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Prevalence of work-related musculoskeletal symptoms among grocery workers

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ABSTRACT

Work-related musculoskeletal disorders (WMSDs) affect all sectors of the working population, and grocery workers have especially high rates. Although the incidence of WMSDs among any worker population can be estimated from workers' compensation claims, musculoskeletal symptom surveys can be used as a proxy estimate of WMSDs. The purposes of this cross-sectional study were to describe the prevalence of work-related musculoskeletal symptoms in grocery store employees from many different departments, and to determine the association between exposure to physical risk factors and presence of symptoms. Study participants (N = 254) were grocery store workers from five different stores in a medium sized grocery chain. Participants completed a self-administered survey consisting of demographic information and job history; the modified Nordic Questionnaire (MNQ); and physical component (PCS) and mental component (MCS) summary measures of the SF-36v2®. Rodgers Muscle Fatigue Analysis (Rodgers) was used to assess exposure to physical risk factors in the most difficult tasks in certain store departments. Prevalence of musculoskeletal symptoms was estimated for each body region and for various subgroups, and multivariable logistic regression analysis was used to identify independent predictors of presence of musculoskeletal symptoms. Approximately 78% of grocery store workers reported work-related musculoskeletal symptoms in at least one body region, with most workers complaining of low back and feet symptoms. The high prevalence of foot symptoms has not been previously reported for this population. Approximately 11% of employees missed work because of symptoms and 25% sought medical care for symptoms. There were no differences among Rodgers rating groups for proportions reporting symptoms. SF-36v2® scores were inconsequential predictors for musculoskeletal symptoms. Gender and age were both significant predictors of symptoms, and age predicted healthcare utilization. These findings are relevant to the grocery industry in order to target WMSD preventive interventions to specific body regions for high-risk activities within a grocery store position.

1. Introduction

Work-related musculoskeletal disorders (WMSDs) are potentially disabling conditions affecting workers. Of all workers' compensation claims, WMSDs account for the highest percentage of costs and permanent disability among workers (Bureau of Labor Statistics, 2014; National Research Council – Institute of Medicine, 2001).

While WMSDs affect all sectors of the working population, grocery workers have especially high MSD rates. Throughout the US, WMSDs are so prevalent among grocery workers that reducing the incidence and severity is Strategic Goal #1 of the Wholesale and Retail Sector National Occupational Research Agenda (NORA) NORA Wholesale (NIOSH, 2009). In Washington State during the period 1997–2005, grocery stores had a rate of musculoskeletal injury 1.8 times greater than the state average and 5th in compensable upper extremity WMSDs (using the prevention index) of all industries (Silverstein and Adams, 2007). Grocery work ranked in the top 25 occupations for injuries including neck, rotator cuff syndrome, wrist tendonitis, carpal tunnel syndrome, and back disorders including sciatica. These findings led the Washington State Safety & Health Assessment & Research for Prevention (SHARP) program to

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conclude that grocery work was one of the "top 12 industries in need of focused research and prevention efforts."

The majority of studies conducted on grocery workers have focused on repetitive hand motions by cashiers and layout of the checkout station (Carrasco et al., 1995; Forcier et al., 2008; Rodacki et al., 2006; Spielholz et al., 2008; Violante et al., 2005). However, all grocery workers perform manual material handling and are exposed to physical risk factors associated with WMSDs. Examples include heavy lifting of garbage from the produce department, forceful hand exertions in the meat and deli departments, and awkward back and shoulder postures while stocking shelves.

The incidence of WMSDs among any worker population can be estimated from workers' compensation claims. A higher incidence or prevalence among an occupational group suggests that these workers have greater exposure to physical risk factors in the workplace. However, estimates of incidence require sampling large populations of workers. In addition, the prevalence of WMSDs is frequently underestimated from workers' compensation claims (Major and Vezina, 2015; Stock et al., 2014). More commonly, occupational health researchers use musculoskeletal symptoms as a proxy estimate of WMSDs (Grzywiński et al., 2016). Although more workers complain of symptoms than have compensable musculoskeletal injuries or illnesses (Major and Vezina, 2015; Merlino et al., 2003), surveys of musculoskeletal symptoms can provide reasonable estimates of the prevalence of WMSDs in various body regions.

