Musculoskeletal risk factors in cleaning occupation—A literature review

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Abstract

The objective of this paper is to present a systematic review of the literature in the field to identify problems, recommended practices, unresolved issues and explore occupational needs related to cleaning problems. Selected for review were published and unpublished reports dealing with musculoskeletal disorders among cleaners. English language summaries of other language articles were also included. The factor mentioned most often is that cleaning is associated with high physical and psychosocial workloads. Recommended ergonomic interventions were summarized in a model to present a systematic overview, useful for research and practical applications. A few studies concern equipment design, working environments and factors affecting individual workers. A need to conduct research on cleaning tools/equipment, working environments and individual risk factors is apparent.

Relevance to industry

Ergonomic strategies and methods are not widely practiced in the cleaning profession. If ergonomic principles can be integrated into existing cleaning industry tools, methods and work environments then efficiencies can be realized and the risk of occupational injuries will be reduced. The work efficiency and injury reduction will reduce employer-operating costs.

Keywords: Cleaners; Building cleaners; Ergonomics of cleaning; Musculoskeletal disorders; Tool design

1. Introduction

The core task of cleaners can be simply described as the removal of dirt, dust, marks, strains and other extraneous materials from surfaces. The work of cleaning has an important role in general work and public environments as it enhances worker/public feeling of health and well-being. Clean work areas also promotes productivity and quality of output. Unclean environments can lead to accidents, and without cleaning there is a greater risk of exposure to irritants which can lead to problems such as allergic reactions and respiratory ailments. The goal of cleaning can thus be described as contributing to the maintenance of hygienic work and public environments. Cleaning consists of tasks such as dusting, mopping, sweeping, swabbing, vacuuming and buffing. Cleaning work may also include additional tasks such as handling waste materials for the purpose of disposal, and the lifting/moving of furniture/equipment (Johansson and Ljunggren, 1989).

Occupations, where cleaning is the sole or primary work activity, are common throughout the world. There are approximately 3 million full or part time cleaners working in the private and public sectors of the European Union (EU), (Louhevaara, 1997). In Sweden 78,800 persons work as cleaners (SCB (Statistiska centralbyråns/Statistics Sweden), 2005). Of this number, 63,300 are females and 15,500 are males. In the United Kingdom there are approximately 800,000 persons working as cleaners (Woods and Buckle, 2005b). According to US Department of Labor (USDL, 2005), over 4 million persons work in building cleaning in the United States. Cleaners work in office buildings, hospitals, stores, apartment houses, hotels, and any other place where people congregate. It is full or part time work, mostly performed alone but, sometimes as groups or teams (Hopsu, 1993; USDL, 2005; World Health Organisation...
(WHO, 1993). The majority of cleaners are older women (WHO, 1993). Many of them are of lower social status, with little education, at a low level and without significant social support (De Vito et al., 2000). Work hours are often early in the morning, during lunch periods and late in the evening (to avoid interfering with the activities of others). Most cleaners learn skills on the job. Beginners are often paired with an experienced workers and carry out the most routine tasks (USDL, 2005). The Dictionary of Occupational Titles reports that learning tasks/duties takes no longer than 1 month; this falls within the “unskilled” category of the classification system used (USDL, 1991).

Wages of cleaners vary widely between labor markets. A report by Corley et al. (2005), that is part of the International Labour Organization’s (ILO) key indicators of the labor market, suggests that wages for work such as performed by cleaners is low in comparison to most other occupations. More specifically, USDL(2004, 2005) employment statistics on jobs in the US show that the median earnings of building cleaners is approximately one-half of the median income for all occupations.

This background information about the occupation of cleaning describes jobs which are common, which do not require specialized education or training, which employ more women than men (who are older), which are frequently performed outside of normal working hours, which are low in status and which have average wages lower than most other occupations.

1.1. Risk factors in cleaning occupation and the extent of the problem

Several studies about cleaning jobs describe typical physical demands of this work (Hagner and Hagberg, 1989; Hopsu et al., 1994; Søgaard et al., 1996). All authors found that the most significant risk factors associated with the physical work of cleaners are static muscle loads (much of which involves bending and twisting of the back) and repetitive movements of the arms and hands using a high output of force. These types of prolonged static and repetitive muscle activities cause muscle fatigue and may lead to musculoskeletal disorders (Krugér et al., 1997; Kumar et al., 2004). Danish and Swedish studies on occupational health among female cleaners describe cleaning as having a high risk of musculoskeletal disorders (Ahlstrand and Lidehäll, 1981; Holm et al., 1984; Petersson 1992; Nielsen 1995). Other Scandinavian studies have reported that physical strain is high for cleaning activities (Hagner and Hagberg, 1989; Louhevaara et al., 1983; Winkel and Ekbolm, 1979; Winkel et al., 1983).

