, where simple clerical tasks have been computerized, they invariably retain their monotonous

nous, repetitive, and demotivating features. VDT task design must therefore seek to minimize repetitive elements in the operator's task by introducing variability in work load throughout the day, instead of long periods of concentrated work.

The problem of VDT-related musculoskeletal disorders is a matter that warrants urgent attention since many computer users have to suffer pain and inconveniences which could and should be avoided. The display terminal and the physical factors of the workplace may contribute significantly, but not solely, to the development of musculoskeletal disorders. Other work-related and sociocultural factors are likely to play an even more important role, such as risk factors in the pathogenesis of the resulting syndrome. A multidisciplinary approach is thus needed to overcome these problems.

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