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Systematic Review Paper

Review on Effects of Ergonomic Interventions for Nurses on Function, Neuro-Muscular Pain and Quality of Life

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ABSTRACT

Background: Musculoskeletal disorders gain importance in the field of nursing because activities done by nurses routinely contribute to their occurrence because they are repetitive and labour intensive. To provide empirical evidence on ergonomic interventions in the field of nursing, this study assessed the effects of ergonomic interventions in nurses on function, neuro-muscular pain and quality of life.
Methods: The standard practices for systematic reviews guidelines were used in defining participants, interventions, comparisons, outcomes and study designs. The MEDLINE search strategy combined with the Cochrane Highly Sensitive Search Strategy for identifying RCTs was used to systematically search for articles published in English between 1990 and 2016. Studies where participants were nurses at the time of the intervention, and had symptoms or were exposed to risk factors for WRMDs in their workplace were considered for this review. Analysis of data were done using Review Manager 5.2 software and risk of bias was graded using sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting and reliability of instruments. Risk ratios for dichotomous outcomes, means and standard deviations for continuous outcomes with 95% confidence intervals were used for outcome measurements.
Results: Following implementation of ergonomic interventions, most studies reported 18% – 72% decrease in musculoskeletal injury incidence with adjusted RR between 0.39 – 0.82. In addition, there was a 27% - 80% substantial reduction in the prevalence of pain symptoms in any anatomical parts. However, a lack of clinical trials in this review highlight limited evidence for numerous aspects on the effects of ergonomic interventions for nurses on function, pain and quality of life.

Key words: nurses, injury, musculoskeletal disorders, ergonomics, interventions, pain, function

1. Introduction

Ergonomics is defined as adapting the worker to the work environment while, ensuring that the most favourable safety and production needs are met [1]. Ergonomic interventions focus on arranging the work environment to fit the worker, changing attitudes towards injury prevention and educating individual workers about the work environment targeting the problems that lead to WRMDs [2, 3]. In a work place, health care professionals are vulnerable to sustaining musculoskeletal disorders during the course of their work routine [4]. Musculoskeletal disorders (MSDs) are inflammatory and degenerative conditions that affects the muscles, tendons, ligaments, joints or peripheral nerves, usually leading to pain or discomfort [5]. Work-related musculoskeletal disorders (WRMDs) among workers in the health care setting exists worldwide and research suggests a substantial and regular increase [6]. They are the most common workplace injuries that are notorious and a common cause of severe long-term pain and physical disability among millions of people [7]. Origins of WRMDs have also been reported to be complex and multifactorial; resulting from disequilibrium between the requirements of the tasks performed at work impose and individual functional abilities to respond to these requirements; modulated by the

characteristics of work organization [8-11]. These disorders account for at least 40% of lost-time and often generate enormous human and economic cost because they produce different levels of functional disabilities that lead to; absence from work, medical treatment, decreased productivity and the payment of social indemnities [9-11]. Besides physical, biomechanical and ergonomic stress, the aetiology of WRMDs may include psychosocial and organizational risk factors, such as high occupational stress, inadequate social support, monotonous activities, anxiety and depression, among others [8-11].

Three primary risk factors associated with WRMDs have been identified as repetitious movements, awkward postures and high force levels [12,13]. These are common in the practice of nursing because nurses routinely perform activities such as assisting weak patients during walking, lifting and transferring patients in and out of the bed or from the floor and lifting of heavy equipment [12-14]. Work-related musculoskeletal disorders gain importance in the field of nursing because activities done by nurses routinely contribute to the occurrence of MSD [8, 15, 16] because they are repetitive and labour intensive.

In order to overcome musculoskeletal disorders or symptoms, interventions such as training, ergonomic modifications, rest breaks, and workplace exercises with various effects have been implemented. The benefits of workplace ergonomics intervention include reductions in the injuries as well as improved work quality and productivity [17, 18, 19].

