Chapter 5

The Relationship Between Workplace Psychosocial Factors and Musculoskeletal Disorders in Office Work: Suggested Mechanisms and Evidence

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Introduction

There are increasing indications that workplace psychosocial factors are somehow involved in the etiology of work-related musculoskeletal disorders. For example, an extensive review of the epidemiologic literature on this subject by Bongers and de Winter[1] concluded that monotonous work, perceived high workload and time pressure, and low control and social support were all related to musculoskeletal symptoms among workers.

The International Labor Office (ILO) has defined workplace psychosocial factors in very broad terms, synonymous with conditions that give rise to job stress.[2] These conditions include not only aspects of work, ranging from the nature of tasks to relationships at work to management practices (often grouped loosely under the rubric "work organization"), but also psychological attributes of workers (needs and expectations, personality, culture, etc).

In this chapter we will attempt to elucidate the potential causal mechanisms and pathways linking workplace psychosocial factors and musculoskeletal disorders in video display terminal (VDT) work. The intent is not to diminish the importance of ergonomic factors or biomechanical mechanisms in the etiology of work-related musculoskeletal disorders, but rather to suggest a more holistic explanatory framework that incorporates psychosocial factors as well as physical environmental or ergonomic factors. Research supporting this framework is presented.

In this discussion, we adopt a vernacular that is generally consistent with the ILO concept of psychosocial factors. Specifically, the expression "psychosocial factors" is used to refer to attributes of both jobs and the individual, including the individual's extra-work environment, which contribute to job stress. The expression "work organization" is used very broadly in reference to any work-related risk factor for job stress, in contrast to "individual factors," which interact with working conditions in the development of job stress.

Musculoskeletal Disorders and Psychosocial Mechanisms

Three types of explanations for the association between work-related psychosocial factors and musculoskeletal disorders seem especially plausible and have

been described by several authors.[1,3–6] In a report on VDT work and musculoskeletal disorders among newspaper editors, NIOSH[7] suggested three possible explanations for this association: (1) psychosocial demands and job stress may produce increased muscle tension and exacerbate task-related biomechanical strain, (2) psychosocial demands may affect awareness and reporting of musculoskeletal symptoms or affect perceptions of their cause, or (3) a causal or correlational relationship exists between psychosocial and physical workload demands. These types of mechanisms have been suggested previously by several investigators.[1,3–6]

The present paper incorporates all of these pathways into a formal causal model, which builds on earlier efforts by the authors to model the relationship between psychosocial factors and musculoskeletal disorders.[5]

According to this model, shown in Figure 1, musculoskeletal disorders can be traced ultimately to the nature of work technology, which includes the nature of both tools and of work systems. In the case of office or VDT work, the chief tool is the VDT and computer and the nature of work can be defined as mechanized or automated information. As shown in the model, there is a direct pathway from VDT or office technology to physical demands (as defined by workstation ergonomics) and a direct pathway from office technology to work organization. (The influence of industrialization and mechanization on the specialization of work, recognized since Adam Smith,[8] is an example of the latter pathway.) The pathway from work organization to physical demands suggests that the physical demands of work are exacerbated by organizational demands, for example, increased specialization leads to increased repetition.

The model shows a direct pathway between work organization and psychological strain (stress) which, in turn, influences musculoskeletal outcomes through two routes. First, psychological strain is hypothesized to increase muscle tension, and possibly other autonomic effects, which compound biomechanical strain induced by physical demands of the task. This effect is depicted by the arrow between psychological strain and biomechanical strain in