The purposes of this cross-sectional study were to describe the prevalence of work-related musculoskeletal symptoms in grocery store employees from many different departments, and to determine the association between exposure to physical risk factors and presence of symptoms. Work prevention and healthcare utilization due to work-related musculoskeletal symptoms were also analyzed.

2. Methods

2.1. Subjects

Eligible study participants consisted of 254 employees from five different stores in a medium sized grocery chain consisting of 11 stores. In general, the stores had a similar physical layout, with a few important differences. For example, the bakery department in one store had a narrow entryway. This required the employees to move bags of dry materials (e.g., flour) from a pallet to a smaller cart, doubling the manual material handling. Also, the meat department in two stores had an older meat grinder with the exit chute at knee level. Other than these store-specific differences, all stores had the same departments, and the work tasks within these departments were similar across stores. These stores were involved in a larger project to implement a participatory ergonomics program throughout the grocery chain. Participants were eligible for inclusion if they were currently employed as a grocery worker and 18 years or older. Participants provided written consent and the Eastern Washington University Institutional Review Board approved all study procedures. Each grocery worker was compensated $5.00 for completing the surveys.

2.2. Self-report surveys

Study participants completed a nine-page, self-administered survey consisting of three questionnaires: 1) demographic and job history, 2) work-related musculoskeletal symptoms, and 3) a functional health and well-being survey. The survey packet took participants about ten minutes to complete.

Workers were asked about demographic variables such as age, height, weight, among others. They were also asked about current grocery work such as job title, years worked with current employer, and second jobs.

Self-reported musculoskeletal symptoms were assessed with the modified Nordic Questionnaire (MNQ) (Kuorinka et al., 1987). The MNQ is well validated and frequently used for studying WMSDs (Anton et al., 2002; Bodin et al., 2012; Merlino et al., 2003; Miranda et al., 2001; Nordander et al., 2013; Parot-Schinkel et al., 2012). The MNQ consists of a diagram of the body with 9 anatomical regions highlighted, e.g., low back or shoulder. For each region, respondents indicated with a yes/no response whether they had a job-related ache, pain, discomfort, or other complaint in each region in the past 12 months. For any region for which a "yes" response was obtained, the respondent then indicated yes/no whether the complaint prevented them from doing a day's work and if they saw a physician for the problem. We used the MNQ results to determine the prevalence of work-related symptoms by body region, and if present, how often the symptoms resulted in work prevention and/or healthcare utilization.

Functional health and well-being was assessed with the SF-36v2® (Ware and Kosinski, 2001). This validated survey of physical and mental health has been used extensively in research, including studies of WMSDs (Palmer et al., 2008; Turner-Bowker et al., 2002). The SF-36v2® is extremely sensitive to changes in worker's perception of health. The physical component (PCS) and mental component (MCS) summary measures were calculated from this survey.

2.3. Ergonomic job analysis

Participants from 17 different grocery store departments identified the most difficult tasks in their part of the store that affected the back (upper or lower) and hand(s)/wrist(s). At least one task, lasting at least 10% of a shift, was analyzed from each department. These tasks were videotaped by the investigators using two video cameras with a frame rate of 30 frames per second. When possible, the cameras were placed orthogonally to record the sagittal and frontal planes. Each task was video recorded for 5–30 min, depending on the task (Anton et al., 2012).

The Rodgers Muscle Fatigue Analysis (Rodgers) was used to assess the video recordings for exposure to awkward postures, forceful exertions, and repetitive movements (Rodgers, 1992). This assessment method estimates muscular fatigue during specific work tasks under the assumption that fatigued muscle is susceptible to injury. The Rodgers is appropriate for tasks performed for an hour or more, and the result of this assessment is a "Priority for Change" rating (Low, Moderate, High, and Very High). For example, if the effort level is high enough that most workers could not accomplish the task, if the continuous effort duration is greater than 30 s, or if effort frequency is greater than 15 per minute, then a task is assigned a "Very High" priority for change.

Using the video recordings, two investigators rated the tasks independently with the Rodgers and derived a Priority for Change rating for the back and hand/wrist regions. When the assessment disagreed among raters for a particular task, the final rating was arrived at by consensus.