Allegedly, increased numbers of sick days per year, premature retirement and poor health have been reported as consequences of WRMDs among nurses [20,8]. In addition, nurses have cited strenuous work and psychological demands as key triggers to premature retirement. In the recent past systematic reviews on WRMDs, their prevention and effectiveness of interventions among nurses have been published [21, 22, 23]. Lelis and others, [8] evaluated the evidence of the susceptibility of nursing professionals to WRMDs. Inevitably, Yassi and Lockhart [21] reviewed causal relationships between nursing tasks and lower back pain while, Schlossmacher and Amaral [22] assessed the methods of evaluating low back injury caused by unfavorable working conditions among nurses. Long and others [5] in their review considered the risk factors and functional consequences of work-related upper quadrant musculoskeletal disorders among midwives, nurses and physicians. Pertaining to anatomical sites, Ellapan and Narsigen [23] in their review described the kinesiology of prolonged vertebral flexion adopted by nurses during patient transfer activities and the gynoid somatotype as a primary intrinsic predisposing risk factor of lower back pain among nurses. The review also considered the examination of different physical therapy strategies adopted to curb the occurrence of WRMDs among nurses. Outcomes from the review suggest that nurses, who regularly participate in physical activity, lower their risk of WRMDs. This outcome is in line with Warming and others [24] who supported the motion that physical therapy is a strong therapeutic modality to resolve the symptoms of lower back injuries and enhances quality of life among nurses. Engkvist and others [25] in their review reported ergonomic-education on the application of proper patient-transfer techniques as an intervention that received considerable attention to curb poor patient -transfer techniques, which is the primary culprit of lower back pain among nurses. However, Warming and others [24] counteracted that education on the application of proper patient-transfer to nurses did not eliminate the incidence of lower back pain. In order to provide empirical evidence on ergonomic interventions in the field of nursing, this study aimed to assess the effects of ergonomic interventions in nurses on function, neuro-muscular (NMS) pain and quality of life. In addition, the review evaluated the effects of environmental, cognitive and medical interventions, on function, NMS pain and quality of life.

2. Methodology

The standard practices for systematic reviews (PRISMA) guideline checklist was adopted in defining participants, interventions, comparisons, outcomes and study designs (PICOS). Intervention studies such as Randomized controlled trials (RCTs), quasi-randomized trials, case-control, crossover trials and observational studies published in English between 1990 and 2016 were considered for this review and included studies where participants were nurses at the time of the intervention, and had symptoms or were exposed to risk factors for WRMDs in their workplace. A nurse in this review was defined as a person formally educated and trained in the care of the sick or infirm including nurse-midwife, nurse-practitioner and registered nurse. Studies examining at least one medical, environmental or cognitive intervention, or a combination of these at the workplace aimed at the preventing and reducing symptoms of WRMDs among nurses were included. Primary outcomes included; Prevalence of WRMDs, Work-related function that was measured by number of workdays lost, loss of function, loss of / change in job, work disability, and level of functioning using the modified functional independence measure and complaints or symptoms such as pain or muscle stiffness in any anatomical part using a dichotomy scale.

The MEDLINE search strategy combined with the sensitivity and precision-maximizing version of the Cochrane Highly Sensitive Search Strategy for identifying RCTs was used to systematically search for articles in English language. Biomed central, the Cochrane Occupational Safety and Health review group database, the Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE, Science Citation Index (ISI), CINAHL, Physiotherapy Evidence Database (PEDro), the US Centers for Disease Control and Prevention, the National Institute for Occupational Safety and Health (NIOSH) database and the International Occupational Safety and Health Information Centre (CIS) database were searched. For unpublished and ongoing studies, the World Health Organization International Clinical Trials Registry Platform, Trials Central, UK National Research Register (NRR), US Centers for Disease Control and Prevention's National and Institute for Occupational Safety and Health (NIOSH) websites were searched. In addition, bibliographies in relevant articles were checked to identify studies on the subject matter, after which, review authors obtained and screened abstracts and citations identified by the searches and then retrieved full-text articles independently to identify eligible studies for

independent selection. Data extraction was performed independently taking into consideration checks for discrepancies, and processing as described in the *Cochrane Handbook for Systematic Reviews of Interventions* [26] were discrepancies are resolved by consensus. Statistical analysis were done using Review Manager 5.2 [27] software. Study were graded for risk of bias using the following domains: sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting and reliability of instruments. Risk ratios (RR) for dichotomous outcomes, means and standard deviations (SD) for continuous outcomes with 95% confidence intervals (CI) were used for outcome measurements.