Other research has found that the tools and equipment used in cleaning require users to engage in both dynamic and static muscular activity (Hopsu et al., 1994). A high cardiovascular load when performing cleaning work (Hagner and Hagberg, 1989; Kumar et al., 2005b) and frequent use of awkward postures (Kumar et al., 2005a; Messing et al., 1992; Woods and Buckle, 2005b) has also been described. There are other studies that describe cleaning activities as strenuous (Hagner and Hagberg, 1989; Johansson and Ljunggren, 1989; Kumar et al., 2005a, b). The Dictionary of Occupational Titles (USDL, 1991) describes building cleaning work as being heavy in physical demand—that system classifies heavy work as requiring occasional exertion of force up to 45 kg, frequent exertion of force up to 23 kg and constant exertion of force up to 9 kg.

Incidence of physical problems is also a consideration; a typical cleaner is an older female who is more likely to experience physical discomfort performing sustained, heavy work. A Danish study of 1166 female cleaners found that in the past 12 months 63% reported having neck discomfort, 63% reported shoulder problems, 36% reported low back pain, 27% reported stiffness in their elbows and 46% reported some type of wrist problem (Nielsen, 1995). In a Swedish study of a representative sample of 62 cleaners Kilbom (1990) found that in the previous 7 days 22% claimed to have trouble with the neck, 33% with the shoulders, 33% with the low back and 11% with the wrist. A German project on health promotion among hospital cleaners found that approximately 90% of their jobs as heavy and 62.4% complained that inadequate time was allocated for proper completion of assigned tasks (Huth et al., 1996). A joint study of approximately 9000 hotel and office cleaners carried out jointly by Arbetsmiljöverket (The Swedish Work Environment Authority) and statistiska centralbyråen (SCB—Statistics Sweden) found that during the period 1997–2001 approximately 51% had pain and discomfort in the shoulders and hands on a weekly basis, 43% had weekly pain and discomfort in the extremities, 46% had pain weekly in the upper back and 39% had weekly pain in the lower back. Other, general descriptions, such as mention of back problems, can be found in descriptions of cleaning work such as from the US Department of Labor’s Bureau of Labor Statistics (USDL, 2005).

The 1993 WHO report on aging and work capacity mentions that cleaning is an occupation that attracts older, unskilled women. This is a group where many members enter the labor market after their children are grown. Any occupational skills acquired earlier are dated or proficiencies have been lost so cleaning work is an occupation they can perform. However, research (e.g. Ilmarinen, 1994) has found that older workers who engage in prolonged static muscular activity, overuse of muscle capacity, repetitive movement, lifting, carrying, bending and twisting—common in cleaning work—are the group at highest risk for musculoskeletal disorders.

1.2. State of the art

A number of researchers have studied cleaning methods and working postures along with the physiological, biomechanical and psychosocial aspects of cleaning (Hagner and Hagberg, 1989; Johansson and Ljunggren,
1989; Kumar et al., 2005b; Louhevaara, 1997; Louhevaara et al., 2000; Nordin et al., 1986; Søgaard et al., 1996). The findings of these studies describe work activities where inappropriate and poor working postures are common (e.g. reaching and stooping to access out of the way places), work areas not designed to be easily cleaned and cleaning tools that require unnecessary levels of force. Organizational factors such as long hours, low salaries and inconvenient working times were also described. All these factors were viewed as likely to increase the risk of musculoskeletal injuries.

In a study commissioned by the EU, Krüger et al. (1997) reported that cleaning tools are not designed to minimize the amount of effort a cleaner must exert to complete a task. This pattern has continued; new cleaning tools introduced into the marketplace generally lack any sort of thorough ergonomic evaluation. For example, the broom and mop handles used by the majority of cleaners continue to be essentially a straight rod with a broom or mop head at one end. Descriptions of tool modifications are more frequently of tools modified for individuals or single workplaces; sometimes as part of an overall ergonomic intervention (e.g. Beato et al., 1998; Hagner and Hagberg, 1989; Haslam and Williams, 1999; Hide et al., 2000; Kumar et al., 2005a, b; Woods and Buckle, 2005a). All these factors paint a picture of marginal support on the part of employers and funding sources for ergonomic intervention in an occupation where there are large numbers of employees.

Woods and Buckle’s (2005a) stated that commonly used cleaning tools were not designed using ergonomic principles; strenuous working postures, repetitive movements, heavy work loads and high force requirements are some of the resulting problems.

The scientific literature that concerns cleaning work often includes mention of different physical activities carried out by cleaners. However, the focus of the descriptions is on elements of cleaning work or the effects of cleaning work rather than on a comprehensive description of the occupation. This creates a fragmented description of the physical and mental demands of cleaning work. For the purpose of this literature review, the definition developed for the US Department of Labor by the The Occupational Information Network is referenced (O*NET, n.d.). Mentioned here are demands of interest to the issue of musculoskeletal injury; other job descriptors such as typical protective equipment worn are not included.

