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Review article

Prevention of musculoskeletal disorders within management systems: A scoping review of practices, approaches, and techniques

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ABSTRACT

The purpose of this study was to identify and summarize the current research evidence on approaches to preventing musculoskeletal disorders (MSD) within Occupational Health and Safety Management Systems (OHSMS). Databases in business, engineering, and health and safety were searched and 718 potentially relevant publications were identified and examined for their relevance. Twenty-one papers met the selection criteria and were subjected to thematic analysis. There was very little literature describing the integration of MSD risk assessment and prevention into management systems. This lack of information may isolate MSD prevention, leading to difficulties in preventing these disorders at an organizational level. The findings of this review argue for further research to integrate MSD prevention into management systems and to evaluate the effectiveness of the approach.

1. Introduction

Musculoskeletal disorders (MSD) represent a large proportion of work-related disabilities in most countries (NRC, 2001). MSD have a substantial work-related component and a consistent set of workplace risk factors including forces exerted, the postures required, the time history of the mechanical exposure, vibration, cold, contact stress, and a range of psychosocial factors (Bernard, 1997; NRC, 2001). MSD negatively impact the worker, firm, and the economy by increasing discomfort, pain, disability, and medical costs, as well as decreasing productivity and employee morale (Martin et al., 2003; Morse, 1999). Hence, as a result of these adverse effects, the prevention of these disorders should be a high priority.

It is the responsibility of organizations to provide safe working conditions through anticipation, identification, assessment, and control of a wide range of hazards in the workplace. If these activities are performed within some organizational level framework, it may be considered a "management system". More formally, a management system is defined as a framework of individual processes, procedures, and resources to ensure effective and efficient achievement of certain objectives (Karapetrovic and Willborn, 1998). Three key internal management systems are: Environmental Management Systems (EMS), Quality Management Systems (QMS), and Occupational Health and Safety Management Systems (OHSMS). Several standards and guidelines have been developed over the years to guide organizations in implementing these management systems, for instance, the Occupational Health and Safety Assessment Series (OHSAS 18001), BS 8800, International Labor Organization guidelines, Health and Safety Executive guide (HSE, 2007), QMS standard (ISO 9001) developed by International Organization for Standardization (ISO), and EMS standard (ISO 14001). OHSAS 18001 is a framework developed to provide a

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"recognizable" health and safety management system that has the potential to be assessed and certified against organizations' management systems. This framework includes elements aiming to improve health and safety systematically. Often, organizations integrate separate management systems (quality, environmental, health and safety, etc.) to increase efficiency and reduce costs; this model is known as an integrated management system (IMS). These management system frameworks are typically based on the Plan-Do-Check-Act (PDCA) model (Deming, 1986) of continuous improvement.

We adopted the definition of ergonomics provided by International Ergonomics Association (IEA), which includes aspects of physical, cognitive, and work organizational factors (IEA, 2000). In the literature, ergonomics appears to be frequently used as a synonym for MSD prevention. Therefore, where applicable, we will clarify which meaning has been used by different authors. Participative Ergonomics (PE) practices are commonly presented as a desirable approach for the prevention of MSD (Noro and Imada, 1991). Ergonomic programs for the prevention of MSD vary in complexity, but most of those reported in the literature appear to be set up in isolation from management system frameworks (Yazdani et al., 2015). This isolation was perhaps first conceived to highlight the work-relatedness of MSD and to increase the awareness that these disorders are as important as acute injuries. However, it is unclear why this general isolation still exists. Furthermore, there remain questions of the possible challenges and barriers that could obstruct the integration of MSD prevention into existing broader management systems.

The purpose of this study was therefore to both identify and summarize the available evidence on embedding the prevention of MSD within OHSMS and thus integrating this specific aspect of prevention into an organization's management system.