3. Results

Sixty-seven potentially relevant references were identified. The key search words included musculoskeletal disorders, MSDs, conditions, musculoskeletal pain, nurses, nursing staff, personnel, work-related injuries, WRMDS or WMSD, ergonomic, workload, workplace, clinical trial, interventions, randomized control trial, quality of life, physical therapy, and exercise. Titles, keywords, and abstracts of these references were assessed and 19 potentially eligible references were selected, and publications obtained. Reference lists from full papers were also assessed and three studies were identified giving a total of 22 potentially eligible studies. An ongoing trial on Prevention of low back pain and its consequences among nurses' aides in elderly care: a stepped-wedge multi-faceted cluster-randomized controlled trial [28] was identified however; this study was not included because the population under study is equivalent to nurse assistants. From the 22 studies, only 12 studies were included in the systematic review. These studies recruited approximately 2390 participants. Table 1 gives an overview of included studies and figure 1 illustrates the selection process. The characteristics of excluded studies are shown in Table 2

Five studies [24, 29, 30, 31, 32] evaluated ergonomic training and environmental interventions, three studies [33, 34, 35] assessed combined interventions (ergonomic training, medical and environmental interventions). The rest of the studies assessed only medical interventions [36, 37] and environmental interventions [38]. Most studies [29, 30, 32, 33, 34, 38] had a follow-up period of between 1-3 years. Most of the studies, which were included in this review, were observational studies. Therefore, a tool to assess risk of bias that contains eight question items measured on a Likert scale for cohort studies was used to assess bias. Overall, the risk of bias in the included studies was unclear Table 3.

Effects of ergonomic interventions on neuromuscular pain.

Effects of ergonomic interventions on neuromuscular pain were reported in eleven studies [29-37, 39]. The program elements in these studies resulted in statistically significant decrease in the rate of musculoskeletal injuries and symptoms of NMS pain post intervention. In four of the studies [31, 33-35] effects of ergonomic interventions on work related function and changes in their risk factors were measured. Outcomes showed a significant reduction in workers' compensation costs, lost workday injuries as well as the number of modified duty days taken per injury after the intervention. In one study [34] there was a statistically significant increase in two subscales of job satisfaction that is professional status and tasks requirements, which subsequently influenced worker retention. After ergonomic interventions five studies [33,34,36-38] reported significant improvement in participants cardiopulmonary function, body mass index, muscle strength, range of motion, flexibility and durability which improved quality of life by promoting health related physical fitness.

Incidence of Work-related musculoskeletal disorders and complaints or symptoms of pain in any anatomical part following implementation of ergonomic interventions

Following implementation of ergonomic interventions, most studies [36,38-43] reported 18% – 72% decrease in musculoskeletal injury incidence with adjusted RR between 0.39 – 0.82 (Figure 2). In addition, there was a 27% - 80% substantial reduction in the prevalence of pain symptoms in any anatomical parts. However, in one study [32] there was an increase in the prevalence of upper back and hip symptoms post intervention but this result was not seen in other body regions.

Work-related function and quality of life

Work-related function was measured by the number of workdays lost, loss of / change in job, work disability and level of functioning. In post-intervention assessment, most studies [24, 29-31, 34, 35,38, 39] highlighted decrease in the number of modified duty days taken per injury, lost workdays and total lost days due to injury. Subsequently, there was an improvement in the quality of life for workers and a reduction in treatment costs and worker compensation. Figure 3 shows work-related function and quality of life. Participants self-reports in some studies [29-32] indicated that implementation of ergonomic interventions increased confidence, motivation, performance in patient handling activities as well as job satisfaction and decreased unsafe patient handling practices and physical stress. After therapeutic intervention [36,37] reported significant improvement in participants cardiopulmonary function, body mass index, muscle strength, range of motion, flexibility and durability which improved and promoted health related physical fitness.