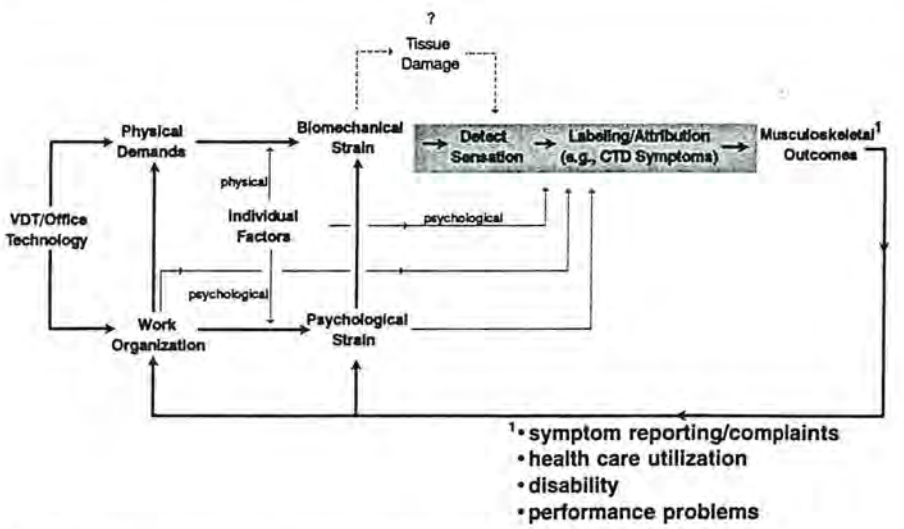

Fig. 1 An ecological model of musculoskeletal disorders in VDT work.

Figure 1. Second, psychological strain is hypothesized to moderate the relationship between biomechanical strain and the appearance of symptoms. (Moderating effects are denoted by the thin arrows in Figure 1.)

The model depicted in Figure 1 suggests that the relationship between biomechanical strains (ie, internal physiologic events) and the development of musculoskeletal symptoms is mediated by a complex of psychological processes (denoted by the shaded area in Figure 1), which involves the detection and labeling or attribution of somatic information (ie, symptoms). As discussed by Cioffi,[9] development of symptoms is not a direct or predetermined response to some internal physical event, rather, it is a highly plastic interpretive process subject to influence by contextual factors. Unfortunately, however, the rather extensive psychological literature on the perception and attribution of symptoms (reviewed by Cioffi[9]) has received little or no attention in ergonomics and occupational health.

With regard to the perception of symptoms, Figure 1 shows that the connection between biomechanical strain and musculoskeletal outcomes is influenced not only by psychological strain, but also by individual and work organization factors apart from the possible contribution of these factors to psychological strain. Factors such as organizational safety climate, for example, may have a direct influence on how workers detect, interpret, and respond to symptom information, regardless of whether safety climate results in stress.

For ease of presentation, multiple effects are combined in Figure 1 under "musculoskeletal outcomes." Space permitting, it would be more appropriate to describe these effects in terms of a continuum of events involving first the development of symptoms, then symptom reporting and health care utilization, then sick leave utilization and disability, and so on. It can be postulated that psychological factors as discussed above are instrumental in the evolution of each stage.

Figure 1 also shows a pathway from biomechanical strain to tissue damage to somatic interpretation. The broken lines comprising this pathway indicate that physical damage or disease is not necessarily integral to the model, ie, all that is essential are conditions that give rise to musculoskeletal symptoms.

Finally, the model suggests that the experience of musculoskeletal disorders feeds back to influence stress at work and it is likely that these disorders also prompt work redesign. It is because of these closed-system properties, as well the fact that the model incorporates input from both the physical and psychosocial work environment, that we refer to the model as an "ecological" model of musculoskeletal disorders.

Recently, researchers from the TNO Institute of Preventive Health Care in the Netherlands have described a generic model of workplace psychosocial factors and musculoskeletal disease with pathways similar to those depicted in Figure 1.[1,4] It should be noted, however, that the authors were reluctant to represent this model as an "explanatory" model. Rather they describe it as a vehicle for their extensive review of studies exploring associations between psychosocial factors and musculoskeletal disorders. However, an important distinguishing feature of the present model is the attention to cognitive processes that mediate between biomechanical strain and the development of musculoskeletal disorders.