2. Methods

We were uncertain about the nature and extent of the literature on the topic and therefore performed a scoping review. As defined by Mays et al. (2001), a scoping review is a literature review methodology that maps the key concepts to examine research questions and evidence. This could be done through a stand-alone project where researchers aim to address a complex research area, or an area that has not been previously comprehensively reviewed (Mays et al., 2001; Arksey and O'Malley, 2005). It follows a methodology that is equivalent to qualitative analysis of literature. Scoping reviews not only itemize and summarize the existing findings on a topic, but also facilitate an in-depth understanding of how those findings relate to each other and to the research question (Poth and Ross, 2009). For the purpose of this paper, we used a framework by Arksey and O'Malley (2005). The authors identified four different reasons to conduct a scoping review: (a) to examine the extent, range, and nature of research activity, (b) to determine the value of undertaking a full systematic review, (c) to summarize and disseminate research findings, and (d) to identify gaps in the existing research literature. Reasons (a) and (d) matched the aims of this paper.

2.1. Scoping review process

The process used in this review was similar to those outlined by Arksey and O'Malley (2005) and consisted of the following steps: (1) the research questions were clearly identified; (2) the inclusion and exclusion criteria were described; (3) search schemes were defined; (4) the literature search was conducted; (5) relevant studies were selected; (6) the evidence was extracted and data were tabulated, and (7) the results of the review were summarized.

2.2. Research question

What is known about preventing MSD within OHSMS and other management systems and how can these MSD prevention activities be integrated into an organization's management system?

2.3. Literature search outline

The search strategy combined two sets of keywords using the Boolean operator "AND", while an "OR" strategy was used to combine the keywords within each group. In addition, the reference lists of documents were manually searched, in case they met the inclusion criteria. The first set of keywords was focused on the following terms: musculoskeletal disorders (MSD), ergonomics, low back pain, cumulative trauma disorders (CTD), upper extremities, repetitive strain injuries (RSI), musculoskeletal injuries (MSI), and injury prevention. The following keywords were used as the second set for management systems: occupational health and safety management system, health and safety management system, integrated management system, quality management system, total quality management system, risk assessment, and risk management. The keywords were searched in the titles, abstracts, and topics of documents. A title and abstract that contain one term from each group of keywords were considered to be eligible for this review.

2.4. Literature search

Electronic databases that were searched for relevant documents included MEDLINE, EMBASE, Compendex, Web of Science, PsycINFO, Ergonomic Abstracts, and 44 other databases using the ProQuest search platform. These databases include a wide range of journals in the fields of health, business, management, and science. The databases were searched for English language studies.

2.5. Inclusion and exclusion criteria

This paper included peer reviewed journal articles and conference papers aiming to describe injury prevention practices and approaches within any management system frameworks, such as OHSMS, QMS, and IMS. We included papers published up to February 2012. The search was updated on April 2014 to extract the most recent literature. Both qualitative and quantitative studies were included. This review excluded studies that lacked information about integration of prevention into management system using assessment techniques, strategies, and approaches. Also, articles not written in English were excluded.

2.6. Document relevance review

One reviewer screened the title and abstract of each article. If the reviewer could not make a decision on relevancy of articles, an additional reviewer was asked to repeat the process. Those articles determined to meet the inclusion criteria were retrieved. Then, the articles were independently reviewed by pairs of reviewers to make a decision on the retention of the article. The decision for each paper was made by reaching consensus.

2.7. Data extraction and synthesis of information

Pairs of reviewers extracted data from articles on context, type of risk assessment techniques, strategies, techniques within management systems, and any authors' comments or recommendations related to MSD prevention within a management system. A thematic synthesis technique was used to combine the findings. This

approach has been used to identify important or recurrent themes, and to summarize findings under thematic headings (Thomas and Harden, 2008).

3. Results

The literature search resulted in 718 citations after removing duplicates. Finally, 21 studies met the relevance criteria. Five main themes were identified from the thematic synthesis: (1) IMS and Occupational Health & Safety (OHS); (2) Workers' involvement or participatory approaches within IMS; (3) IMS and MSD prevention; (4) Risk assessment tools within management systems, and (5) Continuous improvement, Lean, and MSD prevention. Table 1 presents the summary of the results of this review based on the above themes.