The O*NET (2006) definition of janitor/building cleaner mentions the following physical demands (Each demand is followed by a numerical score. The number is out of a possible 100. This number is more a guide as to the relative importance of a particular physical activity with respect to the ability to work as a cleaner. Descriptors with low numbers, such as time spent sitting, have been omitted.):

- **Static strength**—75 (The ability to exert maximum muscle force to lift, push, pull, or carry objects.)
- **Stamina**—71 (The ability to be physically active over long periods of time without getting winded or out of breath.)
- **Trunk strength**—71 (The ability to use abdominal and lower back muscles to support part of the body repeatedly or continuously over time without giving out or fatiguing.)
- **Dynamic strength**—66 (The ability to exert muscle force repeatedly or continuously over time. This involves muscular endurance and resistance to muscle fatigue.)
- **Extent flexibility**—58 (The ability to bend, stretch, twist, or reach with the body, arms, and/or legs.)
- **Handling and moving objects**—83 (Using hands and arms in handling, installing, positioning, and moving materials, and manipulating things.)
- **Performing general physical activities**—83 (Performing physical activities that require considerable use of the arms and legs and moving the whole body, such as when climbing, lifting, balancing, walking, stooping, and handling materials.)
- **Time spent walking and running**—50.
- **Time spent bending or twisting the body**—50 and
- **Time spent kneeling, crouching, stooping, or crawling**—50.

Apparent from this list of descriptors is that the work of a cleaner is physically demanding, constant and often requiring the use of many muscle groups. Individuals with any significant function limitation may have difficulty performing cleaning tasks in the time normally allocated by employers for completion.
1.4. Initial assessment and review objectives

The literature discussed in the preceding sub-sections raises several issues of potential interest to ergonomists. First, is that for an occupation that makes up a significant percent of the world’s workforce, the extent and nature of ergonomic research is disproportionately small when compared with other occupations or occupational groups. Second, is that avenues for efficient ergonomic interventions in cleaning work are not well described. Third is that, despite the lack of any major ergonomic interest in the occupation of cleaning, this work activity appears to be an ideal candidate for the development of ergonomic strategies that can help to create safer and healthier working conditions.

To better understand the different factors that may impact upon the health of cleaners, a literature survey of relevant material was conducted. The objective of the survey was to carry out a systematic review of cleaning literature. By having a clearer understanding of the ergonomic factors affecting cleaning work the best points for interventions could be identified and articulated.

The literature study was carried out using, as a starting point, the database Ergonomics Abstracts. Ergonomics abstract of published papers and unpublished reports from 1979 to 2005 were reviewed for inclusion. Copies of articles found through the search were obtained and reviewed. Articles not in English were included when abstracts/summaries were available. When the literature being reviewed referenced a previously unidentified article then a copy of that article was obtained.

2. Conceptual model of potential factors for musculoskeletal disorders among cleaners

To better support the literature survey, a conceptual model of factors that can contribute to musculoskeletal disorders in cleaners was developed. The model is shown in Fig. 1.

This model looks at the physical load placed on a worker’s musculoskeletal system (Load), the responses of tissues to the loading (Tissue response) and any subsequent adaptation of the worker (positive or negative) from the loading (Outcome). This is a model that incorporates commonly recognized responses to physical demands upon the body such as described by Kumar (2001). In addition, the model recognizes that there can be a range of influencers (Physiological and Psychological Elements) that may affect the physiological response to the same load. The origins of these can vary; irregardless of origin, they cause a body’s physiological response to vary from one time to another. The variation may be minor or it can be large and mean that the physical capacity of musculoskeletal tissue is exceeded. This model recognizes that a worker may adapt to workloads (such as increases in strength, fitness, or conditioning) or experience harmful outcomes that may result in permanent/long-term impairment to a level that prevents performance of essential job functions.

This model includes the following influencing factors which may contribute to the causation of musculoskeletal disorders:

1. Work procedure(s), work environment(s) equipment, tool(s)/method(s).
2. Individual worker factors and traits (e.g. age, health, anthropometry, education).
3. Organizational and psychosocial context(s).

These influencing factors may or may not be present in a wide range of mixes. In concert or individually they influence the load-carrying capacity of musculoskeletal tissue. Recognition that influencing factors, in addition to load and physical capability, can contribute to the causation of musculoskeletal disorders is well established (e.g. Bongers et al., 1993). In this model, intervention through alteration of any of the influencing factors will reduce the risk of musculoskeletal injury.

The following sections review literature about these factors. Emphasis is on literature that concerns cleaners and occupational health issues; studies not directly concerning cleaners have been included when information is relevant to cleaning work and/or there are few studies about cleaning work.

