

The association between janitor physical workload, mental workload, and stress: The SWEEP study

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Abstract.

BACKGROUND: Approximately 2.38 million janitors are employed in the U.S. While high physical workload may explain a lost-work days rate 2.7 times greater than other occupations, little is known about the association between janitors' physical workload, mental workload, and stress.

OBJECTIVE: The objective of this study was to assess the associations between physical (ergonomic) and mental workload exposures and stress outcomes among janitors.

METHODS: Questionnaire data, focused on ergonomic workload, mental workload and stress, were collected from Minnesota janitors for a one-year period. Physical workload was assessed with Borg Scales and Rapid Entire Body Assessments (REBA). Mental workload assessment utilized the NASA Task Load Index (TLX). Stress assessments utilized single-item ordinal stress scale (SISS) and Perceived Stress Scale-4 (PSS-4) measures. Descriptive and multivariable analyses, including bias adjustment, were conducted.

RESULTS: Odds ratios (OR) and 95% confidence intervals (CI) for ergonomic workload (task frequency) effects on SISS were: REBA (1.18 OR, 1.02–1.37 CI); Borg (1.25 OR, 1.00–1.56 CI); combined REBA and Borg (1.10 OR, 1.01–1.20 CI). Mental workload was associated with higher PSS-4 levels (0.15 Mean Difference, 0.08–0.22 CI) and a 3% increased risk for each one-unit increase in the SISS scale (1.03 OR, 1.02–1.05 CI).

CONCLUSIONS: This research demonstrated a moderate effect of physical and mental workloads on stress among janitors.

Keywords: Ergonomics, injury epidemiology, NASA TLX, Perceived Stress Scale

1. Background

Approximately 2.38 million persons work as janitors in the United States [1]. Due to con-

cerns about janitors' workload and injuries, the Service Employees International Union Local 26 [SEIU L26] approached researchers in the Division of Environmental Health Sciences at the University of Minnesota for help in better defining this workload. Janitors experience work-related injuries, particularly musculoskeletal disorders and other adverse occupational outcomes [2]. Their work, involving an allegedly high physical workload, appeared to place them at risk for days away from

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work with a rate 2.7 times higher than all other occupations [3].

In addition to exposure to risk factors associated with musculoskeletal disorders, it has been reported that physical workload factors are potentially related to stress [4–8]. Stress is also potentially problematic with regard to mental health [9, 10]; and it also has been reported as deleterious to physical health [9, 11]. Seixas et al. [12], reported an association between an increase in perceived work intensity and corresponding stress in janitors in Washington State. From a review of the literature between 1981 and 2005, Charles et al. [2], noted that janitors experienced psychosocial stressors and that these stressors are associated with musculoskeletal disorders. Some international labor unions recognize the problem of occupational stress and are implementing programs to address this problem [13].

Janitorial work involves a blend of exposure to physical risk factors for musculoskeletal disorders as well as stressful mental demands [14], which may adversely affect work performance. Research conducted on other occupations has demonstrated associations between physical or mental demands and job performance. For example, Metzger and Parasuraman [15], found reduced mental workload to be a desirable goal for increased performance of air traffic controllers and Yurko et al. [16], found that higher mental workload was associated with poorer performance of laparoscopic surgery.

The objective of this study was to assess routine tasks conducted by janitors of SEIU L26, with regard to the associations between physical and mental workload of these janitors, and the outcome of stress.

2. Methods

2.1. Study design

Following approval of the study by the University of Minnesota Institutional Review Board, ergonomic workload, mental workload, and the outcome of stress were measured among a cohort of Minnesota unionized janitors using the REBA and Borg tools to assess physical workload and an adaptation of the NASA TLX tool was used to assess mental workload. Relevant questionnaire data, including self-reported work-related injuries, were collected over a one-year period using a retrospective cohort design.

2.2. Target population

The target population was the approximately 4,000 janitors who were members of the SEIU L26; however, the study was restricted to the approximately 1,200 janitors who reported working full-time. These janitors were approximately 60 percent Hispanic, 20 percent Somali, and 20 percent other ethnicities. The SEIU L26 facilitated access to this population.