3.1. Theme 1: IMS and OHS

The literature supported the integration of different management systems, and this was recommended as an essential approach to address different risk factors within workplaces (Labodova, 2004; Shen and Walker, 2001). With respect to feasibility and scope, as described in case studies by Labodova (2004), the IMS approach can be implemented in companies with or without a systematic management system and in any kind of company regardless of size and sector, including those of small and medium size. However, as reported by authors, to implement the IMS approach in large organizations, having an expert on risk assessment and evaluation was suggested to be useful because these techniques require specific training (Labodova, 2004).

Integration of OHS into management systems was suggested as an important and essential approach for organizations to improve

Table 1
Summary of key findings based on themes.

Themes	Author	Year	Main findings
Theme 1: IMS and OHS	Shen and Walker	2001	▪ Integration of OHS into management systems improves OHS performance
	Matias and Coelho	2002	
	Hare et al.	2006	
	Saurin	2008	
	Lingard et al.	2009	
	Badri et al.	2012	
	Labodova	2004	▪ The IMS approach is feasible in both small-medium sized and large organizations
	Hare et al.	2006	▪ Better results can be achieved by integrating OHS into the planning phase of projects
	Saurin	2008	
	Lingard et al.	2009	▪ Incorporating OHS into all aspects of decision-making significantly improved the performance of a construction project
Theme 2: Workers' involvement/participatory approaches within IMS	Cohen	1997	▪ An integrated management system model resulted in better participation of workers and significant reduction of RSI severity
	Lingard et al.	2009	▪ Implementation of a model client framework increased employees' participation
	Badri et al.	2012	▪ Systematic integration of OHS into management systems will increase employees' participation resulting in transferring knowledge
Theme 3: IMS and MSD prevention	Cohen	1997	▪ The integration of MSD prevention into the general management structure resulted in successfully addressing MSD problems
	Lewandowski	2000	▪ Considering ergonomics in the management process will result in achieving constant improvement in OHS and quality
	Matias and Coelho	2002	▪ The IMS can be beneficially enhanced through incorporating ergonomics
	Munck-Ulfsfält et al.	2003	▪ Linking ergonomics to KLE strategy resulted in more involvement of stakeholders
	Lee	2005	▪ Integration is required because of the common objectives of ergonomics, OHS, and quality as well as the impacts of ergonomics on productivity and quality
	Cocianni and Williamson	2008	▪ Integration of ergonomics into QMS resulted in positive outcomes
	Caroly et al.	2010	▪ A collective approach for quality, ergonomics, productivity and safety enhanced the assessment of actions and tackled operational problems
Theme 4: Risk assessment tools within management systems	Shen and Walker	2001	▪ Introduced a mechanism to integrate risk management process for different types of risk factors resulting in better workers' involvement and increasing awareness
	Tixier et al.	2002	▪ A review of 62 risk analysis methodologies suggested that there was no unique method to accomplish all risk analyses, and a combinatory methodology should be applied
	Matias and Coelho	2002	▪ The integration of MSD prevention into management systems requires harmonized tools, approaches, and concepts to match other methods used in management systems
	Labodova	2004	▪ Introduced a risk matrix based on financial acceptability and the use of the PDCA model
	Lee	2005	▪ Ergonomics should be presented as an “everyday tool”.
	Shephard et al.	2003	▪ Developed an Ergonomics Failure Mode and Effects Analysis (E-FMEA)
Theme 5: Continuous improvement. Lean, and MSD prevention	Nastasia, Toulouse and Imbeau	2006	▪ The success of integration of ergonomics into continuous improvement methodologies (i.e., Kaizen) depends on the culture of the enterprise.
	Nunes and Machado	2007	▪ Incorporating ergonomics into Lean manufacturing using Ergonomic CAD and Decision Support Systems might improve MSD hazard identification in the workplace
	Caroly et al.	2010	▪ Implementing continuous improvement creates the opportunity to link production management and prevention management
	Badri et al.	2012	▪ Continuous improvement allows for timely intervention

