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Improvements in musculoskeletal health and computing behaviors: Effects of a macroergonomics office workplace and training intervention

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ABSTRACT

Computer use and its association with musculoskeletal and visual symptoms is an escalating concern. Organizations are shifting to a more proactive injury prevention perspective. Accordingly, a macroergonomics intervention consisting of flexible workplace design and office ergonomics training was designed to examine the effects on worker's computing behaviors, postures, and musculoskeletal discomfort, and their relationship to psychosocial factors. Participants were assigned to either group: 1) no-intervention control 2) flexible Workplace-only (WP-only), and 3) flexible Workplace + Training (WP+T). Observational findings indicate both intervention groups experienced positive, significant changes in improved workstation arrangements and computing postures, with the WP+T intervention group exhibiting a higher, significant change of behavioral translation. Also, significant, positive relationships between observed postures and musculoskeletal discomfort/pain were found. The intervention effect was stronger when management was responsive to workers' ergonomics needs. This study suggests that a macroergonomics intervention can produce beneficial effects for office and computer workers and organizations.

1. Introduction

With the increase in computer use within the workplace and its association with musculoskeletal and visual symptoms, a considerable public health burden has arisen as more than 50% of computer users sustain musculoskeletal symptoms and disorders of the upper extremities and low back pain (e.g., Aaras et al., 2001; Bernard et al., 1994; Klussmann et al., 2008; Marcus and Gerr, 1996). This is especially true for those whose work is highly sedentary (prolonged sitting) within a fast-paced work environment involving ergonomic risk factors such as static postures and highly repetitive movements (Straker and Mathiassen, 2009; Straker et al., 2013). As suggested by Wahlstrom (2005) and observed by several other authors, musculoskeletal discomfort associated with computer work is manifested through a combination of the physical workload (e.g., Bernard et al., 1994; Dennerlein and Johnson, 2006), psychosocial issues (e.g., Bongers et al., 1993; Carayon and Smith, 2000), hours worked at a computer (Ijmker et al., 2007), design features of office workplaces (Nelson and Silverstein, 1998) and work organization factors (e.g., Sauter and Swanson, 1996).

To address these adverse health trends requires a shift to a more proactive injury prevention perspective and wellness and health promotion rather than a reactive program focus (Hedge and Puleio, 2014). Organizations are recognizing this emerging need as there is a growing interest among employers to improve office workplaces and provide office ergonomics training (Amick et al., 2003; Hedge et al., 2011; Robertson et al., 2008). Several controlled workplace studies have examined the effects of various office ergonomics interventions on upper body symptoms among computer users. Positive impacts on musculoskeletal symptoms were reported with: 1) adjustable workstations (Nelson and Silverstein, 1998), 2) split keyboards (Tittiranonda et al., 1999), 3) negative tilt height adjustable keyboard tray (Rudakewych et al., 2001), 4) increased frequency of work breaks (Galinsky et al., 2007), 5) ergonomics training (Brisson et al., 1999), 6) adjustable flat panel monitor arm (Boothroyd and Hedge, 2007) and 7) a sit-stand height adjustable workstation (Hedge and Ray, 2004).

There is growing evidence for the efficacy of combining office

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ergonomics training programs with appropriate ergonomic equipment benefiting employees' health and performance (Dainoff et al., 1999; Hedge et al., 2011; Robertson et al., 2009, 2013), and reducing injury costs (Lewis et al., 2002). Intervention studies that provided adjustable chairs with training (Amick et al., 2003; Robertson et al., 2009), sit-stand workstations with training (Robertson et al., 2013), and padded forearm with training (Rempel et al., 2006) revealed reduced musculoskeletal symptoms associated with computer work. Since a benefit of ergonomics training is to provide employees with the necessary knowledge on how they should arrange their individual and collaborative workplaces, coupling training with adjustable and flexible workstations promotes healthy computing habits and effective preventive measures (Amick et al., 2003; Rempel et al., 2006; Robertson et al., 2008). Furthermore, the provision of enhancing workers' control over their work environment through adjustability and knowledge (training) may improve worker's physical health and performance (Karasek and Theorell, 1990; McLaney and Hurrell, 1988; O'Neill, 1994). Nonetheless, there are few well-designed, longitudinal field studies that have examined the effects of office ergonomics interventions on workers' health, computing habits, behaviors, and objective performance (Brewer et al., 2006; Demure et al., 2000; Karsh et al., 2001; Rempel et al., 2006).