The Evidence

There are insufficient data to fully substantiate the pathways between work organization and musculoskeletal disorders illustrated in Figure 1. Key prob-

lems in the extant literature, as pointed out by Bongers and de Winter,[1] include inadequate exposure assessment for the physical or work organization factors and failure to effectively disentangle the effects of these two sets of variables on musculoskeletal outcomes. Further, although many studies link work organization and musculoskeletal outcomes, the effect size is often quite small. Also few studies establish intermediary effects, which is essential to identifying specific pathways. In addition, most of the pertinent studies have cross-sectional designs, which limit casual inferences, including direction of causation, between psychosocial and musculoskeletal measures. These deficiencies notwithstanding, we believe that select studies offer circumstantial support for several of the pathways in Figure 1. These supportive studies are discussed below, with the emphasis on investigations of musculoskeletal disorders in office and VDT workers.

The Pathway From Office Technology to Work Organization

The mechanization of office work, which was associated with the introduction of the typewriter at the turn of the century, produced changes in the organization of office work not unlike the effects of mechanization in manufacturing processes. Guiliano[10] suggested that the mechanized or "industrial" office resulted in the standardization of office jobs and fragmentation of tasks and responsibilities that are characteristic of assembly line work. Video display terminal (computer) technology offers promise for reversal of these effects through enlargement of tasks and skills in office work.[11] However, the indication is that some types of VDT work are still stuck in the industrial age or may even exacerbate the adverse organizational aspects of office mechanization.[12] For example, in a 1981 NIOSH investigation[13] comparing clerical workers who used VDTs with those who did not, VDT users were reported to have significantly less autonomy and role clarity and greater work pressure and management control over work processes. Identical findings were obtained in a subsequent NIOSH investigation of VDT users and nonusers in Wisconsin.[5,14] A much larger study at Columbia University in 1987[12] compared all-day VDT users with part-time users and several groups of typists and clerical workers. In contrast to all other study participants, the all-day VDT users reported significantly higher levels of workload demand and repetition and lower levels of decision latitude, ability to learn new things on the job, and understanding of the overall work process.

Additional studies have investigated organizational aspects of VDT work, but strict comparisons with noncomputerized workplaces have been difficult in recent years because VDTs have become ubiquitous and, thus, suitable comparison groups are unavailable. Still, review of this work suggests a pattern of effects consistent with the reduction of tasks, skills, and autonomy, etc, as discussed above.[15]

Pathways From Work Organization to Musculoskeletal Outcomes

An impressive number of studies in the last decade have linked work organizational factors to upper extremity musculoskeletal signs and symptoms among VDT/keyboard users.[3,14,16–28] Factors predictive of musculoskeletal outcomes in these studies included limited rest pauses, routine tasks, uncertain job future, highly variable workload, time pressure and heavy workload demands, high mental workload, low co-worker and supervisory support, low worker autonomy, and low work group cohesion. Several of these factors (eg, heavy

workload demand, low autonomy, low supervisory support, and low [peer] group cohesion) were predictive of musculoskeletal problems in multiple studies.

Figure 1 shows two principal pathways (thick, or "bold" arrows) from work organization factors to musculoskeletal disease; one mediated by psychological strain and one mediated by increased physical demand. With regard to the latter, it is evident that the VDT itself imposes musculoskeletal demands relating to the posture required to do the work (ie, to view the display and operate the keyboard). However, it is intuitive that the extent of exposure to these demands as well as the exposure to other generic risk factors such as repetitive motion (eg, excessive keying) are influenced by work organization factors such as workload demands and the complexity of tasks (which would affect cycle time). At least two studies have shown a relationship between organizational and physical stressors in VDT work,[5,12] with correlations as high as 0.38 reported between these two classes of variables.[5] Although a purely correlational relationship (resulting from the effect of technology on both work organization and physical demands) cannot be ruled out, data by Lim and Carayon[22] argue for a direct causal link between organizational demands and physical demands. Using path analysis to explore the relationship between organizational factors, ergonomic demands, and psychological stress, Lim and Carayon reported a significant pathway from organizational factors to physical ergonomic demands.