health and safety and performance (Shen and Walker, 2001; Badri et al., 2012; Hare et al., 2006; Saurin et al., 2008; Lingard et al., 2009; Matias and Coelho, 2002). A case study conducted by Shen and Walker (2001) on the integration of quality, environment, and OHSMS, highlighted the importance of an integrated approach in addressing different risk factors in the planning and design phases of a construction project. Badri et al. (2012) argued that implementing standards such as QMS Standard (ISO 9000), without integration of health and safety components, may not necessarily lead to a higher level of organizational OHS performance, and that OHS issues have been overlooked in these types of standards. They suggested that additional approaches are needed to integrate OHS into management systems. The authors also concluded that there was lack of systematic integration of OHS in management systems despite the improvements in legislation and structures (Badri et al., 2012). As reported by Hare et al. (2006) and Saurin et al. (2008) the best results were achieved when OHS was integrated during the planning phase of project. In addition, Lingard et al. (2009) proposed the life-cycle approach, which indicates how the integration of the OHS into all aspects of decision-making by clients could significantly improve the performance of construction projects, and therefore enhance the prevention of injuries.

3.2. Theme 2: workers' involvement/participatory approaches within IMS

Participation and involvement of workers is a key feature of any management system. They are also necessary in the implementation of changes within an organization. The literature supports systematic participation of workers in activities within IMS. Badri et al. (2012) reported that the systematic integration of OHS risk management into project management can increase employees' participation and this leads to transfer of knowledge, including the description of responsibilities and increased employees' involvement (Badri et al., 2012). Activities in organizations, such as those in the construction sector, are usually organized and performed using a project management approach. Furthermore, a participatory approach for the identification and assessment of risks has been suggested, involving several stakeholders such as project managers, team members, risk management team, experts, end users, stakeholders, risk analysis specialists, and even customers, and has been strongly encouraged to achieve the most promising outcomes (Hare et al., 2006).

A model client framework suggested various processes for client involvement in multiple aspects of OHS programs, including the planning, design, procurement, construction, and completing stage of a construction project (Lingard et al., 2009). This model identifies client behaviors. It has been implemented by the Australian government to create a positive OHS culture in construction projects. As reported by Lingard et al. (2009), it consists of three main elements: (a) the Federal Safety Commissioner's OHS Principles with 8 principles including developing a safety culture, leadership and commitment, developing cooperative relations, promoting OHS in planning and design, consulting and communicating OHS information to project stakeholders, managing OHS risks and hazards, maintaining effective OHS measures across the project lifecycle, monitoring and evaluating OHS performance; (b) the project process map, and (c) supporting tools and resources.

In a case study conducted by Cohen, supervisors and managers were ultimately accountable to implement and follow-up with corrective actions (Cohen, 1997). They declared that their integrated approach, particularly with worker involvement, significantly reduced RSI severity. The program was reported to be a part of the company's management system. However, the authors didn't mention the implementation of any systematic risk management strategy with a continual improvement approach.

3.3. Theme 3: IMS and MSD prevention

Prevention of MSD was noted to be rarely incorporated into companies' management systems (Caroly et al., 2010). When considering MSD prevention and ergonomics activities within OHSMS and IMS, Matias and Coelho (2002) proposed that the benefits of incorporating different management systems could be enhanced by the integration of ergonomics into these management systems. Lewandowski (2000) highlighted the importance of integrating ergonomics as a general concept into a total quality management system. He suggested that to achieve the effects of constant improvement in OHS and quality, ergonomics must be considered in management processes. Theoretical work has also identified the incorporation of ergonomics aspects into design as a useful prevention strategy (Imbeau et al., 2001). Munck-Ulfsfalt et al. (2003) suggested that ergonomics is not a separate entity, but a strategy. The authors suggested that the involvement of managers and other employees in ergonomic work was much easier when they saw the link with the KLE strategy. KLE in Swedish stands for Quality, Delivery Precision, and Economy (Munck-Ulfsfalt et al., 2003). The KLE strategy introduced quality as a priority and that everything should be done properly from the beginning. The authors argued that employing ergonomics in work position, job stages, work tasks, equipment, and work technique would automatically lead to better product quality. The authors used the broad term “ergonomics” based on the definition provided by IEA 2000, but the consequences of poor ergonomics at work, such as injury (including MSD), cost, and absenteeism were addressed (Munck-Ulfsfalt et al., 2003). In addition, Caroly et al. (2010) suggested that the integration of quality, ergonomics, productivity, and safety depends on a policy based on integration and involvement of all stakeholders. A collective approach was also promoted to enhance the assessment of actions and tackle operational problems (Caroly et al., 2010).