3. Work procedure(s), work environment(s) equipment, tool(s) and musculoskeletal disorders

3.1. Task physical demands as a work procedure

Literature on the physical demands of different occupations is in general agreement that the greater the physical demand the greater the probability of musculoskeletal injury. For example, many researchers have identified a relationship between musculoskeletal discomfort and frequency of repetitive movements (e.g. Muggleton et al.,
1999; Wilson, 1983). Repetitive movement has also been described as contributing to musculoskeletal disorders (e.g. Chavalitsakulchai and Shahnaz, 1991; Ekberg et al., 1994; Li et al., 1995; Ohlsson et al., 1995). Too, repetitive movement when in an awkward postures has also been described as contributing to different musculoskeletal disorders (Piligian et al., 2000). Researchers have also described a relationship between musculoskeletal discomfort and the duration of repetitive movement (Muggleton et al., 1999; Wilson, 1983). Kumar’s (2001) discussion of theories of musculoskeletal injury causation mentions that loads and repetitive work can result in cumulative load and differential fatigue, which in turn will affect capacity.

Unnatural and static postures have also been described as contributing to musculoskeletal disorders in different occupations (e.g. Monad, 1985; Ohlsson et al., 1995). Forceful arm and hand movement is another motion performed during work activity than can lead to musculoskeletal disorders (Veiersted, 1994). Low back disorders have been associated with working in a forward, bent position (Vingård et al., 2000). In other studies the relationships between poorly designed workplaces resulting in poor posture and disorders of the musculoskeletal system have been described (Kilbom, 1988; Louhevaara et al., 1990; Ohlsson et al., 1989; Strasser et al., 1989).

Although the physical demands and associated musculoskeletal problems described above are based on occupations other than that of a cleaner, the findings and conclusions can be directly related to the work of a cleaner. The descriptions in Part 1.3 of physical activities performed by typical cleaners includes those that match closely with descriptions in the two preceding paragraphs. This suggests that the findings, although concerning different occupations, could be related to the occupation of cleaners as well.

Studies of physical demands imposed by cleaning work have found that both the frequent static muscular work and the repetitive arm/hand movements contribute to the musculoskeletal problems being experienced (Hagner and Hagberg, 1989; Hultman et al., 1984; Lehtinen et al., 1985; Louhevaara et al., 1982). Søgaard (1994) suggested that the sustained repetitive motions of mopping with accompanying infrequent pauses in activity may exhaust the relatively small numbers of muscle fibers being used and result in muscular disorders.

Static and/or poor work postures of the back and arms are reported in studies on cleaning work (Hopsu, 1997; Hopsu et al., 1994; Lehtinen et al., 1985; Louhevaara et al., 1983) reported that a significant amount of time is spent in a forward bent posture (the time reported ranged from 36% up to 56%). The same researchers found that one or both arms were above shoulder level from 24% to 43% of the time in cleaning work. Squatting took up from 3% to 14% of work time. Søgaard et al. (1996) found that a redesigned mop (a bent shaft) can reduce loading and help to avoid awkward postures.

3.2. Working environment

Cleaners usually work in facilities designed for other activities or work processes; how to clean an area is an afterthought rather than a part of design planning (Krüger et al., 1997). As a result of the minimal consideration given to ease of cleaning, the interior design of public spaces and work areas does not facilitate cleaning processes. Poor postures, awkward movements and static work loads may be present because buildings were not designed to be easy to clean. Despite considerable physical effort, design flaws can prevent efforts of cleaners to be thorough.

Research has found that fixtures, furniture and other design elements often require cleaners to adopt difficult working postures which cause pain and discomfort (Kumar et al., 2005a; Woods and Buckle, 2005b). Kumar et al. (2005a) found that cables on floors and behind desks forced cleaners to squat and crawl to lift the cables when mopping. Binding and attaching the cables to the underside of desks provided an extremely simple but effective design solution.

3.3. Cleaning tools/methods

About 80% of cleaning work is manual, using non-powered tools and about 30% of this is spent mopping (Hopsu et al., 2000). Wet/dry mopping entails moving a long handled mop in a figure eight pattern across a floor while slowly walking backwards. The movement is controlled by the wrists and a high muscle force is necessary. Studies comment that this combination of force and repetitive movement places workers at risk for musculoskeletal problems in the hand/wrist area (Hagner and Hagberg, 1989; Toivanen et al., 1993; Søgaard et al., 1996). Specifically, frequent floor mopping seems to lead to a high static load on the upper arm and back muscles (Hagner and Hagberg, 1989). Structural changes in the carpal tunnel region were associated with movements of the lower arms, elbows and wrists when mopping (Pierre-Jerome et al., 1996). In Finland, wet mopping is uncommon as it believed that the results do not justify the amount of strain placed on cleaners (Krüger et al., 1997). Hopsu et al. (2000) and Louhevaara et al. (2000) found that wet mopping causes greater cardiorespiratory and muscular loading. Other studies (Lehtinen et al., 1985; Winkel and Ekholm, 1979) have also reported that wet mopping has a higher cardiorespiratory load than does damp/dry mopping. Hagner and Hagberg (1989) reported that the figure eight mopping pattern has a higher oxygen consumption level than does mopping by pushing backwards and forwards. A comparison of floor scrubbing and mopping by Søgaard et al. (1996) found that both methods had drawbacks. A study by Kumar et al. (2005b) reported that a redesigned mop (a bent shaft) can reduce loading and help to avoid awkward postures.
Messing et al. (1992) recommended redesign of toilet brushes (adjustable handles) to help avoid more difficult postures and movements. A short-handled broom was found to require greater force than a long-handled broom at the L5-S1 level in the back; long-handled brooms described as being less likely to cause musculoskeletal discomfort/injury at the L5-S1 level (Stubbs and Guan, 1996).