Table 1: Characteristics of included studies

Author	Title	Outcomes
Freimann et al, (2015)	Effects of a home-exercise program (Medical intervention) on cervical and lumbar range of motion among nurses with neck and lower back pain: a quasi-experimental study	Intensive home-exercise therapy program improved cervical and lumbar range of motion among intensive care nurses
Owen et al, (2002)	An ergonomic approach to reducing back/shoulder stress in Hospital nursing personnel: a five year follow up	Reduction in back/shoulder injuries, number of lost work and restricted days
Collins et al, (2004)	An evaluation of "best practices" musculoskeletal injury prevention programme in nursing homes	Reduced incidence in handling injury, worker compensation and lost work day injuries
Nelson et al, (2006)	Development and evaluation of a multifaceted ergonomic programme to prevent injuries associated with patient handling tasks	Decreased rate of musculoskeletal injuries and modified duty days taken per injury. Significant increase in job satisfaction
Soon and Jong, (2010)	Development of an intervention to prevent work-related musculoskeletal disorders among hospital nurses based on the participatory approach	Reduced risk factors at the hospital wards and improved activities that involved subject participation
Lagerstrom et al, (1996)	Evaluation of the implementation of an education and training programme for nursing personnel at a Hospital in Sweden	Increased prevalence of upper back and hip symptoms from 1992-1995
Smedly et al, (2003)	Impact of ergonomic intervention on back pain among nurses	Change in risk factors insufficient to produce a substantial reduction in back pain
Hartvigsen et al, (2005)	Intensive education combined with low tech ergonomic intervention does not prevent low back pain in nurses	Intense weekly education, transfer techniques and low-tech ergonomic equipment was not superior to 1 day instructional meeting.
Evanoff et al, (2003)	Reduction in injury rates in nursing personnel through introduction of mechanical lifts in the work place	Lifts were effective in reducing musculoskeletal injuries in nurses.
Knibbe and Friele, (1998)	The use of logs to assess exposure to manual handling of patients illustrated in an intervention study in home care nursing	Reduction in the number of transfers: hoists appeared to provide solution for about 1/3 of the total transfers
Warming et al, (2008)	Little effect of transfer technique instruction and physical fitness training in reducing low back pain among nurses: a cluster randomized intervention study	Ergonomic training minimized chances of lower back pain among nurses. However, education on the application of proper transfer techniques had no effect.
Yuan et al (2009)	An intervention program to promote health-related physical fitness in nurses	Regular exercising nurses had a lower risk of lower back pain

Table 2: Characteristics of excluded studies

Author	Title	Reason for Exclusion
Rasmussen et al (2013)	Prevention of low back and its consequences among nurses' aides in elderly care: a stepped–wedge multifaceted cluster-RCT	Study population comprised nurse assistants
Goshwami et al (2013)	An ergonomic study of postural stress of nurses working in orthopedic wards	Evaluated different work-related musculoskeletal strains to find out ergonomic solutions
Schmidt and Dantas (2012)	Quality of work life and work-related musculoskeletal disorders among nursing professionals	No ergonomic intervention done
Fujishiro et al (2005)	The effect of ergonomic interventions in health care facilities on musculoskeletal disorders	Assessed consultation and financial support for purchase of ergonomic devices
Edlich et al (2004)	Prevention of disabling back injuries in nurses by use of mechanical patient lift systems	No interventions were done
Alexander et al (2001)	Evaluation of a programme to reduce back pain in nursing personnel	Study population comprised nurse assistants
Garg and Owen (1992)	Reducing back stress to nursing personnel: an ergonomic intervention in a nursing home.	Study population comprised nurse assistants

