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Review article

The effect of cushioning materials on musculoskeletal discomfort and fatigue during prolonged standing at work: A systematic review

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ABSTRACT

This systematic review updates the current state of evidence on the effectiveness of softer flooring and cushioned shoe insoles on reducing musculoskeletal discomfort amongst workers who are required to stand for prolonged periods to work and the impact of factors such as age and gender on the outcomes. A systematic search identified 10 unique studies that met the eligibility criteria. The heterogeneity of study designs impacted on the strength of evidence. A moderate level of evidence was found in support of using cushioned materials in reducing discomfort/fatigue among standing workers. A limited level of evidence exists in favour of using insoles over anti-fatigue mats. Insufficient information exists for the impact of gender or age. Larger, good quality prospective intervention trials based in real workplaces that consider the impact of psychosocial and organisational factors on musculoskeletal discomfort whilst standing at work are required to inform industry recommendations.

1. Introduction

Despite significant changes in the way work is done since the transition from mechanisation to automation in the 1950's (Straker and Mathiassen, 2009), standing jobs remain prevalent across many industries around the world. According to the 2008 Australian National Hazard Exposure Worker Surveillance (NHEWS) survey, 31% of workers in the manufacturing, 33% in retail and 39% in the hospitality industries in Australia reported standing in one place often or all of the time (Australian Safety and Compensation Council, 2009). Prolonged standing has also been reported amongst automotive engine manufacturing plant employees in the Northern US (Gell et al., 2011) and amongst process line workers at a metal stamping company in Malaysia (Halim et al., 2013).

Musculoskeletal pain and discomfort affecting the lower back and lower extremities, leg swelling and fatigue (both local and general) has been frequently reported by those engaged in prolonged standing activities (Garcia et al., 2015; Orlando and King, 2004; Redfern and Cham, 2000; Zander et al., 2004). An increase in the risk of plantar fasciitis was found among full-time employees of a US based assembly plant (Werner et al., 2010). In their review of literature on the health effects of prolonged standing amongst workers in various occupations in Europe, Northern and Southern America, Asia and Australia, Waters and Dick (2015) found a positive association between standing still and physical fatigue, discomfort and pain.

Several physiological mechanisms have been proposed to explain the development of these adverse health effects. Musculoskeletal discomfort has been thought to be the result of inflammation caused by pooling of blood in the lower limbs secondary to reduced circulation and venous return and gravity assisted blood backflow (Hughes et al., 2011; McCulloch, 2002). Further, standing induced static muscle contraction may lead to muscle fatigue (Messing et al., 2008) and discomfort (King, 2002; Zander et al., 2004) and may trigger the development of MSDs (Garcia et al., 2015). King (2002) and Madeleine et al. (1998) suggested that the loaded muscles accumulate metabolites and become hypersensitive, further contributing to the risk of MSDs. Lack of joint movement and continuous tissue compression during prolonged standing can contribute to cartilage degeneration and rheumatic diseases over time (Canadian Centre for Occupational Health and Safety, 2008).

In contrast, phasic muscle activity helps to promote good venous return (Brantingham et al., 1970). Standing on softer surfaces has been suggested to create subtle muscular movement, reducing musculoskeletal strain, improving blood flow and decreasing discomfort and fatigue (King, 2002; Orlando and King, 2004). The fundamental principle behind using anti-fatigue mats and insoles is to provide a supportive interface between the floor and the feet and to optimise body weight distribution (White, 2002). In addition, some shoe inserts, particularly customised orthotics, provide biomechanical realignment, reduce shearing forces and alter sensorimotor control (Hatton et al., 2015).

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Material stiffness and shock absorption are considered to be the most significant determinants of discomfort during standing (Wiggermann, 2011).

There is agreement that decreasing standing time through job redesign (primary prevention) is the most effective method of reducing the risks of prolonged standing (Canadian Centre for Occupational Health and Safety, 2008; Jefferson, 2013; Ngomo et al., 2008; Van Dieen and Oude Vrielink, 1998). Unfortunately, some workers remain constrained to a standing working posture with limited opportunities to walk around or sit down, due to suboptimal job design, employment conditions, or cultural norms. For example, operating theatre clinical protocols prevent sitting down in order to protect the sterile field (Hughes et al., 2011). In places such as North America, Asia and Australia, checkout operators usually stand when serving customers, because standing is perceived to deliver better customer service and higher productivity, whereas in parts of Europe and South America this task is usually performed whilst sitting (Konz and Rys, 2002). Standing may also offer more efficiency with tasks that require heavy lifting (Messing et al., 2015).