Powered cleaning equipment such as scrubbers, buffers and vacuum cleaners are not uncommon. Studies have reported musculoskeletal problems from the use of some models of buffing machines. Haslam and Williams (1999) reported the some users of single disc cleaning machines reported discomfort in the hands (39%), shoulders (19%), wrists (7%), lower back (7%) and arms (6%). A study of single disc machines by Hide et al. (2000) reported that high force was required for control. Handle design and height also created control problems. Haslam and Williams (1999) and Woods and Buckle (2005a) have described buffing machine switch and control design deficiencies such as location and the amount of force needed for operation. Vibration and machine size were also seen as deficiencies that made control difficult.

There are few studies on vacuum cleaner design and none of vacuum cleaner users (Woods and Buckle, 2005a). In a study of three vacuum cleaner designs, Looppik et al. (1994) found that subjects had difficulties learning how to use different features. Inappropriate gripping, unintentional operation of the mechanical suction feature, understanding how to regulate power, adjustment of the power suction feature and difficulty in understanding how to change the brush control were the most common problems experienced by the subjects. Schopp et al. (1995) reported that users of self-service vacuum cleaners at places such as petrol stations must exert high levels of force for control because of factors such as high hose diameters, hose stiffness and nozzle design. Woods and Buckle (2005a) have made vacuum cleaners design recommendations. The recommendations do not address all vacuum designs nor fully assess cleaner needs.

4. Individual factors and musculoskeletal disorders

Age (English et al., 1995; Guo et al., 1995), gender (Hales et al., 1994), anthropometry (Heliövaara, 1987; Nathan et al., 1993), smoking (Finkelstein, 1995) and general health/physical condition (Gamperiene et al., 2003) have been described as contributing to musculoskeletal disorders.

4.1. Age

Musculoskeletal disorders are more common among older workers. For example, by the age of 35 many people have experienced their first episode of back pain (Guo et al., 1995). Buckwalter et al. (1993) found that musculoskeletal disorders were the most common and symptomatic health problems in the middle-aged and older population studied. Other studies found that age is associated with musculoskeletal disorders (Biering-Sørensen, 1983; English et al., 1995; Guo et al., 1995). Ohlsson et al. (1989) found that neck and shoulder pain was associated with age among female assemblers.

Ilmarinen (1992) observed that physical capacity and the ability to recover from physically demanding tasks deteriorates with age while the physical demands of jobs do not decrease. After age 55 these decreased reserves make it impossible for most to recover from heavier jobs. Prevalence and incidence of chronic diseases becomes more common as workers age. Loads which are manageable by young, conditioned workers can often exceed the capacity of those over 55 (Ilmarinen, 1992). Muscle mass and the commensurate force generating capacity decreases with age; this process is now being labeled “sarcopenia” (Lanza et al., 2003). Others are describing sarcopenia as an age-related loss of muscle mass, strength and function (Roth et al., 2000; Vandervoort and Symons, 2001; Waters et al., 2000).

Older cleaners are generally sick more often and more likely to retire early (Louhevaara, 1993; Nielsen, 1995).

4.2. Anthropometry

As noted in the part of this article on tools, the size and location of tools/controls can have a critical influence on usability. Roebuck (1995) clearly establishes that body, tool and equipment dimensions must be compatible for optimal productivity and occupational safety. General health is also a consideration when body weight is an anthropometric measurement; well established is the relationship between health and obesity (e.g. Merck Manual, 1999).

The physical characteristics of female cleaners have been described in studies of relatively small populations (Krüger et al., 1997). No studies with anthropometric descriptions of large samples of cleaners were found. However, from descriptions in the preceding parts of this article it is evident that body dimension can dictate work postures. Cleaners usually stand or walk when performing job tasks; body weight affects the total cardiovascular and muscular loads—which may increase the risk of musculoskeletal disorders (Krüger et al., 1997). Hopsu et al. (2005) found that obese Finnish cleaners were more likely to retire early.

4.3. Physical capacity

The relationship of physical capacity and musculoskeletal disorders is more than cause and effect. Excessive activity may lead to injury; however, lack of physical activity will reduce capacity—increasing susceptibility to injury. After injury capacity is temporarily or permanently limited—lowering the risk threshold.