Research is available also in support of linkages in the pathway between work organization and musculoskeletal disorders which is mediated by psychological strain. Using structural analysis methods, Sauter and associates[5] found that factors such as job future uncertainty, social support, and workload demands influenced somatic symptoms in VDT users by way of an intermediary effect on mood disturbances. A study of keyboard operators performing postal letter sorting tasks[17] linked every element in the pathway mediated by psychological strain in Figure 1. Specifically, tasks involving increased visual search and memory demand were associated with reports of increased mental strain, spectral changes in the forearm electromyogram (EMG) and increased forearm tremor, and increased musculoskeletal discomfort. Similar multilink associations were reported by investigators from the Karolinska Institute,[29] although the study population did not include office workers. Increased psychological demands at work were associated with increased worry, fatigue, and sleep problems which, in turn, were associated with behavioral indicators of muscle tension, which were associated with increased back, neck, and shoulder discomfort.

Other studies address specific links within the psychologically mediated pathway. Lim and Carayon[22] and Bergqvist and associates[16] reported associations between indicators of psychological strain (fatigue and stomach reactions, respectively) and upper extremity musculoskeletal symptoms[16,22] and diagnosed disorders of the upper extremities.[16]

As early as 1951, Lundervold[30] demonstrated effects of psychological demands on muscle tension in keyboard operators, supporting the link between psychological strain and biomechanical strain in the present model. More recently, Westgaard and Bjorklund[31] and Waersted and associates[32] investigated static muscle loading as a possible mechanism linking work organization, psychological strain, and musculoskeletal disorders among VDT users. Consistent with extensive prior research showing effects of psychological demands on muscle tension (as reviewed by Ursin and associates[6] and Waersted and associates[32]), increases in low level muscle tension in the trapezius were induced

by increasing the complexity and attentional demands of VDT tasks. Although the overall group effects were modest, averaging about 0.5% to 1.0% of maximum voluntary contraction (MVC), considerable interindividual variability was seen, with some subjects producing sustained loads up to 6.0% MVC. The latter level is within the range thought by Jonsson[33] to pose risk for musculoskeletal disease with chronic exposure. In this regard, it is notable that Kogi[34] reported Japanese research showing sustained loads in the range of 10% to 30% MVC in the forearm extensors among office machine operators (although a linkage to psychosocial demands was not suggested).

It is plausible that the direct, neurogenic effects of psychological demand on muscle tension and biomechanical strain are complemented by stress-related endocrine effects on neuromuscular function.[22,29] However, there has been little empirical study of such mechanisms.

Despite the evidence supporting the pathway in Figure 1 from organizational factors to musculoskeletal outcomes via psychological strain, it is difficult to rule out a competing pathway involving direct effects of organizational factors or psychological strain on the perception and attribution of symptoms, ie, the pathway denoted by the thin arrows from work organization and psychological strain in Figure 1. (This effect is examined in the discussion of somatic interpretation below.) But a more fundamental issue is whether effects attributed to the pathways from work organization to psychological strain or symptom perception are possibly confounded by physical effects related to (1) the path from work organization through physical demands, or (2) the covariation of physical and organizational demands resulting from the effects of technology on both of these classes of variables.

Two lines of evidence can be raised against the confounding hypothesis. First, for several types of variables found to predict musculoskeletal outcomes among VDT users, a significant effect on physical demand would seem unlikely. Examples of these types of variables include low group cohesion, work clarity, and staff support, which were predictive of repetition strain injury (RSI) cases in the study of Ryan and Bampton[26] or uncertainty regarding job future and reduced supervisory support, which were predictive of musculoskeletal symptoms in a NIOSH study of telecommunications workers.[24] Unlike organizational variables such as time pressure or repetitive work, it is difficult to see how changes in these conditions could elicit changes in physical workload demands (ie, the pathway to physical demands would not seem to be operative).