Lee (2005) speculated as to why the promotion of ergonomics has not had more success. One of the main reasons is that instead of promoting the discipline's methods as “everybody's tool”, ergonomists have kept the tools to themselves. Another reason is the lack of an effective way to use ergonomics in management systems. Common objectives of ergonomics and quality, health and safety management systems, as well as other effects of ergonomics in productivity and quality argue for its integration.

Most of the case studies have been published in conference proceedings and the literature is still not conclusive on organizations' experiences with these techniques. The following three studies presented three different strategies to prevent MSD. The first example was the integration of ergonomics into an overall QMS. Cocianni and Williamson (2008) presented a methodology for the practical involvement of ergonomics in mobile pumping and coiled tubing equipment and operations as a part of an overall QMS. Implementing this multi-step methodology resulted in positive outcomes. The authors concluded that ergonomics must be included as an integral part of the design of new equipment. They suggested that engineered solutions to design oilfield equipment, including ergonomics, would contribute to the overall QMS of an oilfield services company. However, the authors did not provide more information about how the integration of this method to QMS has been accomplished. The authors used the broad term “ergonomics” based on the definition provided by IEA 2000, but the prevention of injuries was also discussed as a consequence of poor ergonomics in the workplace. The second example described the development of a stand-alone program (Murphy and Mitchell,

2002). This multi-component approach formed a continuous process and was designed for the health care sector. This method had a systematic approach that could have been integrated into a management system; however, the authors aimed to develop a self-sustainable program rather than an integrated approach. The third example described integrating MSD prevention into the general management structure of a company. Cohen (1997) described a program developed by an electronic manufacturer in California, United States of America. The program was implemented by four different sub-committees working under a larger committee and was managed through the company's management structure. The program was reported to be successful.

3.4. Theme 4: risk assessment tools within management systems

The risk management process in all management systems is similar. It involves: (a) hazard identification, (b) risk assessment and analysis, and (c) determining the control actions. Our analysis suggests that the literature is very small on the topic of management systems and MSD, and it was unclear how the integration of MSD risk assessment could be achieved with different risk assessment approaches commonly employed for assessing other types of risk factors. However, some authors suggested various approaches. A risk matrix developed by Labodova (2004) was based on a common scale of financial acceptability to compare levels in different areas (quality, environmental, health and safety) in the IMS and was the result of top management decisions. The risk matrix was noted as an element of the risk analysis based approach, which was described as a combination of risk analysis and PDCA approaches. Similarly, Shen and Walker (2001) suggested a mechanism to integrate risk assessment into management processes. The mechanism is similar to risk assessment processes outlined in management system frameworks and includes: (a) baseline assessment of risk factors and strategy planning to overcome these risks, (b) identification and assessment of risks, and (c) control of risk. The authors argued that since this process is similar for quality, health & safety, and environmental issues, the risk management process can be integrated. They reported that this method enhanced workers' involvement and increased their awareness of integration of these systems. It was also suggested that the integration could be achieved by using different methods and tools, but this was not elaborated on further.