Hopsu et al. (2005) found that lack of physical fitness is one reason for the early retirement of cleaners. Physical conditioning to increase physical capacity has caused cleaners to experience less physical discomfort (Anneli
et al., 2000; Hopsu et al., 1997). Also of interest is that cleaning work seems to have a higher proportion of workers with a lower than average physical capacity (Gamperiene et al., 2003; Hopsu et al., 1994).

5. The relationship of organizational and psychosocial factors with musculoskeletal disorders

Beginning in the 1960s there has been a trend in Europe and elsewhere for cleaning work to be contracted out to specialist private companies (Krüger et al., 1997). These companies stress efficiency and may have workers specialize in performing specific cleaning tasks as members of teams (e.g. Aguiar, 2001; Krause et al., 2005). In the public sector most cleaners work full-time and 80–90% of cleaners working in the private sector are part-time. The majority of cleaners are unskilled, low-salaried females (Krüger et al., 1997). A study by Woods and Buckle (2000) reported that significant percentage of the population of cleaners were expected to work at an intensive, fast pace.

Psychosocial factors have been described as the combined attributes of a worker and their job that then influence perceived psychological demands and thus contribute to job stress (Sauter and Swanson, 1996). Interactive effects of physical and psychosocial exposures upon musculoskeletal disorders have been observed (Billinghjörnsson et al., 1999; Fredriksson et al., 2001). Davis and Heaney (2000), and Cohen et al. (1997) noted that factors such as job dissatisfaction, monotony of work, limited job control, and lack of social support contribute to the causation of musculoskeletal disorders. Hopkins (1990) reported a positive association between job dissatisfaction and musculoskeletal symptoms. Low job satisfaction was not found to be a predictor for neck and shoulder problems in a study of Finnish workers (Viihakari-Juntura et al., 1991). The reasons for the difference between the two, similar problems were not evident from the available information; further research seems necessary. In a study of data processors Ryan and Bampton (1988) found that self-reports of “being bored most of the time” were highly associated with neck symptoms. Linton (1990), in a study of approximately 22,200 Swedish workers, found that monotonous work was positively associated with neck/shoulder pain during the preceding year.

Finnish questionnaire studies found that 50–70% of cleaners reported overexertion because of excessive work rates (Krüger et al., 1997). Other studies have reported that cleaning work has psychosocial risk factors such as workload, monotony, time pressure and no control over work/rest (Aickin, 1998; Louhevaara, 1997; Woods et al., 1999).

6. Summary and relationship to the proposed model

As was shown in Fig. 1, the basic process shown in the model was

Load → Tissue response → Outcome.

The core concept being illustrated is that the amount of load dictates whether tissues are handling a load that is within or not within their capacity. If tissue capacity is not exceeded then a healthy, adaptive state is maintained. If tissue capacity is exceeded then a temporary or permanent unhealthy state occurs. This is a basic ergonomic concept. Literature reviewed in the initial parts of this article restates the principles behind this concept.

But, are cleaners more likely to experience permanent musculoskeletal problems that leave a long-term or permanent functional impairment significant enough to prevent a return to work? Table 1 summarizes literature reviewed that addresses health information that concerns this question.

Apparent from Table 1 is that no single study assesses all possible factors that can contribute to musculoskeletal discomfort/disorder. This is true for both general studies and those that are concerned with musculoskeletal issues for cleaners. This consideration aside, the literature does demonstrate that musculoskeletal disorders can be caused by physical motions/movements where load exceeds tissue capacity; as shown in the central part of the model depicted in Fig. 1. Importantly, the literature indicates that impairment is often severe enough to prevent an individual from performing a full range of cleaning tasks.

With respect to the occupation of cleaner, these findings show that the relationship between cleaning tools, methods and biomechanical loads should be examined when evaluating new equipments/tools, methods and task design/structuring. In Table 2, the literature on these factors is summarized.

From this summary it is apparent that there is a relationship between work procedure(s), work environment(s) equipment, and tool(s) and load, tissue response and outcome. In other words any or all of these factors can contribute to the causation of musculoskeletal disorders. Also apparent is that there is a need to systematically classify different elements of cleaning tasks, their duration and the risk associated with them. This will be an important step in addressing the issue of risk reduction for this occupation.

Research that addresses any association between workload, strain on cleaners and the interior design of the buildings, facilities and furniture is minimal. The effect of design on the health of cleaners seems to be an area that is largely overlooked. More research in this area and its relationship to design is clearly evident.