2.3. Focus groups

In order to guide initial development of the questionnaire form, an initial focus group of approximately 30 janitors was convened, drawn from a group of janitors identified by the SEIU L26. This group was used to assess critical job tasks. To guide the focus group discussion, janitors were asked: ‘What are the most frequent tasks?’ ‘What do you believe are the most dangerous tasks?’ ‘What are the most difficult tasks?’ ‘How often are each of these performed in a one-week period’ and ‘Is that estimate of the number of times a job is performed during a week representative of longer periods (up to six-month periods)? Utilizing feedback from this focus group, a draft of the full questionnaire was created by the research team. This draft was assessed for content, understanding, and readability using a second focus group of approximately 30 janitors.

2.4. Data collection instruments

The final version of the paper questionnaire was used to collect retrospective data regarding occupational outcomes and exposure data for two sequential six-month recall periods combined into a one-year longitudinal study (May 2016–October, 2016 and November 2016–April 2017). In each period, union stewards were responsible for distributing approximately 1,200 questionnaires to the entire population of full-time SEIU L26 janitors at the participating workplaces. Questions included demographic information (age, gender, smoking status, etc.), ergonomic task exposures, mental workload exposures, and stress outcomes. Task-specific information was collected within the broad job categories of Floor Cleaner, Bathroom Cleaner, and Special Projects (everything else), as established from the focus-group discussions. The questionnaire met a Flesch-Kincaid Grade Level of 5.7 [17]. For their participation, all

janitors were offered the opportunity to join in a drawing for one of 110 gift cards worth \$50 each.

2.5. Measures

2.5.1. Ergonomic workload

This project operationally defined ergonomic workload as a construct of exertion of force, repetition of movements, and posture, including synergistic effects. Janitorial tasks were examined for ergonomic workload using the Rapid Entire Body Assessment (REBA) and the Borg scale (a measure of perceived exertion). Both of these are widely-used tools to assess domains of ergonomic workload. The REBA is a practitioner's field tool [18, 19] designed to assess non-neutral working postures. The Borg scale is a self-report of perceived exertion [20, 21]. Ergonomic measures such as the REBA and Borg scales have also been used to measure stress as a marker [22–25].

Ergonomic workload for individual work tasks was determined by observing 30 people, 15 men and 15 women. Balanced tertile cut points of this sample were made, based on age, with age groups of 21–39, 40–56, and 57–71. On average, men were 5 feet 6 inches tall and 177.8 pounds in weight; for women these values, respectively, were 5 feet 2.6 inches and 160.5 pounds. The sampling dimensions of gender and age were selected due to the posture-driven nature of ergonomic workload [26, 27]. Buchholz et al. [28], determined that a randomly selected worker from a sufficiently numerous crew performing the same operation is appropriate to measure that operation.

A team of ergonomists and trained assistants assessed each janitor's task with both the Borg and REBA instruments. Multiple point samples (snapshot measurements) were taken for each task and then averaged to obtain a task-specific score. The REBA and Borg were combined to create an additive ergonomic workload score to serve as another measurement of ergonomic workload for each task. Task-specific scores were utilized with the questionnaire-based individual task frequencies to obtain a task-summed total ergonomic workload measurement for the targeted 1,200 janitors.

Eight tasks were identified from the focus group as a result of the janitors being asked, "What are the most frequent tasks? What do you believe are the most dangerous tasks? What are the most difficult tasks?" The eight tasks identified were: emptying trash cans less than 25 pounds; emptying trash cans of more than 25 pounds; mopping/sweeping; vacuuming; dusting; cleaning mirrors; cleaning sinks; and cleaning toilets.

Realistic simulations of these tasks were created in a working environment to enable assessment of the janitors' workloads using the REBA and Borg scales.

Questionnaire results regarding ergonomic task frequency data were sometimes unclear. In cases where janitors did not provide a numeric answer to a frequency item but, rather, indicated that they did a task (writing an "x", checkmark, or "yes"; 2% of surveys), their response was imputed to the average value of all respondents who answered a numeric value for that task. Potential outlier responses were truncated to International Sanitary Supply Association standard production rates, based on an 8-hour work shift (which was supported from the questionnaire) [29]. Task cycle times were computed for the three non-discrete tasks of mopping, vacuuming, and dusting [29]. These time-based variables were standardized as counts of work cycles to have an integer measurement consistent with the discrete, frequency-based variables such as cleaning a sink or emptying a trash can. The task-specific REBA and Borg scores from the ergonomic assessments were then multiplied by the individual task frequencies for the eight tasks as determined from the questionnaire to give an estimate of daily exposure. Ergonomic exposure scores were standardized by age and gender and linking the janitor-specific questionnaire task frequencies to the REBA and Borg assessments, conducted with the established janitors' age/gender groups.