2.4. Data analyses

Means and standard deviations or frequencies and percentiles were calculated from the demographic, job history, MNQ, SF-36v2®, and Rodgers rating data. The median age for the sample was 34.5 years. An age-group variable was formed based on the median age which classified employees into one of two groups, <35 or ≥ 35 years of age, resulting in 127 employees in each group.

Prevalence of work-related musculoskeletal symptoms was based on responses to the MNQ. Prevalence estimates were developed for each body region and for various subgroups, including age group, gender, and Rodgers rating for the back and hand/wrist. Prevalence estimates were compared within subgroups with Chi-square analyses.

Correlation was used to explore the association between presence of musculoskeletal symptoms in the upper back, lower back, and hand/wrist with the physical and mental components of the SF-36v2®.

Multivariable logistic regression analysis was used to identify independent predictors of presence of musculoskeletal symptoms and symptom-related healthcare use in the upper back, lower back, and hand/wrist. Logistic regression models were constructed with forward stepwise maximum likelihood procedures. Age group, gender, years working in a grocery store, and Rodgers rating served as the predictor variables. The possibility that exposure or healthcare use could interact with age, gender, and years working at a grocery store prompted the inclusion of interaction terms in the logistic regression model between Rodgers rating and each of the demographic variables. Odds ratios (OR) and corresponding 95% confidence intervals (CI) were assessed for significance of predictive ability. Statistical analyses were performed with SPSS version 19.0 (SPSS, Chicago, IL). All analyses employed a type I error rate of $p \leq 0.05$.

3. Results

Data were collected on 254 employees in 17 departments at five stores. Table 1 presents summary statistics for demographic characteristics and proportion in each Rodgers Muscle Fatigue Analysis rating group. Table 2 displays the various grocery store departments that were included in the sample, specific back and hand/wrist tasks analyzed with the Rodgers per department, and Rodgers ratings for each task.

The Rodgers ratings for the most difficult tasks were the same across all stores with a few exceptions (Table 2). For example, grinding hamburger was rated 'Very High' in two stores since meat department workers had to bend over to catch meat coming out of the grinder chute. At other stores with elevated chutes, this task was rated 'Moderate.' Other low back task ratings differing between stores included frying doughnuts (low or moderate), stocking milk (high or very high), and stocking dog food (moderate or high). Other hand/wrist task ratings differing between stores included cutting meat into steaks (moderate or very high) and stocking milk (moderate or high or very high).

3.1. Prevalence of work-related musculoskeletal symptoms

Table 3 displays prevalence of work-related musculoskeletal ache, pain, or discomfort by body region and for various subgroups. Approximately 78% of grocery store workers reported work-related musculoskeletal symptoms in at least one body region in the 12 months preceding the survey. Half or more of the employees reported symptoms in the lower back or feet. More than one-third reported symptoms in the hands and wrists. Approximately 11% of employees missed work because of symptoms in the previous 12 months, with low back pain being the most frequent cause of missed work (5% of employees). Approximately 25% of employees sought medical care for symptoms, with low back pain being the most frequent cause of physician visits (13% of employees). Chi-square analyses found no differences in prevalence of symptoms among age groups ($p = 0.694$); however, prevalence of musculoskeletal symptoms was significantly greater in females than males ($p = 0.001$). Proportions reporting work prevention did not differ among age groups or males/females (both $p > 0.230$). A significantly larger proportion of employees 35 years of age and older sought healthcare for work-related musculoskeletal symptoms ($p = 0.003$). Proportions seeking medical care did not differ among males and females ($p = 0.365$).

Table 4 displays prevalence of work-related musculoskeletal ache, pain, or discomfort by body region and by department. Low back pain was most prevalent for the bakery department workers, and lowest for stockers. Workers in the bakery reported the highest number of wrist and hand complaints, while stockers, dairy, produce, and "other" departments had the lowest. Foot pain was

Table 1
Summary statistics for demographic characteristics and proportion in each Rodgers Muscle Fatigue Analysis rating group ($n = 254$).