A strong need for research into the ergonomic elements of tool and equipment design is also apparent. For example, the most commonly used mop has two basic parts; one is the long handle and other is the mop head. The handle is a straight shaft; Kumar et al. (2005b) reported that a bent shaft can reduce physical demand in some types of mopping. The different mop heads and materials now used (e.g., micro fibber, cotton, etc.) is another area where research that may lead to greater efficiency. For example, research on the friction characteristics of different mop materials (wet/damp/dry, on

\[ \text{Tissue response} \rightarrow \text{Outcome} \]
### Table 1
Factors contributing to musculoskeletal discomfort and/or disorders

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<td>Strasser et al. (1989)</td>
<td>O</td>
</tr>
<tr>
<td>Ohlsson et al. (1989)</td>
<td>O</td>
</tr>
<tr>
<td>Kilbom (1988)</td>
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<tr>
<td>Hagner &amp; Hagberg (1989)</td>
<td>X</td>
</tr>
<tr>
<td>Hultman et al. (1984)</td>
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</tr>
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<td>X</td>
</tr>
<tr>
<td>Louhevaara et al. (1982)</td>
<td>X</td>
</tr>
<tr>
<td>Louhevaara et al. (1983)</td>
<td>X</td>
</tr>
<tr>
<td>Søgaard (1994)</td>
<td>X</td>
</tr>
<tr>
<td>Hopsu (1997)</td>
<td>X</td>
</tr>
<tr>
<td>Hopsu et al., 1994</td>
<td>X</td>
</tr>
<tr>
<td>Søgaard et al. (1996)</td>
<td>X</td>
</tr>
<tr>
<td>Nordin et al. (1986)</td>
<td>X</td>
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</tbody>
</table>

The letter “O” means that the item referenced was about a population other than cleaners, while the letter “X” means that the item was about a population of cleaners.

### Table 2
Procedure(s), environment(s) and equipment/tool(s) as contributors to musculoskeletal discomfort and/or disorders

<table>
<thead>
<tr>
<th>Literature</th>
<th>Procedure(s), Environment(s) and equipment/Tool(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design for ease of cleaning</td>
</tr>
<tr>
<td>Krüger et al. (1997)</td>
<td>X</td>
</tr>
<tr>
<td>Kumar et al. (2005a, b)</td>
<td>X</td>
</tr>
<tr>
<td>Woods and Buckle, (2005a, b)</td>
<td>X</td>
</tr>
<tr>
<td>Hopsu et al. (2000)</td>
<td>X</td>
</tr>
<tr>
<td>Hagner &amp; Hagberg (1989)</td>
<td>X</td>
</tr>
<tr>
<td>Toivanen et al., 1993</td>
<td>X</td>
</tr>
<tr>
<td>Søgaard et al. (1996)</td>
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</tr>
<tr>
<td>Pierre-Jerome et al. (1996)</td>
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<tr>
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</tr>
<tr>
<td>Lehtinen et al. (1985)</td>
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</tr>
<tr>
<td>Winkel and Ekholm (1979)</td>
<td>X</td>
</tr>
<tr>
<td>Messing et al. (1992)</td>
<td>X</td>
</tr>
<tr>
<td>Stubbs &amp; Guan (1996)</td>
<td>X</td>
</tr>
<tr>
<td>Haslam and Williams (1999)</td>
<td>X</td>
</tr>
<tr>
<td>Hide et al. (2000)</td>
<td></td>
</tr>
<tr>
<td>Loopik et al. (1994)</td>
<td>X</td>
</tr>
</tbody>
</table>

The letter “X” means that the item referenced was about a population of cleaners.
different types of floors) can lead to the development of a tool that requires less effort to accomplish the same cleaning. Toilet scrubbers and brooms are two other tools where considerable ergonomic investigation remains to be accomplished. While this literature review did find that there has been research into tool design, it was also apparent that the amount of research is extremely limited. From this information it does appear that among the factors of building/interior design, task structuring and tool/equipment design that tool/equipment design will be the most cost effective alternative. Tools have a relatively short life cycle; employers can be persuaded that trying new designs will not require major investment/restructuring/redesign.

Individual worker factors and traits (e.g., age, health, anthropometry, education) was the second of the three influencing factors shown in the model in Fig. 1. Table 3 summarizes the influence of these on musculoskeletal disorders.

The literature summarized in Table 3 concerned general working populations rather than cleaners. However the descriptions for general populations can be considered as applicable to a population of cleaners as comparisons made are of similar factors/traits. These descriptions paint a picture of an older population performing heavy work that causes them to be at a higher than average risk of injury (age and health causes slower recovery from loads). In earlier descriptions it was noted that cleaning work is almost continuous throughout a work period. In other words, cleaners do not have enough time to recover between tasks and are thus at a higher risk of injury when performing heavy tasks later in work periods. It does appear that additional research can help to gain a better understanding of the extent of risk that cleaners face. This information can be helpful for practical applications where jobs can be redesigned and reasonable accommodations can be made.