Tixier et al. (2002) conducted a review of 62 risk analysis methodologies which were used to manage risks. They grouped risk assessment methodologies into three different phases, including: (a) identification to identify workplace hazards, (b) evaluation to assess risk factors, and (c) hierarchisation to prioritize risk factors, often based on their severity and frequency. The authors described these methodologies based on three main themes: (a) types of methods (deterministic, probabilistic, qualitative, and quantitative), (b) types of input data (i.e., plans or diagrams, substances, probability and frequency, and policy and management), (c) types of output data such as management actions, lists of errors and hazards, probabilities related to error and accident frequency, and hierarchisation related to level of the risk. Authors noted that all risk assessment methodologies may not necessarily contain these three phases, and that these phases are important in management of risk in any systematic approach to control health and safety risk factors in the workplace. They concluded that taking all risks into account is challenging. The authors noted incompatibility between human risk factor analyses and classical methods. They reported that this might be due to the complexity of human risk analysis. Their review concluded that there was no unique method to accomplish all risk analyses and a combinatory methodology should be applied (Tixier et al., 2002). The review did not address the implementation of these methodologies within a management system. However, most of the methodologies described can be used within any management system and have been widely used to address health, safety, environment, and quality risk factors. This review could assist health and safety specialists to select the appropriate risk assessment to use within IMS, but it is silent on how this integration could be done.

With respect to MSD prevention, Matias and Coelho (2002) argued that integration of MSD prevention into management systems requires harmonized tools, approaches, and concepts to match other methods used in management systems. To do so, it is necessary to acknowledge that there are specific techniques and approaches that organizations use to manage quality and other aspects of health, safety and environment. Lee (2005) suggested that it is important to make ergonomics an “everyday tool” in workplaces and in design departments. The author used the term “ergonomics” in its wider definition.

There is a lack of information on tools and methods that could be used for integration of MSD prevention into management system frameworks. A promising exception was Shephard et al. (2003) who developed an Ergonomic Failure Mode and Effects Analysis (E-FMEA). FMEA has been widely used by quality and health and safety practitioners to assess different types of risk factors. This is one of the rare attempts identified in this search that provided a detailed description of a way to harmonize ergonomic assessments with common risk assessment methods.

3.5. Theme 5: continuous improvement, lean, and MSD prevention

As continuous improvement is the main feature of any management system, integration of any prevention activities within an organization's management system can benefit from this. However, only a few studies discussed this phenomenon with respect to the integration of MSD prevention activities into organizations' management systems. Caroly et al. (2010) examined how a “safety and production logic” approach could be integrated into a “continuous improvement” system for the sustainable prevention of MSD. The authors tried to address the ways that companies overcame MSD problems through management, based on what they called a dual logic of safety and production. As defined by the authors, the continuous improvement process initially aimed to control production costs and quality by optimizing information, physical flow and products. Management system standard frameworks use this approach based on the PDCA model to continuously improve quality, health and safety, environment, and production. The authors proposed that implementing continuous improvement provides the opportunity to link production management and prevention management. Such integration has been reported to result in continuous improvement and better and sustainable prevention of injuries. Badri et al. (2012) reported that attempts were underway to integrate OHS through timely intervention within a framework of continuous improvement.

A different approach was taken by Nastasia et al. (2006) who studied the integration of ergonomics into continuous improvement methodologies such as Kaizen. This Japanese inspired approach aims to help businesses make low-cost changes with the assistance of a multidisciplinary team within the organization. They highlighted the importance of addressing MSD and OHS problems in a productive and efficient process. However, they found it difficult to integrate OHS into Kaizen. The authors concluded that accounting for the company's culture and context could facilitate this integration, and the success of integration might be closely related to the culture of the enterprise. The authors also noted that the integration of ergonomics was influenced by: (a) the workers' involvement in the improvement process, and (b) the company's

experience with continuous improvement. In a related study, Nunes and Machado (2007) emphasized the importance of merging ergonomics principles into lean manufacturing. They suggested that using computer-based tools such as Ergonomic CAD applications and Decision Support Systems might help improve the identification of MSD risk factors in the workplace. The use of these techniques were suggested to help ergonomists to work, collaborate, and communicate with engineers. The Decision Support Systems was described as a computerized information system designed to help engineers in decision-making activities (Nunes and Machado, 2007).