Characteristics	Proportion or mean (SD)*
Demographics	
Female (%)	61
Age (yrs)	36.8 (13.9)
Height (m)	2.0 (0.13)
Weight (kg)	79.0 (18.5)
Body mass index (kg/m^2)	27.1 (6.0)
Caucasian (%)	93
High school/trade school graduate or some college (%)	81
Currently pregnant (%)	1
Years employed with grocery chain	6.5 (5.4)
Employed in second job (%)	9
Hours per week in second job	15.6 (12.7)
SF-36v2® Physical component score	51.8 (7.4)
SF-36v2® Mental component score	49.6 (10.3)
Rodgers priority score – back	
Low (%)	42
Moderate (%)	46
High (%)	4
Very high (%)	8
Rodgers priority score – hand/wrist	
Low (%)	21
Moderate (%)	16
High (%)	19
Very high (%)	45

*Proportions may not add to 100% due to rounding.

Table 2
Grocery store departments included in the sample (with number of workers assessed in parentheses, total $n = 254$), specific back and hand/wrist tasks analyzed with the Rodgers per department, and Rodgers ratings for each task. Rodgers ratings varied for some tasks due to the environment within a store in which the task was performed. For these tasks, numbers in a particular rating category are presented in parentheses following the rating.

Store department	Task analyzed for rodgers back rating	Rodgers back rating[a]	Task analyzed for rodgers hand/wrist rating	Rodgers hand/wrist rating[a]
Bakery (21)	Doughnut frying	L(7),M(14)	Cutting dough into loaves	VH
Bookkeeping (4)	Sitting at computer typing	VH	Sitting at computer typing	M
Cake decorator (5)	Frosting cake	M	Frosting cake	M
Checker (62)	Cashiering	L	Cashiering	VH
Coffee shop (3)	Standing for light work duty	VH	Making beverages	L
Courtesy clerk (18)	Bagging/loading groceries	M	Bagging groceries	VH
Custodian (3)	Floor buffing	H	Floor buffing	VH
Customer service (28)	Standing for light work duty	VH	Standing for light work duty	L
Dairy (4)	Stocking milk	H(3),VH(1)	Stocking milk	M(2),H(1), VH(1)
Delicatessen (38)	Slicing meat	M	Stirring salad/preparing displays	H
Floral (7)	Standing for light work duty	L	Making flower arrangements	L
Freight (8)	Freight stocking dog food	M(3),H(5)	Freight stocking dog food	H
Meat (16)	Grinding meat	M(7),VH(9)	Cutting meat into steaks	M(6),VH(10)
Produce (14)	Stocking onions	M	Stocking onions	M
Stocker (9)	Stocking products	M	Stocking products	L
Scan coordinator (5)	Creating signage on computer	VH	Creating signage on computer	L
Seafood (9)	Mixing seafood dips & salads	M	Mixing seafood dips & salads	M

[a] L = low priority for change, M = moderate priority for change, H = high priority for change, VH = very high priority for change.

Table 3
Prevalence of work-related musculoskeletal symptoms during the past 12-months for all for all grocery positions from the modified Nordic Questionnaire ($n = 254$). Values are percentages with n in parentheses.

	Work-related ache, pain, discomfort	Symptoms prevented daily work	Sought healthcare for symptoms
Body region			
Neck	27 (69)	2 (5)	9 (23)
Upper back	29 (74)	1 (3)	8 (20)
Shoulders	31 (79)	1 (3)	9 (23)
Elbows	10 (25)	2 (5)	4 (10)
Wrist/hand	39 (99)	2 (5)	8 (20)
Lower back	51 (130)	5 (13)	13 (33)
Hips/thighs	17 (43)	1 (3)	5 (13)
Knees	29 (74)	2 (5)	8 (20)
Feet	50 (127)	2 (5)	8 (20)
Age group[a]			
<35 y o.	74 (94)	8 (10)	14 (18)
≥35 y o.	83 (105)	13 (17)	35 (44)
Gender[b]			
Male	73 (72)	10 (10)	18 (18)
Female	82 (127)	11 (17)	29 (45)

[a] Proportion seeking healthcare differed significantly among age groups at $p \leq 0.05$.
[b] Prevalence estimates differed significantly among males and females at $p \leq 0.05$.