More compelling are the results of studies that statistically separated effects relating to physical and organizational factors and, thus, are able to demonstrate effects unique to the psychological pathway. This counterargument to the confounding hypothesis, however, rests on the adequacy of the exposure assessment for physical demands (and also psychosocial factors), which has been a difficult issue and may be problematic in many studies. Using multiple regression methods, Sauter and associates[5,14] reported a significant association between worker autonomy and musculoskeletal symptoms in VDT users after adjusting for a wide variety of variables denoting physical stressors. Similarly, NIOSH[3] found an association between supervisory support and hand/wrist symptoms in news editors after adjusting for the amount of time spent typing. Additionally, Bergqvist and associates,[16] Lim and Carayon,[22] and Ryan and Bampton[26] all were able to separate to some extent the effects of physical and organizational factors in predicting musculoskeletal problems in VDT users.

Similar evidence of effects uniquely attributable to psychosocial variables comes from Arndt,[35] Linton,[36] and Theorell and associates,[29] although none

of these studies employed VDT users. The Arndt[35] and Theorell and associates[29] studies are of particular interest. Arndt found increased EMG activity in assembly line workers who were asked to speed up, but who were unable to respond with increased work speed (virtually eliminating any possibility of a confound with a physical influence on the muscle response observed). Like several VDT studies, Theorell and associates[29] found effects of psychological demands on back, neck, and shoulder symptoms after adjusting for physical demands (lifting demands, awkward postures). Like Gomer and associates,[17] however, he was also able to demonstrate intermediate linkages of psychosocial demands to psychological strain, self-reported muscle tension, and, ultimately, musculoskeletal discomfort.

Finally, inherent limitations of cross-sectional studies (the predominant methodology in VDT health research) pose a potential problem. The cited associations between organizational factors and musculoskeletal disorders might result from an influence of symptoms on job perceptions, not the reverse. Two studies, however, tend to discount this possibility. Hopkins[21] studied the organizational environment in workplaces with high and low prevalences of RSI. Ratings of organizational factors, however, were obtained from asymptomatic workers only (thereby eliminating the possibility of a symptom influence on job perceptions). Almost without exception, ratings of organizational factors were more negative in the high (RSI) prevalence workplaces. Similar findings are reported by Hales and associates,[20] who observed an association between fear of job loss and neck, shoulder, and elbow symptoms in directory assistance operators. Fear of job loss ratings within job sites were rescored based on ratings obtained from asymptomatic workers, and then associations with musculoskeletal symptoms were re-examined. Reanalysis showed that symptom levels were still positively associated with fear ratings; ie, higher in units with higher fear ratings.

Psychological Mediation of the Pathway From Biomechanical Strain to Musculoskeletal Outcomes

Thus far, it has been suggested that psychosocial factors might contribute to musculoskeletal disorders via two pathways: one involving effects on physical workplace demands and a second involving stress-related effects on muscle function. A third possible mechanism bears some similarity to what has been referred to as an "iatrogenic" process.

The iatrogenic hypothesis has been heavily promoted as an explanation for the surge in upper extremity musculoskeletal disorders witnessed internationally in the last decade. According to this hypothesis, musculoskeletal discomfort and fatigue are endemic to VDT work. Environmental forces, including not only medical practitioners, but also social and cultural factors, legal/compensation systems, and workplace industrial relations then encourage the interpretation of discomfort as signals of underlying injury and promote the development of sick roles and disability.[37–40] Although the iatrogenic hypothesis has not been tested empirically in the context of VDT work, this type of explanation finds support in the medical anthropologic and sociologic literature that identifies significant cultural variations in response to somatic symptoms.[41,42]

The iatrogenic hypothesis converges with an extensive area of investigation in psychology, which may offer a theoretically broader and richer formulation for explaining iatrogenic-like effects on musculoskeletal disorders. Extensive research in social and cognitive psychology in the last two decades has tried

to explain how people interpret internal somatic information such as sensations associated with emotional response or illness. Space does not permit more than the briefest summary of this work[9,43] but the theory and findings suggest that response to somatic signals involves a multistage perceptual and attributional process that is governed by cognitive and environmental factors.