The third influencing factor, that of organizational and psychosocial context(s), can have different meanings for different occupations. For cleaners, the most relevant research (Aickin, 1998; Krause et al., 2005; Krüger et al., 1997; Louhevaara, 1997; Woods et al., 1999) points towards two key problem areas: monotony and intensity. Information from these studies describes a trend among employers to reorganize work so that tasks can be completed quickly and more efficiently. For cleaners, this means that they must work faster and that there is less of an opportunity to vary task pace to reduce physical stress and monotony. Work such as that reported by Karasek and Theorell (1990) has found that factors such as the combination of intensity, monotony and lack of control create conditions where workers are more likely to have health problems; consistent with the model shown in Fig. 1. In this instance, negative organization and psychosocial factors contribute to musculoskeletal injury through accentuation of load.

<table>
<thead>
<tr>
<th>Literature</th>
<th>Individual worker factors/traits and musculoskeletal disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age</td>
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<tr>
<td>English et al. (1995)</td>
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</tr>
<tr>
<td>Guo et al. (1995)</td>
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<td>Hales et al. (1994)</td>
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<td>Helio¨vaara (1987)</td>
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<td>Nathan et al. (1993)</td>
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<tr>
<td>Finkelstein (1995)</td>
<td>O</td>
</tr>
<tr>
<td>Gamperiene et al. (2003)</td>
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<tr>
<td>Buckwalter et al. (1993)</td>
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<tr>
<td>Biering-Sorensen (1983)</td>
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<tr>
<td>Ohlsson et al. (1989)</td>
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<tr>
<td>Ilmarinen (1992)</td>
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<tr>
<td>Lanza et al. (2003)</td>
<td>O</td>
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<tr>
<td>Roth et al. (2000)</td>
<td>O</td>
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<tr>
<td>Vandervoort and Symons (2001)</td>
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<td>Waters et al. (2000)</td>
<td>O</td>
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<td>Louhevaara (1993)</td>
<td>X</td>
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<td>Nielsen (1995)</td>
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<td>Roebeck (1995)</td>
<td>O</td>
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<tr>
<td>Krüger et al. (1997)</td>
<td>X</td>
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<tr>
<td>Hopsu et al. (2005)</td>
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<tr>
<td>Anneli et al. (2000)</td>
<td>X</td>
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</tbody>
</table>

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7. Ergonomic interventions in cleaning occupation

Mitigation of musculoskeletal disorders among cleaners through ergonomic interventions have been carried out by several groups of researchers (Carrivick et al., 2005, Hopsu et al., 1997, 1994; Hultman et al., 1984). Reduction of the risk of musculoskeletal injury was reported in all studies. For example, Hopsu et al. (1994) found that through a developmental ergonomic process cleaning methods and tools were improved. Time spent on floor cleaning decreased from 30% to 25%, and high-risk back postures were reduced. Another study by Hopsu et al. (1997) reported that a physical exercise program reduced body fat and increased cardiorespiratory and muscular strength of cleaners participating in intervention. The cleaners reported that they were more effective and satisfied with their work after the intervention than before the intervention.

None of these interventions can be described as comprehensive—none attempted to make changes or study all of the influencing factors described in the model (Fig. 1). This is understandable as a global intervention would be resource intensive. Nevertheless, the weight of the evidence does suggest that such a comprehensive intervention could be successful and cost-effective.

However, the reality is that cleaning work is a low paid and replacement workers are readily available; the majority of employers have little incentive to consider supporting comprehensive interventions. In regions such as the EU and North America the occupational health and safety laws make it probable that employers will at some point be obligated to consider comprehensive ergonomic interventions. For the time being however, it does appear that low-cost ergonomic interventions (e.g. tool design) have the greatest likelihood of acceptance.

8. Conclusions and recommendations

(1) The current design of buildings, furniture and facilities is not considered from the view point of cleaning and maintenance. Work areas and public places can be more easily and economically maintained/cleaned when designs include cleanability and maintainability. Floors, walls, fixtures and furnishings can be designed to use materials and shapes that can be cleaned and maintained more easily economically. No scientific research was found that systematically dealt with the relationship between the workload and strain of cleaners and the design characteristics of buildings, furniture and facilities. Therefore, a comprehensive research is needed in this area.

(2) During the past decade, cleaning tools and machines have technologically developed and affected the cleaning methods. Nevertheless, research to date regarding efficient and ergonomic design of cleaning tools, equipment and methods has been disproportionately small in comparison to other occupations. Hence, more research is warranted emphasis on the relationship between cleaning tools, equipment methods and their impact on cleaners will likely help to significantly alleviate the problem.

(3) Cleaners have little possibility to influence or control their work arrangements, work pace, tools/machines, and selecting the partners. They also cannot develop their occupational career as it is a terminal job. Therefore, development and implementation of both micro and macro ergonomic strategies in cleaning work can significantly contribute to the reduction of physical and psychosocial stressors which will in turn improve the well-being and health of cleaners and reduce the cost to employers.

Acknowledgments

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Whitehouse Station, NJ.

http://www.bls.gov/oes/current/oes_00Al.htm