4. Discussion

A major theme in the review was workers' involvement or participatory approaches within IMS. PE as an approach was frequently advocated for MSD prevention. The term appears to have originated with Noro and Kogi in 1983 (Motamedzade et al., 2003). Early literature promoted PE simply as a good way to get ergonomics implemented (Noro and Imada, 1991). In a similar vein, PE has been described as "practical ergonomics", a strategy to improve problem solving (Kuorinka, 1997). Many PE approaches have since been reported in the literature over the last three decades (Nagamachi, 1995; Kuorinka, 1997; Laing et al., 2005; Driessen et al., 2010), with several taxonomies proposed (Haims and Carayon, 1998; Cole et al., 2009). However, there is no general definition of the term PE (Haines and Wilson, 1998) and any mention of the relationship of PE activities to management systems is rare.

A main feature of the PE approach is an "ergonomics" team. This may consist of an employee representative, manager, and technical person such as an ergonomist or health and safety personnel (Rivilis et al., 2006). Ideally, this approach actively involves workers in managing their work activities to decrease exposure to psychological, physical, and/or work organizational risk factors for MSD (Westgaard, 1999; Wilson and Haines, 1997). Risk assessment, later stages of solution generation or interventions, and the process of implementation were shown to be enhanced by using a PE approach. Nagamachi (1995) reported that PE promoted the workers' acceptance of interventions, because they had participated in the redesign and the reforming of their organization. Rivilis et al. (2006) noted that there was partial to moderate evidence that PE interventions had a positive impact on health outcomes.

Another theme identified in the review was the prevention of MSD within management systems. As Caroly et al. (2010) noted, the integration of MSD into management systems would result in better prevention within a continuous improvement approach. Others supporting this idea included Lewandowski (2000) and Matias and Coelho (2002). As brought up by Hendrick and Kleiner (2002) and Lee (2005), micro-ergonomics approaches (vs. macro-ergonomics approaches) only addressed MSD prevention at the department level and didn't promote ergonomics as a part of "everybody's tool". This may be why promotion of ergonomics has had limited success. It was suggested that this integration might also contribute to the overall QMS (Cocianni and Williamson, 2008). More benefits can be achieved by integrating MSD prevention into the design process (Imbeau et al., 2001; Hendrick and Kleiner, 2002). Studies of the sources of workplace risk factors have shown that critical decisions made during the design of products, facilities, and work routines all contribute to the eventual presence of MSD hazards in those workplaces (e.g. Neumann and Village, 2012; Neumann et al., 2006; Neumann and Wells, 2008). From a design science perspective, changes to a design become progressively more difficult and expensive to make as the design process proceeds (e.g. Neumann, 2004). The incorporation of MSD prevention into engineering tools was reported to be useful for ergonomists to work with engineers (Nunes and Machado, 2007). The same approach was taken by Tarawneh et al. (2002) who introduced a method to incorporate ergonomics, in its more general sense, into Data Dependent Systems (DDS); a technique used within engineering disciplines that uses available quantitative data to identify underlying properties of the system.

A further theme involved hazard identification and assessment. Hazard identification and risk assessment are crucial and are required in management systems, but using comparable assessment techniques for all types of hazards appears to be challenging (Fera and Macchiaroli, 2010; Tixier et al., 2002). Methods introduced in Tixier et al. (2002) could potentially be used to analyze different types of risk factors. ISO 31010 was published in 2009 to introduce general guidance on the implementation of risk management across many industries and types of systems. This standard focused on the management of risk within organizations and can be used for all risk categories such as quality, environment, and health and safety. Techniques such as HAZard and OPerability (HAZOP), Layer of Protection Analysis (LOPA), and Failure Mode and Effects Analysis (FMEA) are examples of techniques described by ISO 31010 that have been widely used by health and safety and quality practitioners. Although ISO 31010 introduced many qualitative and quantitative tools that could be used to assess workplace risk factors, integrating MSD prevention into FMEA (Shephard et al., 2003) and CAD software (Chaffin, 2005) were the only attempts to describe the integration of MSD prevention into risk assessment approaches used by other disciplines. The report by Lin et al. (2012) attempted to integrate human factors into FMEA. This approach took ergonomic assessment methods directly to the people who arguably should be using them, i.e., engineers, by incorporating them directly into their tools and methods.