Macroergonomics, rooted in sociotechnical systems (STS) principles, is an organizational design approach that can have a significant impact on reducing health risks, and increasing safety and performance. The goal of ensuring a fully harmonized, effective work system can be achieved by understanding the interrelationships among the sociotechnical elements within a larger work system. This includes the personnel and technological subsystems and the internal/external environmental components (Hendrick and Kleiner, 2002). By focusing on the work systems' elements, such as job design (internal environment), physical work environment (internal environment), training (personnel subsystem), technology design (technological subsystem), cultural issues (external environment) and organizational factors, and their interactions allows for optimal joint-optimization and work system congruency. Moreover, these different system levels and their interactions can influence workplace safety, workers' health and performance.

A recent model of a sociotechnical system for workplace safety, including health and performance outcomes, is proposed by Carayon et al., 2015 where the sociotechnical system is represented as a set of concentric layers where the elements of the outer layers influence safety and health through proximate and distal layers (Carayon et al., 2015). Core to the model is the work system which defines the local context where work activities are performance and the system is viewed from a human-centric perspective. The complexity of the multifaceted role of the human in relation to the other elements of the system is defined (Smith and Sainfort, 1989). The larger socio-organizational context exists around the work system, for this study and includes the activity of the computer and office knowledge worker, including the organizational structural elements and factors of work relationships (Huys et al., 2011). As macroergonomics is a STS approach recognizing the complexity of the different systems levels and their interactions, this bridging of micro and macroergonomic variables and their relationship to each other is reported by Zink (2000) where the design of the tools and technologies used by workers were influenced by decisions made at the organizational level. These types of interrelationships between the micro and macroerognomic elements and how their interactions can influence worker's safety and health are seen in several theoretical models by Carayon and Smith, 2000; Sauter and Swanson, 1996; Bongers et al., 1993 as they relate to describing the complex systems and interactions of workplace stressors on musculoskeletal health.

Part of this approach is the participation of employees in the workplace design process to understand how the work process needs and business requirements will be optimally supported through the workplace design effort. Also, according to this approach, enhancing the workers' control over the work environment and providing them with knowledge allows them to influence decisions about where and how they might work, which can, in turn, lead to improved health and performance (McLaney and Hurrell, 1988; Robertson and Huang, 2006). Furthermore, a fundamental element of the macroergonomics approach is ergonomics training which can integrate ergonomics into an organization and play a key role in linking the corporate goals with ergonomics practices. Training can be viewed as another element of the socio-organizational context that can influence the work system, such as when companies invest resources in providing safety training and the translation of this training to actual skills, knowledge and abilities to be used at the local work system provides another example of the interface between the socio-organizational context and the work system. Demonstrated benefits of ergonomics training include providing employees with knowledge on how to arrange their individual and team workplace to promote healthy computing habits (e.g., Hedge et al., 2011; O'Neill, 2007).

We (Robertson et al., 2008), previously reported the effects of a longitudinal field intervention study which utilized a macroergonomics framework. This office ergonomics intervention consisted of two important work systems elements: training and workplace flexibility. Providing well-designed office environments with affordances, including a high degree of flexibility and user adjustable features, allowed individuals and groups to adapt to the ever-changing project process and enhanced workplace satisfaction and work effectiveness (Dainoff et al., 2012; O'Neill, 2007). An office ergonomics training workshop was developed using the instructional system design (ISD) as a guide (Salas and Cannon-Bowers, 2001), which consisted of six phases of needs analysis, design, development, implementation, evaluation and feedback. Each step provided specific activities to determine training objectives based on a needs assessment, selection of appropriate media delivery, adult learning techniques and learning styles, and the trainee's acceptance and skill development. The goal was to motivate workers to conduct ergonomic self-evaluations and to exert control over how to use the workplace. Follow-up messages and communication mechanisms were created to reinforce the training principles. Study outcome measures were collected 2 months prior to the intervention and 3 and 6 months post-intervention. Participants in this macroergonomics intervention were assigned to one of the following groups: 1) no-intervention control, 2) flexible Workplace-only (WP-only), and 3) flexible Workplace + Training (WP+T). Compared to the control group, the two intervention groups reported significant increases on the psychosocial work environment factors and work-related musculoskeletal symptoms. The intervention effects were more pronounced for the WP+T group, including business process efficiencies of time and costs, than for either the WP-only or control groups (Robertson et al., 2008).

While the previous article examined intervention effects with regard to organization perceptions and reports of musculoskeletal symptoms, the current study is based on the intervention effects on observed individual worker behaviors. Additionally, we investigated the relationship of these observational measures to self-reported musculoskeletal symptoms and the psychosocial work environment factors including ergonomics climate, corporate culture and workplace design satisfaction. Fig. 1 shows a conceptual model guiding our research and questions highlighting the specific