Figure 1: Study selection process

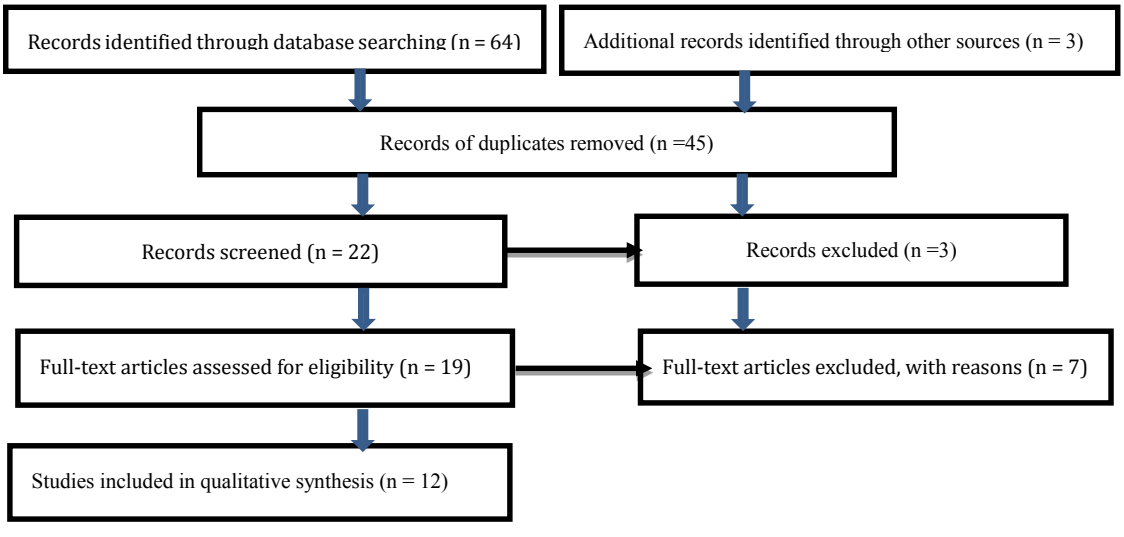

Figure 2: Complaints or symptoms of pain following ergonomic interventions

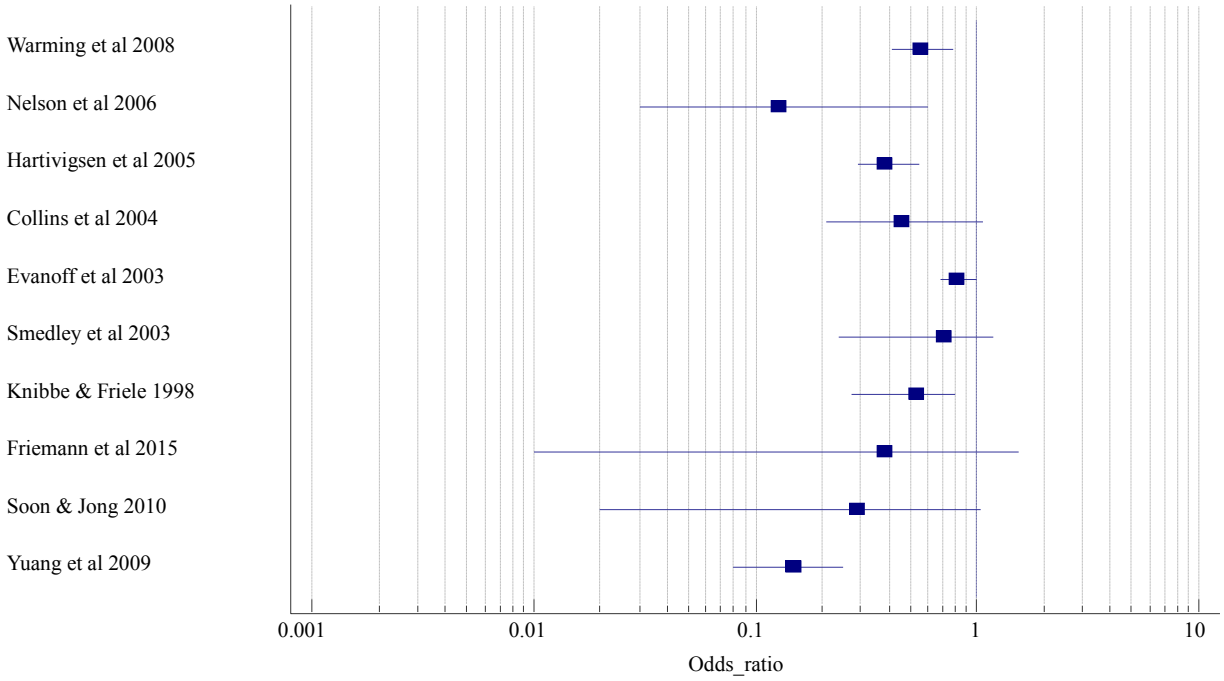

Figure 3: Work-related function and quality of life

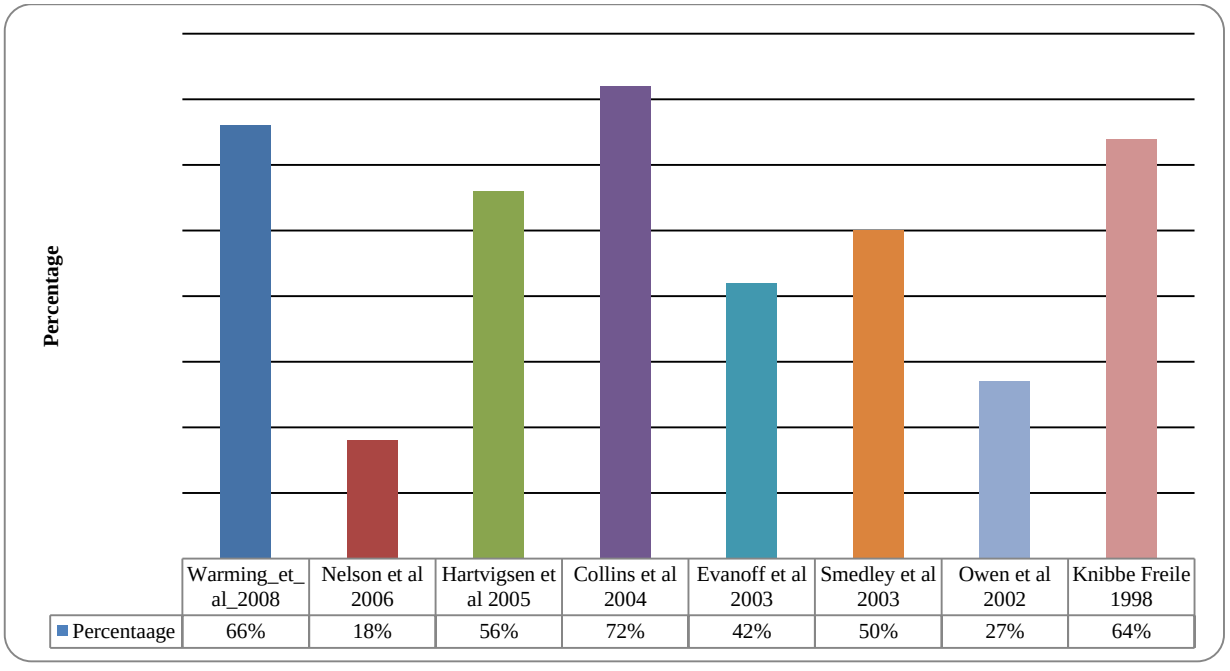

Table 3: Risk of Bias in included studies

	Freimann et al (2015)	Owen et al, (2002)	Collins et al (2004)	Nelson et al, (2006)	Soon & Jong (2010)	Lagerstrom et al (1996)	Smedley et al (2003)	Hartvigsen et al (2005)	Evanoff et al (2003)	Knibbe & Friele (1998)	Warming et al (2008)	Yuan et al (2009)
Exposed and non-exposed cohorts drawn from the same population	√	x	x							?	√	
Confident in the assessment of exposure	?	x	x	?	?	?	x	x	√	x	?	x
Outcome of interest was not present at start of study	√	√	√	x	x	x	?	?	?	x	?	x
Matched all variables associated with outcome or adjusted for these prognostic variables		x	?							x	x	x
Confident in assessment of the presence or absence of prognostic factors	?	?	x	?	?	?	x	x	?	?	?	?
Confident in the assessment of outcome	?	?	?	√	?	?	?	√	?	?	x	√
Adequate follow up of cohorts	?	√	?	?	?	√	√	√	√	√	√	√
Co-Interventions similar between groups	?		?		?		?		?	x	x	x