Attempts have been made to manage standing related risk factors by using secondary level interventions including anti-fatigue mats, cushioned shoe inserts (Aghazadeh et al., 2015; King, 2002; Redfern, 1995) and replacing flooring with softer materials (Wahlstrom et al., 2012) such as rubber, carpet, vinyl or wood (Canadian Centre for Occupational Health and Safety, 2015). A number of industry bodies, among them the Association for Peri-Operative Registered Nurses (AORN) (Hughes et al., 2011), the Canadian Centre for Occupational Health and Safety (Canadian Centre for Occupational Health and Safety, 2008), Health and Safety Executive in the UK (Health and Safety Executive, 2012) and the Occupational Health Clinics for Ontario Workers (OHCOW) (Occupational Health Clinics for Ontario Workers Inc., 2012), have developed guidelines which recommend these methods.

The effects of various types of cushioning materials have been investigated using subjective reporting of fatigue and discomfort and objective measures including changes in local muscle activity, weight shifting, and changes in leg volume and local skin temperature. Previous reviews on this subject provided mixed results and focused largely on a general overview of the health outcomes of prolonged standing at work using a wide range of interventions. The methodological and reporting quality of these reviews was limited (Halim & Omar, 2011; Mohd Noor et al., 2013; Redfern and Cham, 2000; Waters and Dick, 2015). Redfern and Cham (2000) reviewed 11 studies published in the period between 1988 and 1999 and concluded that overall, softer floors were associated with decreased reports of lower back and leg pain. Material properties characterised by greater elasticity, stiffness and thickness contributed to greater comfort by improved absorption and transmission of forces. However, due to significant methodological differences between the studies, the results of objective outcomes such as leg volume, weight shifting, electromyography (EMG) findings and skin temperature, were mixed. The researchers discovered that significant subjective and physiological changes were not observed until a minimum of 3 h of exposure to standing, and suggested longer testing durations. Findings from a review by Halim and Omar (2011) and a review by Waters and Dick (2015) also supported the use of anti-fatigue mats and ergonomic footwear. Mohd Noor et al. (2013) found limited evidence that supports the effectiveness of these interventions in real industrial workplaces. Age and gender effects were not addressed in the literature to date.

Standing related occupational injuries come at a cost to both the individuals and the organisations, attributed to decrements in performance and productivity, absenteeism, medical costs and worker health and well-being (Ahmad et al., 2006). It is therefore important to seek clarification about the benefits of currently utilised interventions in order to target risk control strategies that maximise worker health and well-being and consequently profitability to organisations.

This review aims to deliver a methodologically and rigorously sound evaluation of literature on the effectiveness of softer flooring, anti-fatigue mats and shoe insoles on a range of outcomes related to discomfort and fatigue in those who stand for prolonged periods at work. It will also consider longer exposure periods as recommended by Redfern and Cham (2000). The review will also attempt to assess the impact of age and gender on the outcomes of prolonged standing as these important factors remain largely unexplored, yet there is evidence that a greater proportion of men than women usually stand at work (Tissot et al., 2009) but more women report work-related musculoskeletal pain (Messing et al., 2015). The ageing workforce adds further complexity to the issue of prolonged standing at work. In Australia for example, labour force data indicates a sharp increase in the representation of workers who are 45 years and older in the public sector since 1998 (Public Sector Commission, 2010). Research exploring age related injury factors confirms that older workers are more susceptible to injury and suffer delayed recovery (Quinlan, 2010).

This review will attempt to fill the existing gap in research and help to substantiate and further inform industry recommendations and future research directions in this area, by answering the following research questions:

- Does a cushioning material, compared to a hard floor, reduce lower body musculoskeletal discomfort in workers who work in a constrained standing position for prolonged periods?
- Are cushioned surfaces more effective than shoe inserts in reducing musculoskeletal discomfort of the lower body?
- Is there an age difference in the effectiveness of cushioning materials on musculoskeletal discomfort?
- Is there a gender difference in the effectiveness of cushioning materials on musculoskeletal discomfort?

2. Methods

The review was registered with the International Prospective Register of Systematic Reviews (PROSPERO), with registration number CRD42016039442. The registration can be accessed at http://www.crd.york.ac.uk/PROSPERO.

2.1. Search strategy

Problem/Population, Intervention, Comparison and Outcome (PICO) plus Setting model was selected to frame the research questions and the methodology (Huang et al., 2006; Methley et al., 2014).

To identify the relevant peer reviewed studies, a search of seven electronic databases was performed using a pre-determined set of search keywords, developed in collaboration with a content specialist librarian (Table 1).

The relevant databases included Medline, EMBASE, CINAHL, PsychInfo, Web of Science, PubMed and Cochrane Library. In addition, in order to minimise the risk of publication bias, an internet search of grey literature including conference proceedings, was performed using Google Scholar. A search of bibliographies of the included articles was conducted and cited references for included articles were searched using Web of Science. Advice from two subject matter experts was sought via email communication with regards to the completeness of the search results.

The screening for eligibility process occurred in two stages. The relevant studies were screened by title and abstract in the first instance, then by full text against the inclusion and exclusion criteria. Two researchers (GS and TK) were independently involved in the screening process and resolved any differences through discussion. A third author (KH) was available to arbitrate if consensus regarding eligibility was not reached.

Once all relevant studies were identified, a data extraction form was designed.

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