2.5.2. Mental workload

"Workload is a term that represents the cost of accomplishing mission requirements for the human operator" [30]. One of the most cited measures of mental workload is the NASA Task Load Index (TLX), which is a multidimensional rating scale that uses six dimensions of workload to "provide diagnostic information about the nature and relative contribution of each dimension in influencing overall operator workload" [31]. Since 1986, the TLX has been extensively modified for research globally [30, 32, 33]. It, along with other mental workload measures, can be used to measure stress [30, 34–36]. TLX subscales are Likert-type scales with 21 selection points from "Very Low" to "Very High". The six dimensions assessed are mental demand, physical demand, temporal demand, performance, effort, and frustration. The ratings indicate how a person "appraises their interaction with the task environment" [34]. This is consistent with the operational definition of workload used in this study. A raw-TLX scale was used because the weighted scale

adds participant burden and is correlated to the unweighted scale with an $r = +0.94$ [37]. In this study, the standard TLX form was simplified to a five-item Likert scale, based on janitor feedback during questionnaire development. The five items were “Very Low Demand”, “Low Demand”, “Medium Demand”, “High Demand”, and “Very High Demand”.

2.5.3. Stress

Validated single-item or short-item scales were used to collect participant data on stress. Stress was measured by a single-item stress scale (SISS) created for occupational health professionals to monitor perceived well-being [38]. The item, measured on a 5-item Likert scale (“not at all” to “very much”), was stated as: “Stress means a situation in which a person feels tense, restless, nervous or anxious or is unable to sleep at night because his/her mind is troubled all the time. Did you feel any stress (asked for two specific six-month periods)?”

From previous efforts, the SISS was validated through comparison with the Nordic Questionnaire for Psychological and Social Factors at Work which includes the emotional exhaustion scale of the Maslach Burnout Inventory. This comparison facilitates analysis of construct validity (i.e., does the measure capture the trait?), and concurrent criterion of validity (does the measure give the same answer as another, trusted, measure?) [38].

Stress was also measured by the 4-item version of the Perceived Stress Scale (PSS-14). This version, known as the PSS-4, contains 4 of the 14 items of the original PSS-14 [39]. The PSS-4 was chosen in preference to the 14-item version to limit participant burden. The four items, asked about the past month, were: “how often have you felt that you were unable to control the important things in your life?”; “how often have you felt confident about your ability to handle your personal problems?”; “how often have you felt that things were going your way?”; and “how often have you felt difficulties were piling up so high that you could not overcome them?” The five responses for each item ranged from 0 = “Never” to 4 = “Very Often”. An overall PSS-4 score was summed across all four items. The SISS and the PSS-4 approach a definition of “stress,” differently. Psychological stress can be considered a “particular relationship between the person and the environment, which is appraised by the individual as taxing or exceeding his resources, and endangering his well-being” [40]. This is the definition of stress that the PSS series utilizes [41, 42]. The SISS defines stress as situational anxiety [38].

Both of these definitions focus upon the assumption that resources for coping with life situations are not sufficient. The operational definition of stress for this study was a simplified version of the PSS-4, i.e., the extent to which people perceive that demands are greater than their ability to cope with those demands.

2.6. Data analysis

The REBA and Borg were used to assess ergonomic workload. Ergonomic task frequency, mental workload, and stress were measured, individually, based on data reported in the respective questionnaires. Data were independently entered by two researchers into a Redcap database [43]. The Redcap software enabled comparisons for consistency of entries; any conflicts were resolved by the research team. Descriptive analyses were conducted to identify the frequencies and distributions.

The PSS-4 scores were treated as continuous, and linear regression was used to test for associations with the workload-exposure categories. Linear regression models enabled calculations in the mean differences (MD) in PSS-4 scores for each 1,000-unit increase in ergonomic workload measurement or 1-unit increase in mental workload. Ordinal logistic regression was used for the SISS outcome and measured the odds of having a higher SISS score with each 1,000-unit increase in workload measurement or 1-unit increase in mental workload. Potential confounders such as smoking, age, gender, and second job status were identified *a priori* using relevant literature and research team expert knowledge.