Table 4
Prevalence (%) of work-related ache, pain, or discomfort (%) during the past 12-months by department (Dept.) from the modified Nordic Questionnaire ($n = 254$). Courtesy = courtesy clerk; Deli = delicatessen; Service = customer service; Other = barista, floral, custodian.

Body region	Dept.										
	Bakery n = 26	Checker n = 62	Courtesy n = 18	Dairy n = 4	Deli n = 38	Meat n = 16	Produce n = 14	Stocker n = 17	Seafood n = 9	Service n = 37	Other n = 13
Neck	31%	34%	28%	0%	26%	19%	21%	24%	33%	19%	39%
Upper back	35%	34%	22%	25%	32%	38%	14%	29%	0%	22%	39%
Shoulders	58%	63%	22%	50%	58%	63%	50%	47%	44%	35%	46%
Elbows	35%	37%	22%	50%	34%	38%	36%	41%	33%	8%	31%
Wrist/hand	27%	7%	6%	0%	18%	13%	0%	0%	22%	5%	0%
Lower back	69%	42%	39%	50%	40%	44%	21%	12%	33%	30%	46%
Hips/thighs	31%	16%	11%	0%	26%	19%	7%	0%	0%	16%	15%
Knees	31%	34%	17%	50%	26%	25%	14%	41%	22%	32%	23%
Feet	69%	57%	39%	0%	63%	38%	43%	41%	33%	38%	46%

greatest among workers in the bakery, while the dairy had the lowest reports of foot pain.

Chi-square analyses did not reveal differences among Rodgers rating groups for proportions reporting musculoskeletal symptoms in the upper back, lower back, or hand/wrist (all $p > 0.28$).

3.2. Prediction of mental and physical health and well-being from musculoskeletal symptoms

Table 5 displays correlations among yes/no ratings for presence of musculoskeletal symptoms in the upper back, lower back, and

Table 5
Point-biserial correlations among yes/no ratings for presence of job related pain, ache, or discomfort in the upper back, lower back, and hand/wrist in the past 12 months, and the physical and mental component scores of the SF-36v2®. Two-tailed p-values are in parentheses. Means (standard deviations) are also presented for the physical and mental component scores of the SF-36v2® based on presence of job related pain, ache, discomfort in the upper back, lower back, and hand/wrist in the past 12 months.

Anatomical region	Statistic	Symptom present	Physical component score	Mental component score
Upper back	Point-biserial correlation (p-value)		−0.140 (0.026)	−0.174 (0.006)
	Mean (standard deviation)	Yes	50.1 (6.8)	46.8 (10.7)
	Mean (standard deviation)	No	52.4 (7.6)	50.7 (10.0)
Lower back	Point-biserial correlation (p-value)		−0.204 (0.001)	−0.111 (0.079)
	Mean (standard deviation)	Yes	50.3 (7.4)	48.5 (10.5)
	Mean (standard deviation)	No	53.3 (7.1)	50.8 (10.1)
Wrist/hand	Point-biserial correlation (p-value)		−0.150 (0.018)	−0.244 (0.001)
	Mean (standard deviation)	Yes	50.4 (6.9)	46.4 (10.9)
	Mean (standard deviation)	No	52.7 (7.6)	51.6 (9.4)

hand/wrist, and the physical and mental component scores of the SF-36v2®. All relationships were negative indicating that presence of musculoskeletal symptoms in any of the three regions was associated with poorer mental and physical well-being. With the exception of mental health in the presence of lower back symptoms, all correlations differed significantly from zero. However, the proportion of variance accounted for by SF-36v2® scores only ranged from 1% to 6%. Thus, we considered SF-36v2® scores to be inconsequential predictors for musculoskeletal symptoms.

Table 5 contains means and standard deviations for the physical and mental component scores of the SF-36v2® based on presence of musculoskeletal symptoms in the upper back, lower back, and hand/wrist. Independent group *t*-tests revealed significantly lower mean PCS and MCS scores in each region for workers with musculoskeletal symptoms (all $p < 0.027$) with the exception of mental health in the presence of lower back symptoms ($p = 0.079$).