First, as in the perception of any stimulus, whether or not a somatic stimulus is even noticed depends on factors such as the degree of arousal of the individual and the salience of competing stimuli (which could mask the somatic stimulus). Second, once detected, explanations for the somatic sensation are sought, which involves labeling the sensation and then deducing its cause. Social psychological research has shown that this inferential process is highly influenced by situational factors. In the classic studies in this area, subjects were injected with epinephrine to induce psychological and physiological arousal, but were uninformed about the effects. It was then demonstrated that self-labeling of the resulting arousal state as euphoria or anger could be readily manipulated by exposure of the subjects to euphoric or angry confederates.[44] Importantly, this attributional process is understood to be a natural, probably hard-wired, and lawful process that has survival value for the organism;[9,43] ie, it is normal to seek causal explanations for events in and around us and to rely on contextual cues when the stimuli are ambiguous, which is often the case with somatic sensations.

In the current model of musculoskeletal disorders, it is suggested that somatic interpretation processes as discussed here (shaded area in Figure 1) mediate between biomechanical strain and musculoskeletal outcomes, and that these processes are influenced by various psychosocial factors (thin parallel inputs to the shaded processes). Within this framework, several effects of stress and psychosocial factors on musculoskeletal disorders seem plausible, although studies to confirm these effects have not been undertaken.

With regard to the detection of symptoms, it is possible that stress-related arousal may sharpen sensitivity to otherwise subthreshold musculoskeletal stimuli. Similarly, work organization might influence the relative salience of musculoskeletal signals. For example, competition for attention to musculoskeletal stimuli may be considerably reduced in dull routine tasks in comparison to more varied, challenging tasks that provide richer environmental stimulation. This may help to explain, for example, why clerical-level VDT jobs are associated with increased musculoskeletal symptoms[13,16,18] or why monotonous work was associated with neck symptoms in a Swedish working population.[36] Ironically, as discussed by Pennebaker,[43] this mechanism might also increase the health risk for workers in more challenging, engrossing tasks by reducing their relative awareness to somatic danger signals. Could this suppression phenomenon partially explain, for example, the reportedly high prevalence of musculoskeletal disorders among news editors?[7,45]

It is also possible to suggest ways in which psychosocial conditions might influence the labeling and attribution of musculoskeletal sensations. Assuming that people hold implicit hypotheses that stress promotes disease, it is predictable that musculoskeletal sensations arising in the context of stressful working conditions might be interpreted as signals of injury or disease. Further, attribution of these symptoms to the job might seem natural in the presence of adverse organizational conditions such as a negative safety climate. NIOSH[7] found, for example, that perceived lack of management support for ergonomic programs nearly doubled the odds for neck symptoms among news editors.

Effects of personality or dispositional factors on musculoskeletal disorders in office work[16,27] and in other occupations[6,46] might also be explained within

the somatic interpretation framework. It is possible, for example, that negative affectivity, referring to a state (or trait) characterized by undifferentiated subjective distress,[47] colors the labeling of sensations in negative (disease) terms. In this regard, Bergqvist and associates[16] found that negative affectivity predicted both neck and shoulder discomfort among VDT users. (Self-reports of working conditions might be similarly [ie, adversely] affected, tending to inflate associations of organizational factors and musculoskeletal outcomes.) Although negative affectivity is commonly discussed as an individual or personality characteristic,[47] it is plausible that, like job attitudes such as job dissatisfaction, negative affectivity could be shaped by chronic exposure to stressful working conditions. These two perspectives would have different implications (ie, in terms of focusing on the person or the job) in attributing the cause of health outcomes associated with negative affectivity and in the design of interventions.