A directed acyclic graph (DAG) is a valuable tool for developing a hypothesized multivariable causal model for analyzing a potential association between an exposure and outcome, while controlling for confounding but excluding extraneous or unnecessary variables that could bias the results [44]. A master DAG was created, depicting each known or hypothesized causal pathway among exposure and outcome variables [45], based on the scientific literature. For each research question about the potentially causal association between a particular exposure and outcome, a multivariable model, based on the DAG, included the smallest sufficient subset of potential confounders (Fig. 1), using the methods described in Hernan et al. [44, 46].

As shown in the example of a DAG in Fig. 1, it was hypothesized that ergonomic workload is positively associated with stress. To analyze the relation between ergonomic workload and stress, the multi-

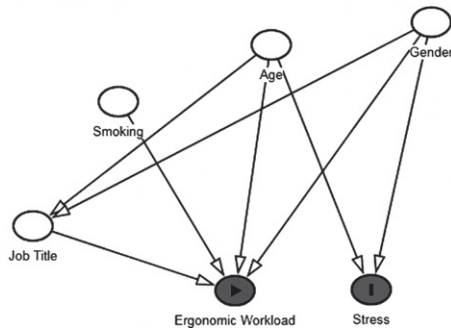


Fig. 1. Directed acyclic graph of the relation between ergonomic workload and stress: the SWEEP study.

variable model was adjusted for smoking, gender, job title, age, and non-response.

Generalized estimating equations (GEE) were used to account for potentially correlated data: If individual janitors completed two surveys over the respective study time periods, GEE was used to limit clustering bias [47]. Potential response bias, resulting from a lower response rate, was minimized by inversely weighting observed responses by probabilities of response, estimated as a function of characteristics available from the SEIU L26 [48]; those characteristics were gender, age, and janitorial contracting company. This technique used re-weighting of estimates using group response characteristics to account for the potential differences in responses [49].

3. Results

There was a response rate of 32.5%, with 390 janitors responding to at least one of the two surveys; 137 janitors responded to both surveys (Fig. 2).

Of the 390 janitors who responded, 55% were women; 10% were aged 18–30, 30% were 31–40, 30% were 41–50, 23% were aged 51–60, and 6% were over 60 years of age. By race, 57% of janitors self-identified as black or African American, 30% as white, and 13% as Other.

3.1. Ergonomic workload

A total of 720 ergonomic workload measurements were conducted across all eight job tasks included in the assessment. After categorizing the level of risk exposure on REBA as negligible, low, medium, high, and very high, a Fleiss' Kappa of 0.54 was identified for ratings performed by a sub-sample of the evalu-

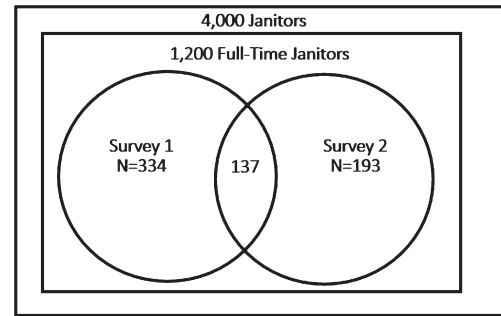


Fig. 2. Study size flow chart for the SWEEP study.

ators, indicating moderate agreement [50]. Through further analyses, the task-specific REBA and Borg scores from the quantitative ergonomic assessments were adjusted to the total participants by multiplying the individual task frequencies, identified by the janitors' responses on the questionnaires. Ergonomic exposure scores were standardized by age and gender. Both ergonomic measures (REBA and Borg) were tested for correlation, resulting in a Pearson Correlation Coefficient of 0.99 ($p < .005$). The means of the ergonomic impact per shift are shown in Table 1.

3.2. Mental workload

There were 444 responses to the TLX (Table 2); approximately 100 were from the same people over both survey periods. Partially answered scores were not counted. The TLX scores ranged from six to 30, with 30 identifying the highest mental workload. The mean score was 20.60 with a standard deviation of 4.08.

3.3. Stress

There were 438 responses to the SISS; approximately 100 were from both survey periods. The most common response ($N = 158$) was that they were sometimes stressed. The distribution is seen in Table 3.

There were 310 responses to the PSS-4 (Table 4). No partially answered scores were counted. The PSS-4 responses ranged from four to 20, with 20 establishing the highest stress level. The mean score for this population was 9.04, with a standard deviation of 2.51. A moderate correlation was found between the PSS-4 and the SISS responses (Pearson's $r = 0.35$, $p < .005$) [51].