3.3. Prediction of musculoskeletal symptoms from work-related exposure and demographic variables

In multivariable logistic regression, the single significant predictor of work-related upper back pain symptoms in the previous 12 months was gender. Females were nearly twice as likely to report upper back symptoms than males (OR = 1.92; 95% CI = 1.07–3.45, $p = 0.029$). The model was able to correctly classify 71% of workers by their report of presence of upper back symptoms.

Significant predictors of work-related hand/wrist pain symptoms in the previous 12 months were gender (OR = 2.16; 95% CI = 1.14–3.31, $p = 0.006$) and the interaction between age group and Rodgers rating group (OR = 0.17; 95% CI = 0.05–0.62, $p = 0.007$). Females were more than twice as likely to report hand/wrist symptoms than males. Being in the under 35 year-old age group and having a low Rodgers rating reduced the odds of hand/wrist symptoms by 83%. The model was able to correctly classify 62% of workers by their report of presence of hand/wrist symptoms.

For work-related lower back pain symptoms, none of the predictor variables or interaction terms were significant predictors of reports of pain. With only the constant in the model, classification accuracy was unimpressive at 51%.

3.4. Prediction of healthcare utilization from work-related exposure and demographic variables

In multivariable logistic regression, none of the predictor variables or interaction terms were significant predictors of healthcare utilization for work-related upper back pain symptoms. With only the constant in the model, classification accuracy was 74%.

Age group was the single significant predictor of healthcare utilization for work-related lower back pain symptoms in the previous 12 months (OR = 0.44; 95% CI = 0.19–1.00, $p = 0.05$). Employees less than 35 years of age had 56% lower odds of using healthcare for lower back symptoms than those 35 years of age or older. The model was able to correctly classify 76% of workers by their use of healthcare for lower back symptoms.

None of the predictor variables or interaction terms were significant predictors of healthcare utilization for work-related hand/wrist pain symptoms. With only the constant in the model, classification accuracy was 80%. The frequency of daily work prevented by musculoskeletal symptoms was so low that no analyses were conducted.

4. Discussion

The prevalence of musculoskeletal symptoms was high in this cohort of grocery workers with approximately 80% of study participants reporting job-related pain (Table 4). Comparably, Forcier and colleagues reported that approximately 83% of grocery workers had symptoms in at least one anatomical region (Forcier et al., 2008). In contrast, Ryan reported that 33.5% of a sample of 513 grocery workers had musculoskeletal symptoms (Ryan, 1989). The differences between the current study and Ryan's may be due to the different time periods over which presence of symptoms were reported. The current study examined symptoms over a 12-month period while Ryan assessed symptoms over two months.

Similar to other studies of grocery workers (Forcier et al., 2008; Ryan, 1989; Violante et al., 2005), the low back was the anatomical region with the highest prevalence of symptoms. With the exception of Forcier and colleagues (Forcier et al., 2008), the prevalence was higher in the current study (51%) than other investigations of grocery workers. In a study of 3702 grocery workers, Violante et al., 2005 reported a 34.5% 12-month prevalence of low back pain (Violante et al., 2005). These investigators found that workers in the produce department had the highest prevalence of low back pain, in contrast to the checkers and meat department workers in the current study. However, in contrast to Violante et al., 2005 no variables predicted low back pain in the current study. Studies have shown a relationship between age, gender, and back pain (da Costa and Vieira, 2010). Back pain is second only to headaches for causing lost work time (Stewart et al., 2003), and approximately 8% of current study participants missed work due to symptoms in the back and neck. However, no significant predictors were found for the association between missing work and low back pain. Worker age was the only predictor of healthcare utilization for low back symptoms, although some studies have suggested older age as a protective factor (Stewart et al., 2003).

In contrast to several other studies, aching in the feet accounted for the second most prevalent work-related problem. Approximately 50% of study participants reported pain in this region compared to only 14% of those surveyed by Forcier and colleagues (Forcier et al., 2008) and 4.7% by Ryan and colleagues (Ryan, 1989).