Hazard identification and risk assessment are also prominent in ergonomics programs for the prevention of MSD. Although there is general consensus on the necessity for this element, there appear to be few general tools; instead a multitude of specific methods are described in the ergonomics literature to identify and assess MSD hazards (Fallentin et al., 2001; Dempsey et al., 2005; Takala et al., 2010). An issue relevant to training stated in Fallentin et al.'s (2001) and Takala et al.'s (2010) reviews were the lack of information on the education and training required to use any of these methods effectively. They noted that the majority of the tools were not particularly user friendly, and that most of them targeted highly skilled workers, specialists, and experts. This would tend to make the proposed tools more difficult to use in most organizations' risk assessment processes.

The research question grew out of the notion that integration of MSD prevention into OHSMS could be desirable. The effectiveness of an OHSMS itself in improving health and safety performance is a pre-requisite to pursuing this goal. Robson et al. (2007) conducted a systematic review on the effectiveness of mandatory and voluntary OHSMS interventions. They found that OHSMS interventions were generally effective in managing health and safety related issues. However, they were concerned that studies in the literature had a number of methodological limitations. Nonetheless, as described above, attempts to integrate MSD prevention into management systems appear to be beneficial for preventing injuries (Caroly et al., 2010; Lewandowski, 2000; Matias and Coelho, 2002; Lee, 2005). For instance, Bunn et al. (2001) reported a 24% decrease in illness or injury frequency, and a 34% decrease in lost-time case rate over three years as a result of voluntary OHSMS. Likewise, Yassi (1998) and Alsop and LeCouteur (1999) indicated a 25% and 52% drop in premium rate of workers' compensation cost, respectively. In addition, the literature suggested that the successful

implementation of OHSMS can be done in medium and small sized enterprises as well as in large organizations and can result in safer work environments (Arocena and Nunez, 2010).

This scoping review had a number of limitations. It is possible that the studies describing the integration of MSD prevention into management systems used different terminology and were therefore missed in this review. However, the authors employed multiple search terms commonly used in the MSD prevention literature. In addition, the type of risk factors was not restricted to the search terms. Most of the papers focused on MSD physical risk factors, and none of the papers discussed psychosocial risk factors for MSD prevention or the integration of approaches and techniques to address these risk factors within a management system framework. Also, organizations may not publish details of their approaches to integrate MSD prevention activities into their management system in the peer-reviewed literature. We might not have therefore located information on the topic through the described literature search approach. The literature searched was not irrelevant however, as in our experience many professional ergonomists use this literature to help inform their practice of MSD prevention. A different approach would be required to access the information located within organizations.

The number of published studies found in this review was small. However, there was support for integrating MSD prevention into OHSMS and IMS. Such a practice may not only promote health and safety in general, but more importantly, have the potential to improve the prevention of MSD. This integration would help avoid OHS and MSD prevention becoming a “sidecar” function (Neumann and Dul, 2010), thus reducing the effectiveness of MSD prevention activities.

5. Conclusion

There was little information on the integration of MSD prevention into management systems in the peer-reviewed literature. The small literature did however indicate that incorporating MSD prevention into organizational level approaches could improve production in addition to preserving workers' health in workplaces. The high prevalence of MSD within workplaces may be due to the fact that MSD hazards are not being addressed as effectively as they should be, because MSD hazard assessment and risk prevention are partially outside of the main management processes. For these reasons, information concerning MSD hazards may not be “on-the-table”, and thus, may not receive adequate attention. Incorporating MSD prevention into tools and techniques used by other stakeholders within an organization will likely increase awareness and improve communication with respect to MSD prevention. Bringing ergonomics as a means of preventing MSD into organizations' overall safety and injury prevention approach, incorporating it into organizations’ management systems, and avoiding “silos” appears to be highly desirable. Further research is needed to document best practices, explore the integration opportunities, and evaluate the effectiveness of these approaches.

Based on the scoping review of the limited literature available, we do not see that a full systematic review is possible. The findings of this review argue for further research to integrate MSD prevention into management systems and to evaluate the effectiveness of the approach.

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