Multivariable regression (Table 5), identified associations between the exposures of ergonomic

Table 1
Mean ergonomic impact per shift: the SWEEP study

Measures	N	Mean	SD	Minimum	Maximum
REBA	500	2122.40	1434.30	12.18	8167.83
Borg	500	1548.29	988.40	9.97	5879.17
Combined	500	3676.16	2417.55	22.20	14068.39
Standardized REBA	448	2131.25	1433.75	20.23	8019.00
Standardized Borg	448	1616.24	1227.92	16.09	8086.17
Standardized Combined	448	3751.09	2579.13	36.33	16110.48

SD = Standard Deviation.

Table 2
Mental workload distribution of janitors as assessed by NASA Task Load Index: the SWEEP study

Demand Level	Survey Questions											
	How mentally demanding has it been working as a janitor?		How physically demanding has it been working as a janitor?		How rushed have you been working as a janitor?		How successful were you in completing what you were asked to do?		How hard did you have to work to do your job?		How frustrated have you been with your as a janitor?	
	N	%	N	%	N	%	N	%	N	%	N	%
Very low demand	26	5.86	10	2.25	8	1.8	3	0.68	25	5.63	41	9.23
Low demand	59	13.29	43	9.68	41	9.23	31	6.98	45	10.14	83	18.69
Medium demand	185	41.67	148	33.33	156	35.14	140	31.53	145	32.66	168	37.84
High demand	125	28.15	172	38.74	165	37.16	199	44.82	165	37.16	103	23.2
Very high demand	49	11.04	71	15.99	74	16.67	71	15.99	64	14.41	49	11.04

Table 3
Stress distribution of janitors as assessed by the Single Item Stress Scale: the SWEEP study

Survey Question		
Stress means a situation in which a person feels tense, restless, nervous or anxious or is unable to sleep at night because his/her mind is troubled all the time. Do you feel this kind of stress these days?		
Response	N	%
Not at all	69	15.75
Very Little	66	15.07
Sometimes	158	36.07
Often	101	23.06
Very Much	44	10.05
Missing	89	16.89

workload and mental workload, and the outcome of stress; increased risks of stress, using the SISS measure, were identified for increases in REBA, Borg and combined REBA+Borg. While ergonomic workload measures were not statistically associated with the PSS-4 measure of stress, increases in mental workload were associated with higher stress measures using the PSS-4; an increased risk of stress, measured by the SISS, was also identified.

4. Discussion

Average REBA scores for the janitors' eight tasks were identified in the high-risk category. This is con-

sistent with Nawi's [52] study of Malaysian palm oil harvesters whose seven tasks resulted in REBA scores ranging from high risk to very high risk. Gentzler [53], used REBA to study emergency medical technicians and firefighters, finding extreme risk for some of the similar postures (lifting and reaching) that janitors utilize. Ansari [54], reported that 53% of studied Indian factory workers were working at high REBA risk levels while 33% were working at medium risk levels.

Average Borg scores ranged between the very light and somewhat difficult categories. This is similar to data reported by Jakobsen et al. [55], in their comparison between the Borg scale and muscular load in Danish manual laborers, finding that many blue-collar workers reported a moderate level of exertion.

From multivariable analyses, used to identify the relations between ergonomic workload and the outcome of stress, increased but not significant risks of stress were identified using the SISS measure. Using the PSS-4 measure, reduced but not important risks were identified for stress from ergonomic workload. However, mental workload was identified as a significantly protective factor for stress using the PSS-4 stress scale while, in contrast, mental workload demonstrated a significantly increased risk for stress when measured by the SISS. These findings are somewhat analogous to Hess's [56] finding of a relation between perceived stress and development of repetitive strain injury symptoms in computer users

Table 4
Stress distribution of janitors as assessed by the Perceived Stress Scale-4: the SWEEP study

Response Level	Survey Questions							
	In the past month how often have you felt that you were unable to control the important things in your life?		In the past month how often have you felt confident about your ability to handle your personal problems?		In the past month, how often have you felt that things were going your way?		In the past month, how often have you felt difficulties were piling up so high that you could not overcome them?	
	N	%	N	%	N	%	N	%
Never	61	19.68	55	17.74	38	12.26	52	16.77
Almost Never	60	19.35	107	34.52	95	30.65	92	29.68
Sometimes	129	41.61	103	33.23	141	45.48	125	40.32
Fairly Often	41	13.23	20	6.45	21	6.77	33	10.65
Very Often	19	6.13	25	8.06	15	4.84	8	2.58