The population prevalence of foot pain has been estimated at 24% (Thomas et al., 2011). It is unclear why the prevalence was substantially higher in the current study since grocery tasks and flooring type are largely similar between stores. Differences among studies in the number of years working in the industry and differences in demographic characteristics, such as gender distribution among samples, could lead to variation in prevalence among studies. In addition, high prevalence of foot pain has been reported among salespersons (Pensri et al., 2009) and assembly plant workers (Werner et al., 2010). In the current study, prevalence of foot pain was mostly higher among workers who did more standing than walking during the day, a finding similarly noted by (Messing et al., 2008).

Approximately 40% of study participants complained of symptoms in the wrist and hand. Cashiers have been found to have a higher prevalence of hand/wrist symptoms with approximately 63% having symptoms consistent with carpal tunnel syndrome (Margolis and Kraus, 1987). Highly repetitive work such as cashiering is associated with carpal tunnel syndrome and other hand/wrist WMSDs (da Costa and Vieira, 2010; Osorio et al., 1994) with approximately one in four American workers exposed to repetitive work (Tak and Calvert, 2011). In the current study, approximately 42% of cashiers reported hand/wrist symptoms. However, the prevalence was higher among those who performed forceful exertions of the hand and wrist, such as bakers and dairy workers.

Palmer et al. (2008) found that those who reported a fair to poor mental health score on the SF-36 had approximately twice the risk of developing persistent arm pain (OR 2.1, 95% CI 1.4–3.1). Violante et al. (Violante et al., 2005) reported that "stress-related psychosomatic symptoms" were positively associated with low back pain. In contrast, we found low correlation between the Mental Component Score on the SF-36v2® and back or other pain complaints. This finding is consistent with previous findings of insufficient evidence of a relationship between low back pain and psychosocial occupational stress (Deeney and O'Sullivan, 2009; Hartvigsen et al., 2001; Lang et al., 2012). Results of the current study were only able to predict between 1% and 6% of the variance in SF-36v2® scale scores from musculoskeletal symptoms suggesting a lack of practical significance in the relationship. However, the construct assessed by the SF-36v2® may be different than the psychosocial questionnaire used by Violante and colleagues, which was based on Karasek's demand-control model (Karasek and Theorell, 1990).

Gender was a significant predictor of upper back and hand/wrist symptoms in this cohort. Comparable to other studies (Cote, 2012; Juul-Kristensen et al., 2004; Nordander et al., 2008; Widanarko et al., 2011), females in the current cohort were more likely to report musculoskeletal symptoms than males. Recent data from the Bureau of Labor and Industries indicates that females have a lower incidence rate of WMSDs than males, although injuries and illnesses related to repetitive work are higher among females (Bureau of Labor Statistics). Thus, the higher prevalence of hand/wrist symptoms among females is not surprising in the current study. Females accounted for approximately 61% of the respondents in the current study, comparable to the grocery workers surveyed by Ryan and colleagues (Ryan, 1989) (67%) but contrasting with Forcier and colleagues (Forcier et al., 2008) (45%). Ages were similar (37 years compared to 32 years). Our cohort consisted of experienced grocery workers with an average of 6.5 years of employment. Similar to other reports, checkout workers were predominantly female (65%) and stocking was mainly performed by males.

The Rodgers Muscle Fatigue Analysis was not associated with musculoskeletal symptoms. Several possibilities exist for this result. First, the Rodgers may not be a sensitive measure of cumulative exposure. Although infrequently used by ergonomists (Bernard, 2015), the Rodgers is easy for inexperienced evaluators to learn and use. The current study was part of a larger project to implement a participatory ergonomics program at the grocery chain. Members of the safety committee were taught how to perform rudimentary ergonomic analyses, and the Rodgers was used to help them focus on all anatomical regions during an assessment.

A second, and more probable, reason why Rodgers may not have been associated with symptoms is that insufficient proxy measures of exposure were used. Although proxy measures of exposure allow for more efficient sampling, they have the undesired effect of diluting exposure – outcome relationships, i.e., Type II error is more likely (Keyserling et al., 2010). Also, use of proxy exposure measures can also result in misclassification of exposure, likely towards the null (Gardner et al., 2000). Regardless, Violante and colleagues (Violante et al., 2005) used proxy measurements of exposure with a smaller sample of grocery workers. In the current study, the investigators made the a priori assumption that the most difficult tasks, i.e., peak exposure, would be primarily associated with musculoskeletal symptoms. However, it is possible that cumulative exposure may be more associated. Future studies on this population may benefit from exposure assessment that is based on a cumulative exposure model, or assessment of motions and forces with different grocery tasks, and in other anatomical regions than the wrist/hand and back.