√ = definitely yes ? = probably yes x = probably no blank = not indicated

4. Discussion

Nurses report one of the highest rates of work-related disorders and accidents compared to other professions [40, 41]. Across all specialty areas of nursing, patient- handling activities have been acknowledged as major contributors to the high incidence of these debilitating injuries, in particular the lower back, neck and shoulders [30, 34]. Over the years, wide ranges of intervention strategies have been used to manage this problem. These could be divided into factors focusing on the organisation, and the individual. This review aimed to review the literature to assess the effects of ergonomic interventions in nurses on function, pain and quality of life in relation to WRMDs prevention. Ergonomic interventions in this review included; environmental, ergonomic training/education, therapeutic and combined interventions. Following implementation of interventions, most studies [24, 29-31, 34, 35, 38, 39] reported decrease in musculoskeletal injury incidence and substantial reduction in the prevalence of pain symptoms in any anatomical body part. However, in one study [32] an increase in the prevalence of upper back and hip symptoms post intervention was recorded and was attributed to an increase in cumulative physical exposure over time. Lack of clinical trials or high quality studies in this review highlight limited robust evidence for numerous aspects of WRMDs prevention. Nevertheless, moderate evidence from studies reviewed suggests that combined interventions or multidimensional strategies are effective in the management and prevention of WRMDs in the field of nursing. Similarly previous research, highlights that owing to the multidimensional nature of work-related injuries, no single intervention is likely to be effective at preventing the overall problem of these injuries, although there is likely to be benefit from getting all the players onside [28,33,41].

According to Nelson and Baptiste [41], patient handling tasks are performed in diverse clinical settings and are characterized by significant biomechanical and postural stressors. In addition, factors such as the patient's weight, transfer distance, confined workspace, unpredictable patient behavior, and awkward positions such as stooping, bending, and reaching significantly contribute to the risk of performing patient handling tasks. To minimize the effects of these activities environmental interventions, implemented in this review, included; hoists, mechanical lifts, transfer belts, sliding sheets, lifting equipment and other low-tech ergonomic aids. Environmental interventions are engineering control changes made to the work environment, layout, tools, or equipment used on the job, or changing the way a job is done to avoid work-related musculoskeletal hazards [42]. In addition, engineering controls are the best line of defense for worker protection and can be effectively applied to patient handling. These controls are a preferred solution because they create permanent changes that eliminate risks at the identified source. However, the degree of effectiveness of using patient handling equipment and devices to prevent musculoskeletal disorders is significantly dependent on factors related to availability, maintenance, and sufficient space. Trinkoff and others [43] submits that disrepair and dilapidation of this equipment may unnecessarily subject both caregiver and patient to preventable risk for injury. There was significant reduction in the incidence of musculoskeletal injuries, number of lost workdays and worker compensation in studies were mechanical lifts and hoists were implemented which suggests that lifts and hoists are effective in reducing musculoskeletal injuries associated

with patient handling. However, in studies were low-tech ergonomic aids, sliding sheets and transfer belts were implemented changes in risk factors were insufficient to produce a substantial reduction in pain and musculoskeletal injuries. Taking into consideration the methodological quality of these studies, the evidence is insufficient to recommend for or against these gadgets.

Ergonomic training on the application of proper patient transfer techniques has received considerable attention in the past. Shepherd [44] highlights that ergonomic training is a behavioral or work practice control which involves training of staff in body mechanics, or other joint protection principles such as manual patient lifting, training in proper use of lifting equipment/devices, and the use of unit-based peer leaders. In this review, ergonomic training alone did not minimize chances of musculoskeletal injuries. Lagerstrom and others [32] reported that the prevalence of upper back and hip symptoms increased following the training intervention. Similarly, Warming and others [24] reported that education on the application of proper patient transfer to nurses did not eliminate the incidence of lower back pain. Therefore it is assumed that either the advocated techniques did not reduce the risk of injury or training did not lead to adequate change in lifting and handling techniques among the participants. The outcome in this review may suggest that ergonomic training/education without lifting equipment or other intervention is inadequate in the prevention of WRMDs or consequent disability. Hence, the need for conducting other intervention studies to provide clinical evidence of its value in combating WRMDs.

Physical activity acts as a protective measure against WRMDs when adhered to by nurses [25]. Proper and colleagues [45] and Warming and others [24] support the notion that exercise is a strong therapeutic modality to resolve the symptoms of lower back injuries and enhances quality of life. Often a physical exercise intervention is accompanied by other interventions and may be more effective when combined with manual therapy [46]. Therapeutic interventions highlighted in this review include exercise and physical therapy. These studies demonstrated significant positive effects towards exercise and physical therapy in the prevention of recurrence of sick leave due to cervical and lower back pain [34, 35]. Particularly, Yuan and others [35] documented that nurses who regularly participate in physical activity and exercise lower their risk of WRMDs. This finding corresponds with that of another review, in which exercise had positive effects among workers with neck and upper limb pain [47]. In another review, Kupper and others [48] reported that despite the lack of strong scientific evidence, anecdotally physiotherapy was an effective treatment option for upper limb disorders.

The World Health Organization (WHO) characterized WRMDs as multifactorial to indicate that a number of risk factors i.e. physical, work organizational, psychosocial, individual, and sociocultural contribute to causing these disorders [11]. This implies that possible risk factors of physical, psychosocial or personal origin can reinforce each other. Therefore, an integrated approach is a promising strategy in prevention of WRMDs. In a systematic review Meijer and others [49], reported that effective treatment programmes appear to contain multiple components, such as relaxation exercise, physical, work, knowledge and psychological conditioning. Outcomes form combined interventions in this review shows significant decreased rate of musculoskeletal injuries, modified duty days taken per injury and reduced worker compensation. In addition, an increase in job satisfaction and improved activities involved subject participation. Similarly, Rasmussen and others [28] echoes that multifaceted interventions consisting of Physical and participatory ergonomics, cognitive behavioural training and physical exercises reduce sick off days, pain intensity and frustration in workplaces.

5. Conclusion

It is undeniable that ergonomic interventions are worth undertaking in the field of nursing because high-risk patient-handling tasks cause significant biomechanical and postural stressors on the spine and extremities resulting in musculoskeletal injuries. However, a lack of clinical trials in this review highlight limited evidence for numerous aspects on the effects of ergonomic interventions for nurses on function, pain and quality of life. Earlier studies concluded that use of specialised or lifting equipment such as ceiling lifts, hoists or mobile lifts to reduce physical strain on nurses' in-patient handling tasks is an element associated with reduced WRMDs. However, in developing countries this is not practical, as most hospitals do not have the provisions for installing hoists. Nevertheless, this review submits that a combination of optimal clinical, rehabilitation and environmental interventions is more effective than single elements in management of WRMDs in the field of nursing. This is because, the origins of WRMDs are complex and multifactorial arising from disequilibrium between the requirements the nursing task performed and individual functional abilities. In addition, the economic costs associated with investing in these pieces of equipment my not be feasible in most developing countries. Therefore, it is recommended that detailed studies regarding hoist installations based on engineering efficacy, cost and applicability be done in developing countries. In addition, the Ministry of Health and Hospital Administrators in developing countries must consider introducing ergonomic interventions in health care institutions such as regular exercise by nurses as it contributes to the reduction of neuromuscular pain and improves quality of life and productivity.

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Conflict of interest declaration

None

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