Table 5
Multivariable regressions of the relations between workload exposures and stress outcomes: the SWEEP study

Measures	PSS-4				SISS			
	MD*	95% CI		p-value	OR**	95% CI		p-value
REBA [‡] *	0.16	−0.02	0.35	0.0853	1.18	1.02	1.37	0.0279
Borg [‡]	0.24	−0.05	0.52	0.1015	1.25	1.00	1.56	0.0525
Combined (REBA + Borg) [‡]	0.10	−0.02	0.21	0.0906	1.10	1.01	1.20	0.0359
Standardized REBA [‡]	0.21	−0.00	0.43	0.0549	1.15	1.00	1.33	0.0578
Standardized Borg [‡]	0.25	−0.06	0.56	0.1186	1.13	0.94	1.36	0.1940
Standardized Combined [‡]	0.12	−0.01	0.25	0.0714	1.07	0.99	1.17	0.0929
Mental Workload	0.15	0.08	0.22	<.0001	1.03	1.02	1.05	0.0002

Adjusted for SES. [‡]Adjusted for gender, age, smoking and job title. *MD = Mean Difference in PSS-4 for a 1,000-unit increase in ergonomic workload or a 1-unit increase in mental workload. **OR = Odds Ratio for SISS associated with a 1,000-unit increase in ergonomic workload or a 1-unit increase in mental workload.

and those by Chen et al. [57], who reported an association between musculoskeletal pain and psychosocial factors in Chinese offshore workers.

Mental workload was significantly associated with both the PSS-4 and the SISS. This is supported by the similarities of the constructs of mental workload and stress. The tool used to measure mental workload, the NASA TLX, includes subscales of frustration and temporal demand, both of which are components of stress. When researchers use both stress scales and the TLX together, there is an element of overlap in the constructs of stress and mental workload [58].

4.1. Advantages and limitations

Because much of the data for this study was questionnaire-based, requiring self-reporting, the low response rate of 32.5% was a limitation. However, potential response bias was reduced by inversely weighting observed responses by probabilities of response, estimated as a function of janitor characteristics provided by SEIU L26 [49].

Another potential limitation was that there was potential fear of reprisal should injuries and adverse occupational outcomes be reported [59]. It has also

been reported that there is a perceived stigma for reporting stress outcomes [60]. Underreporting may also be related to an unwillingness to reveal activities associated with injury incidence [61, 62].

A strategy to mitigate recall bias was considered in the study design [62–64]; thus, the study period of one year was divided into two sequential six-month periods to lessen recall error. While questionnaire distribution by union stewards may have introduced potential information bias to the responses, the research team ensured that stewards received comprehensive training on the questionnaire content and distribution in an attempt to ameliorate this potential bias. In addition, while the cross-sectional study design is efficient [65] and provides important information on a population that has been difficult to access, the results cannot be interpreted as causal. Rather, they serve as a basis for further research and potential evaluation of relevant prevention strategies.

There were many advantages associated with this project. In particular, it involved participant-driven research, in that the subjects were enthusiastic about the project and requested assistance to study the potential effect of their workload on injury. Access

to the janitors, by the SEIU L26 greatly assisted the feasibility and conduct of the research; thus, the ability to consult relevant to appropriate study design with active janitors allowed the research team to design a study that was responsive to the needs of the target population. In addition, the number (720) of individual ergonomic assessments conducted on the participating janitors is unusually large for a study of this type and enabled analyses of data important not only to this population but, also, potentially to other similarly active occupational populations. Most important, is that this is among the first research efforts to address this seriously neglected population.

5. Conclusions

To reduce the amount of stress that janitors experience, it would appear important to test strategies that could reduce both ergonomic workload and mental workload. Expansion of this work should involve investigations of the relation between ergonomic workload and stress in different populations. Such populations might include hotel housekeepers and construction workers. Aside from examining different occupational burdens, it will be particularly important to develop relevant interventions that can be implemented and transformed into practice to ensure reduction of the burdens on such occupations.

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Conflict of interest

None to report.

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