Although the current model highlights somatic interpretations, it is important to emphasize that this process has not been investigated in the context of work-related musculoskeletal disorders, and thus the significance of this mechanism in comparison with other mechanisms suggested in the current model is unknown. It is very doubtful that this mechanism alone could fully explain the relationship between psychosocial factors and musculoskeletal disorders seen in the extant literature. Several studies have demonstrated significant associations between workplace psychosocial factors and more objective indices of musculoskeletal disorders involving clinical evaluation of subjects.[16,20,24,26,47,48] Use of more objective methods for assessing musculoskeletal disorders obviates, to a considerable extent, the influence of cognitive and inferential effects integral to the somatic interpretation mechanism.

Feedback Effects

Finally, the current model shows reciprocal effects of musculoskeletal disorders on work organization and psychological strain. This pathway is highly intuitive. For example, adjustments in job tasks such as assignment to "light duty" or other forms of work redesign are commonly made for injured or symptomatic workers. Regarding effects on psychological strain, Ghiringhelli[49] reported fear of health impairment to be an important source of stress among VDT users. Data supporting such effects are very limited, however. Sauter and associates[5] conducted a series of analyses showing reciprocal prediction of illness symptoms and mood states in a sample of office workers, including VDT users. One other study, with a longitudinal design permitting stronger causal inference, reported this type of effect in a sample of office and production workers. Leino[48] found that 1973 to 1978 stress symptom scores predicted rheumatic symptoms and clinically defined musculoskeletal disorders upon follow-up in 1983. Among male workers, however, rheumatic symptoms and musculoskeletal disorders from 1973 to 1978 also predicted stress symptoms in 1983.

Summary and Direction

A theoretical model suggesting multiple causal linkages between workplace psychosocial factors and musculoskeletal disorders in VDT work is presented. This model does not diminish the importance of physical environmental/ergonomic factors in the etiology of musculoskeletal disorders in VDT work that is supported in prior research.[50,51] Rather, psychosocial effects are depicted as

complementary to and interactive with effects of physical workplace demands. Furthermore, the psychological mechanisms linking or mediating psychosocial factors and musculoskeletal disorders are discussed as normal psychological processes, in contrast to clinical or abnormalistic characterizations by others.[52,53]

Evidence presented in support of the psychosocial pathways suggested in these models is neither perfect nor complete. More powerful study methods employing longitudinal designs, improved exposure (to both psychosocial and ergonomic demands) and health assessment, and improved analytical schemes, such as structural analysis, would be useful in substantiating and isolating the effects of psychosocial factors. Further research is needed to evaluate the strength of specific pathways postulated in the model. For example, to our knowledge, studies have not investigated the magnitude of static muscle loads during actual workplace exposure to known psychosocial stressors (eg, deadline work, electronic monitoring, etc) in the office workplace. Thus, the need for further analytic study is evident.

From a prevention imperative, an additional course of investigation is worth consideration. Specifically, case studies of organizational interventions to prevent musculoskeletal disorders in VDT work suggest rather powerful effects of psychosocial factors. According to Westin,[54] for example, the Federal Express Corporation has been able to maintain high levels of productivity with minimal experience of musculoskeletal disorders among VDT users by adopting a "people-technology" philosophy that gives priority to improving job design to minimize monotony, by adoption of participative management practices, and by improved employee education, among other measures.

Intervention studies often do not permit the type of control or manipulation needed to define specific mechanisms or pathways of effect. Furthermore, naturalistic interventions are not always pure enough to isolate specific causal factors. Indeed, the people-technology philosophy at Federal Express also included a commitment to improve ergonomics. Still, these types of studies have a high degree of ecological validity and can be much more powerful motivators of preventive action than the more molecular investigations that have been examined in this paper.

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