There are additional limitations in the current study that may have affected the results. As previously indicated, other exposure assessment methods could have been used. For example, in a study of low back injuries among grocery workers, Violante and colleagues (Violante et al., 2005) used the NIOSH lifting equation to estimate low, medium, and high risk from heavy lifting. Use of an exposure assessment method that measures a single physical risk factor may overestimate or underestimate true exposure (Kapellusch et al., 2013). However, the Rodgers simultaneously assesses several risk factors in one index, similar to other observational methods such as the Strain Index, Rapid Entire Body Assessment, and Ovako Working Assessment System (Hignett and McAtamney, 2000; Karhu et al., 1977; Moore and Garg 1995; Takala et al., 2010). Regardless, many exposure assessment methods are not amenable to teaching those with limited knowledge of ergonomics and the need exists for more "user-friendly" methods.

5. Conclusions

The prevalence of musculoskeletal symptoms was high in this cohort of grocery workers with approximately 80% of study participants reporting job-related pain. Although back pain was most common, the foot was the second most commonly reported region of pain in contrast to other studies of grocery workers. This unexpected finding should be evaluated in future studies of this population since risk factors for foot pain are infrequently reported in occupational health literature. Biomechanical studies have suggested a relationship between foot pain and musculoskeletal symptoms in more cranial joints such as the knee, hip, and low back. Further studies with grocery workers could evaluate the relationship between interventions that reduce the impact of standing on hard working surfaces (e.g., foot orthoses) and musculoskeletal complaints of other anatomical regions.

Although musculoskeletal symptoms have been studied among grocery workers for years, the results of this study suggest that little has changed despite the adoption of newer technology such as hand scanners. These findings hold relevance to the grocery industry in order to develop WMSD preventive interventions, generally for high-risk activities within a grocery store position,

and specifically for symptoms in the back and feet.

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References

Anton, D., Goldrick, S., Modderman, S., Weeks, D., Hansen, D., 2012. Ergonomic exposure assessment methods for identifying musculoskeletal disorder risk in the workplace: an example from the grocery industry. Orthop. Phys. Ther. Pract. 24, 62–66.

Anton, D., Rosecrance, J., Merlino, L., Cook, T., 2002. Prevalence of musculoskeletal symptoms and carpal tunnel syndrome among dental hygienists. Am. J. Ind. Med. 42, 248–257.

Bernard, B.P. Analysis Tools for Ergonomists. Retrieved June 25, 2015, from http://personal.health.usf.edu/tbernard/ergotools/index.html.

Bodin, J., Ha, C., Serazin, C., Descatha, A., Leclerc, A., Goldberg, M., Roquelaure, Y., 2012. Effects of individual and work-related factors on incidence of shoulder pain in a large working population. J. Occup. Health 54, 278–288.

Bureau of Labor Statistics, 2014. Economic News Release: Nonfatal Occupational Injuries and Illnesses Requiring Days Away From Work, 2013. Retrieved June 25, 2015, from: http://www.bls.gov/news.release/osh2.nr0.htm.

Carrasco, C., Coleman, N., Healey, S., Lusted, M., 1995. Packing products for customers: an ergonomics evaluation of three supermarket checkouts. Appl. Ergon. 26, 101–108.

Cote, J.N., 2012. A critical review on physical factors and functional characteristics that may explain a sex/gender difference in work-related neck/shoulder disorders. Ergonomics 55, 173–182.

da Costa, B.R., Vieira, E.R., 2010. Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies. Am. J. Ind. Med. 53, 285–323.

Deeney, C., O'Sullivan, L., 2009. Work related psychosocial risks and musculoskeletal disorders: potential risk factors, causation and evaluation methods. Work A J. Prev. Assess. Rehabil. 34, 239–248.

Forcier, L., Lapointe, C., Lortie, M., Buckle, P., Kuorinka, I., Lemaire, J., