REVIEW PAPER

Ergonomic Interventions as a Treatment and Preventative Tool for Work-Related Musculoskeletal Disorders

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Abstract

Background: Musculoskeletal disorders are one of the most common chronic disorders and can develop from repetitive micro-traumas, which occurs often from one's occupation. Work-related musculoskeletal disorders (WMSD) cost the United States billions of dollars annually. Many traditional therapeutic interventions, like manual therapy. electrical stimulation and hot and cold packs, are being utilized to treat WMSD however there is minimal evidence supporting the use of these interventions to treat WMSD. Therefore, ergonomic interventions (EI) has been proposed as a conservative, non-invasive, and cost-effective intervention to treat WMSD as it functions to correct the cause of repetitive micro-traumas due to one's occupation by adjusting posture, workstations design, and product selection.

Aim: The aim of this paper is to (a) briefly overview the theories of WMSD and EI (b) analyze the efficacy of traditional therapeutic interventions (c) establish the practical applications of EI (d) analyze the efficacy of EI, (e) discuss the contraindications of EI and (f) draw conclusions and discuss the future directions of EI in preventing WMSD.

Results and Discussion: It was found that traditional therapeutic interventions provides only short-term pain relief for musculoskeletal disorders, prompting the need for a different approach. EI was found to have promising results in treating WMSD, however there is limited evidence in the form of randomized controlled trials (RCTs) to truly determine the efficacy of EI in addressing WMSD. Further research is needed to determine the efficacy of EI and the long term effects of this intervention in treating WMSD.

Keywords: work-related musculoskeletal disorders, ergonomic intervention, micro-traumas

Introduction

Musculoskeletal disorders are one of the most common chronic disorders that result in sprain/strain of musculoskeletal system. The theoretical mechanism of these injuries involves repetitive and accumulative micro-traumas/motions damaging the musculoskeletal tissues, especially of the lumbar, cervical, and shoulder regions. These repetitive micro-traumas can arise from any repetitive activity with the most common activity being the daily tasks associated to an individual's occupation. As the average American between the ages of 22-65 spends 40 to 50 percent of their day at the workplace, it has been established that there is a strong correlation between musculoskeletal disorders and occupational duties (Leigh et al. 2000).

Currently work-related musculoskeletal disorders (WMSD) are a serious issue with major economic implications. WMSD are the most common non-fatal injury reported annually in the United States (Bernard 1997). According to the data released by the Bureau of Labor Statistics on Workplace Injuries and Illnesses of 2010, it was reported that there were 2.9 million work-related injuries in the United States (BLS 2011). A general estimation by Leigh (2011) of the economic implications of WMSD found that the total costs of nonfatal injuries and illnesses from 2007 were approximately $46 billion dollars. Upper extremity WMSD was estimated to cost the United States $2 billion annually (Pilligan et al. 2000). This pattern of high WMSD incidence rates is not limited to the United States, as it has been seen to be a global issue.

Besides the financial burden of WMSD, the risk of negatively affecting the quality of life of workers is magnified. WMSD are known to cause chronic pain, psychological stress, overexertion, and a variety of other negative health-related symptoms (Sizer et al. 2004a). Another detrimental outcome of WMSD is delayed return-to-work status, due to the chronic nature of this work-specific disorder.

Common work-related movements and body positions that can contribute to WMSDs include and are not limited to lifting with improper technique, awkward postures, cradling with the shoulders, typing for extended periods of time and general over-loading. WMSDs originate and/or are maintained primarily by damaging tissues of the musculoskeletal system in a variety of ways (Sizer et al. 2004a). Damage to blood vessels due to repetitive motions have been observed to vasoconstrict the arteries causing ischemic injury and edema due to anoxic damage (Sizer et al. 2004a). Revel et al. (1992) found that repetitive micro-traumas of WMSD alter tissues at the cellular level, specifically altering the morphology of the spinal tissues, which elicits a variety of responses including edema, inflammation, and pain.

Increased inflammation due to tissue damage triggers a positive feedback system that promotes inflammatory proteins. This process contributes to the chronic nature of inflammation that can occur. However, the causation of WMSD extends beyond the physical factors related to an individual's occupation. Psychosocial (stress) and organizational (work station design) risk factors have been identified as contributing to the prevalence of WMSD (Arnell & Kumar 2002). The multi-factorial nature of WMSD adds complexity to the diagnosis and especially the treatment of this disorder.

Currently, treatment of WMSDs consists of traditional therapeutic modalities that include and are not limited to strength-building exercises, electrical stimulation, hot and cold modalities, and injections. It is thought that these modalities reduce pain, inflammation, increase/maintain strength, and promote tissue healing (Poitras & Brosseau 2008). However there is contradictory evidence on the efficacy of these modalities. Several evidence-based studies have found high efficacy of therapeutic exercises as a treatment protocol for WMSDs, but there are contradictory studies that found insufficient evidence supporting the use of therapeutic exercises (Novak, 2004; Ludewig & Borstad, 2002; Indahl, 2004). There are a limited number of studies showing that transcutaneous electrical nerve stimulation (TENS) is effective in reducing pain and muscle spasms with pain reduction being temporary to short-term at best (Brosseau et al., 2002; Poitras & Brosseau, 2008). Studies evaluating the efficacy of hot and cold modalities are limited and of those limited number of studies, the evidence supporting the use of hot and cold packs were considered not strong (French et al. 2006).

The use of injections as a treatment for low back pain is limited and inconclusive to be utilized as a reliable intervention (Staal et al. 2008). With limited non-invasive interventions for treating WMSD, a higher proportion of individuals with WMSD are relying on pharmacological methods for pain management, which have not be firmly determined to be effective (Hurwitz et al. 2008). With the high economic burden of WMSDs, a different approach to the treatment of WMSDs should be considered.

Ergonomic interventions are one of many proposed interventions for treatment and prevention of WMSD. Ergonomics is defined by the International Ergonomics Association as "the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize human well being and overall system" (International, 2000). Ergonomic interventions involve adjusting a workers' environment, behavior, and other long-term educational approaches to treat and prevent further damage due to WMSD. EI are a therapeutic approach to treating and ultimately preventing WMSD with the goal of long-term musculoskeletal pain relief. EI works to limit muscle tension, promote blood flow and nutrient circulation as these physiological processes may be neglected during the workday, due to exclusive focus on productivity. EI has the potential to successful address the economic burden that WMSD are currently placing in the United States.

Interest in EI as a WMSD intervention began in the 1980's however it is not until recently that EI research and its efficacy have been thoroughly studied. Despite the promising research, EI has yet to be closely analyzed to determine whether it can be utilized as an intervention for WMSD, despite being non-invasive and economically advantageous. Therefore, the *purpose* of this paper is to (a) briefly overview the theories of WMSD and EI (b) establish the relevance and practical applications of EI (c) analyze the efficacy of EI, (d) discuss the contraindications of EI and (e) draw conclusions and proposes future research of EI in preventing WMSD.

Internship at Therapeutic Associates, Inc.-Valley Keizer (TAI)

The inspiration for this thesis topic was sparked by my internship at Therpaeutic Associates, Inc. (TAI) as a physical therapy (PT) aide. The duties of a physical therapy aide includes cleaning and organizing exam rooms, observing and taking notes on patient progress and responses, instruct therapeutic exercises, clerical duties, and performing ultrasound and electrical stimulation therapy. After establishing my role as a PT aide, my interest in work ergonomics formed.

TAI in Keizer offers a unique service that provides an ergonomic assessment and a set of interventions for patients who would like their workstation evaluated. This service was started over 10 years ago to "properly set up [a] work space so that it fits the biomechanics of [an individual's] body and the job [the individual is] performing (Therapeutic Associates, Inc. 1999a). The trained physical therapist travels to the patient's workplace to evaluate the components of a workstation. By taking precise measurements and making close observations, the physical therapist performs an ergonomic assessment, developed in collaboration with Country Financial. After the assessment is finished, the physical therapist makes ergonomics changes to the patient's workstation. This non-traditional approach to addressing chronic pain caught my attention as it is not a commonly discussed intervention.

Methods

36 scholarly journal articles were included which examined the use of ergonomic interventions on WMSD. Studies were found using the following databases: Science Direct © by Elsevier, Academic Search Premier © by EBSCO Industries, PubMed.gov by the National Institute of Health as well as the Summit Interlibrary Loan network. Search terms used were permutations of the following:

Ergonomic intervention, work-related musculoskeletal disorders, ergonomic assessment, occupational musculoskeletal disorders, ergonomics, ergonomic pain, musculoskeletal pain, workstation design, participatory ergonomics,

Inclusion Criteria

In selecting sources for this paper, a major inclusion criterion was the use of ergonomic interventions, which included any combination of posture changes, workstation design, ergonomics education, and organizational modifications. Sources that only addressed chronic musculoskeletal disorders of the upper extremity, cervical, and lumbar spine were included as they are the most common WMSD with the most available data. A mixture of experimental studies and literature reviews were included. A selection of sources directly from TAI were also included. All sources included were written in English.

Exclusion Criteria

Sources that addressed acute musculoskeletal symptoms were not included in the research for this paper. Sources that solely investigated traditional therapeutic modalities were not included in the analysis portion of this paper, and only utilized for background information.

Theoretical Mechanisms of EI

Ergonomics is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize human well being and overall system (International 2000). Ergonomic interventions function to address the complex nature of WMSD and manage this potentially preventable musculoskeletal disorder. Prior to implementing EI for an individual's work environment, a crucial step needs to occur: an ergonomic assessment. Each job has unique demands and EI for one occupation may not be the same for another. Without knowing what the specific issues of a worker's unique environment are, a proper EI cannot be established. Understanding the nature and associated tasks of the occupation is crucial to administering an effective intervention. Once the specific demands of an individual's occupation is known, the associated strains of the work tasks can be addressed.

EI comes in many forms to addresses issues of awkward postures, improper lifting techniques, and high stress development in the workplace. EI has been found to be most effective when applied at multiple angles. Considerations of workstation design and product selection, implementing educational tools, and reducing the stress-inducing aspects of an occupation are all crucial to the effectiveness of EI. Ketola et al. () found that a combination of ergonomic education with workstation modifications elicited the greatest positive effects on the symptoms of WMSD.

EI aims to go beyond the surface causes of WMSD, to the less visible factors that may contribute to the development of WMSD, like workstation design and postures. EI goes beyond simply providing adjustable equipment as it has been found that the availability of adjustable office furniture alone is not enough to prevent chronic musculoskeletal injuries (Robertson et al. 2009). It is a combination of adjustable equipment with proper ergonomic education that increases the likelihood that workers ergonomically adjust their workspace (Robertson et al. 2009). EI also utilizes educational tools, behavior modifications, brief stretches and exercises to treat and prevent the chronic nature of WMSD. It is thought that through the implementation of an educational work ergonomics program, workers will be intrinsically motivated to alter postures and behaviors (Robertson et al. 2009). EI takes a different approach than traditional therapeutic interventions as it targets habits that are developed due to occupation-specific repetitive motions (Rappaport 2010).

Relevance and Practical Application of EI

Postural Modifications

Posture modifications are one of the key aspects of ergonomic interventions to treat WMSD. Even the lowest constant levels of muscle contractions can strain the musculoskeletal system. Posture is a factor that affects how much strength is generated (Vieira & Kumar 2004). When working postures are not biomechanically advantageous, the musculoskeletal system is strained, leading to injury, pain, and fatigue. Neck and shoulder pain are commonly observed in many WMSD of the upper extremities.

There is no ideal posture that works for all individuals, so guidelines have been established to help in standardizing EI with the focus of posture correction being promotion of neutral body positions. A head-forward posture is known to cause neck and shoulder discomfort as it increases muscle tension (McCoy, 2002). Recommended EI including seating adjustments and desk height to prevent a head-forward position. Literature by TAI indicates guidelines about how to maintain seemingly simple postures, like sitting during the workday, to promote proper posture. It is emphasized that while sitting, the feet should be flat on the ground, if possible, with the head balanced on the shoulders (Therapeutic 1999a). The hips should be placed at the back of the chair to provide lumbar support, as the lumbar spine is one of the most common areas of the body susceptible to WMSD (Therapeutic, 1999a). A balanced alignment of the body is stressed to prevent excessive anatomical motions (Therapeutic, 1999a)

Organizational Modifications

Workspace adjustments involve modifying the organization and type of equipment used to enhance work ergonomics as proper equipment and products are another crucial component to having an ergonomically effective work environment. Designing an office workers' desk specifically for the individual by modifying chair positioning, monitor height, keyboard placement, document placement, and other parts of the employees work environment aid in decreasing repetitive reaching and straining of the neck, shoulders, back and wrists (Rappaport, 2010). The organization of the workstation directly influences the amount of loading applied to structures of the back, neck, and upper extremities (Vieira & Kumar 2004).

Equipment Adjustments

Proper equipment positioning customized to the worker decreases muscle tension that contributes to WMSD. A simple equipment adjustment like an individualized, adjustable chair has been found to decreased shoulder and neck pain of seated workers (Rempel et al., 2007). An example of a product/equipment adjustment could apply to a medical receptionist who uses a keyboard for typing during phone calls with patients. The worker cradles the phone by doing a shoulder shrug with lateral neck flexion, which strains the structures of the neck, upper back, and shoulders (Novak). Therefore, a hands-free head set would be an ergonomic intervention to prevent or treat musculoskeletal disorders associated with the duties of a medical receptionist. McCoy depicts an example with a worker at a pharmaceutical laboratory who uses pipettes on a daily basis (2002). The pipette relies exclusively on thumb flexion for extended periods of time, which can fatigue the associated muscles and potential cause chronic tendinitis (McCoy, 2002). This is another situation, in which a change in product selection would be beneficial to decrease loading on the thumb.

Reducing Psychological and Behavioral Stresses with EI

Ergonomic interventions also work to address the psychological and behavioral aspects of an occupation that contribute to WMSD. Stress and anxiety are known to causes physical strains and the workplace is one of many areas of everyday life where these potentially detrimental effects originate. Work-related stress and anxiety can manifest from occupational pressures to increase productivity, maintain a fast-paced work environment, oversee too many responsibilities, etc. These pressures translate to insufficient amount of breaks throughout the workday and prolonged, static postures (Therapeutic 1999a). These stresses can be addressed by restructuring what one would consider a typical workday for a worker (Rappaport 2010).

It has been suggested that including micro-breaks during the workday can disrupt static postures that restrict blood and nutrient flow. It has been recommended that 5-7 minute breaks be taken every 45-60 minutes of a workday as an alternative to a typical workday of 2-hour work shifts with approximately 15-minute breaks (Rappaport 2010). These micro-breaks do not need to be long and highly involved as little as a 20-sec break has been found to be effective in disrupting high muscle tension (Fabrizio 2009).

With modern day work demands increasing and physical activity decreasing during the workday, these micro-breaks could potentially beneficial to reduce physical workloads and stress (Straker & Mathiassen 2009).

Efficacy of EI

Ergonomic Education

Despite the extensive research on WMSD and EI, currently there is conflicting evidence on the efficacy of EI as treatment and prevention of WMSD. Several studies have found that ergonomic assessments and workstation modifications have a greater effect on reducing WMSD symptoms than ergonomic education alone (Ketola et al., 2002). Loisel et al. (1997) found that a full intervention that included work-site ergonomic assessments and interventions returned workers 2.4 times faster than those who received treatment only from their physician. Longitudinal studies have shown that office ergonomics training along with adjustable equipment allowed for workers to adjust their work environment to be more ergonomically- sound (Robertson et al. 2009). Subjects of the study perceived the ergonomic intervention to be beneficial and applicable to their work environment (Robertson et al. 2009). Despite a lack of significant results, the study exhibited the way in which ergonomic intervention training and education encourages self-motivated workstation modifications, which is a key initial step in implementing any type of preventative intervention (Robertson et al. 2009).

However there are studies that did not support the use of ergonomic training in treating WMSD. A randomized controlled trial by Haukka et al. (2008) found that a participatory ergonomic intervention that educated kitchen workers about working postures and recognition of physical risk factors did not prevent WMSD symptoms. This can be attributed to the ambiguity of ergonomic interventions and a lack of standardization.

Workstation Modifications

A case study by Fabrizio (2009) found that traditional physical therapy decreased the subject's overall level of pain rating on the VAS by 1.0 cm while the subject's level of pain rating decreased an additional 3.6 cm following the addition of ergonomic intervention, that primarily involved workstation modifications to promote neutral postures. The subject's "worst pain" rating remained unchanged during traditional physical therapy sessions compared to a decrease in pain level by 4.4 cm after including ergonomic interventions. This study suggested that EI with traditional physical therapy that consists of manual therapy and a home exercise program could be a beneficial treatment for WMSD. Martin et al. (2003) found the combination of workstation adjustments and ergonomic training improved numerous outcome measures related to musculoskeletal pain and fatigue.

However other studies have provided mixed or minimal evidence supporting the use of EI to alleviate WMSD symptoms. Driessen et al. (2009) reviewed the currently available randomized controlled trials on the efficacy of ergonomic interventions and found a low number of high-quality evidence with strong methodology showing the effectiveness of ergonomic interventions. Only ten total studies met the standards of the review, making it difficult to determine whether ergonomic interventions are effective in treating low back and neck pain. Brewer et al. (2006) reviewed the use of ergonomic interventions to prevent WMSD amongst computer users and found moderately strong evidence on workstation adjustments and micro-breaks having no effect on musculoskeletal outcome measures.

Cost-Effectiveness

There is some evidence that shows that implementing an ergonomic intervention program decreases work-related health costs (Fabrizio 2009; Lewis et al. 2002). Fabrizio's case study (2009) demonstrated the economical advantages of EI by conducting an economic analysis of EI. It was estimated to cost $450 total for the ergonomic assessment and interventions in comparison to traditional physical therapy sessions, which would cost approximately $1200. Lewis et al. (2002) observed a decrease in employee claims costs from $15,141 to $1,553.

The economic analyses that have been conducted on the cost-effectiveness of EI have been critiqued for only taking into consideration the direct costs related to WMSD (Tompa et al. 2010). A variety of indirect costs should be considered to obtain an accurate depiction of cost-effectiveness, not a single measure like workers' compensation claims costs (Tompa et al., 2010). These factors must be taken into consideration when evaluating the validity of economic analyses. However even with this factor taken into consideration,

Contraindications & Limitations

Due to the distinctiveness of each occupation, standardization of ergonomic interventions has been an obstacle. This limitation can largely be attributed to the individualized nature of WMSD depending on the job description and demographics of the worker (Sizer et al. 2004; Amell & Kumar, 2001). There is no ideal posture that eliminates loading to the musculoskeletal system, therefore it is difficult to establish a generic standard for posture modifications (Vieira & Kumar 2004).

With EI being a highly individualized approach to treating WMSD, a contraindication for the use of EI may originate from the structure of modern day medical practice. McCoy (2002) emphasizes the necessity for physicians to analyze work conditions in relation to their patients WMSD by providing interventions that address a patient's specific occupation. Assessments for WMSD are limited in a physician or physical therapist's office on several levels. Physicians and physical therapists may not be able to observe the true behaviors and habits of an individual during their workday. Suggestions can be made by healthcare professionals to adjust chair height, monitor height, desk organization, etc. However without an actual assessment of an individual's workplace, the symptoms of WMSD may not be fully relieved (Fabrizio 2009). The greatest value of ergonomic advice comes from physical therapists making observations and ergonomic suggestions for the patient while in their natural working environment performing daily tasks (Ketola et al. 2002). This may call for a need to make medical services more mobile to go to work sites to perform ergonomic assessments. As much as a therapist asks for a patient to mimic their posture, behaviors, and movements similar to their work environment

A limitation of EI that should be considered is an engineering limitation. Ergonomic equipment and products are still being developed and are not available to optimize working conditions. McCoy (2002) provides a solution to possible muscle fatigue due to repetitive thumb action of a laboratory technician who pipettes for long periods of time of utilize an in-line grip pipette to allow muscle rotation putting less strain on the thumb and its respective musculoskeletal structures. However it must be noted that this type of equipment is not currently available aid in preventing this type of WMSD.

Conclusions

It is evident that WMSD are a significant health concern today, with the economic burden at billions of dollars annually. Employees are losing work hours due to WMSD and a new intervention is necessary. EI remains to be a fairly novel area of research and it has been demonstrated that more research is needed to determine the true efficacy of this type of intervention. There are a limited number of RCTs testing the effectiveness of EI, which is partly due to the complex nature of the disorder. Of the research conducted, methodology is not particularly strong, as sample sizes are small with a lack of diversity (Kumar 2001). Despite the lack of high-quality evidence supporting the use of EI to prevent WMSD, there is also growing evidence showing the benefits of this type of conservative intervention. Research shows that EI is a promising intervention that can be cost-effective, non-invasive, and long-term.

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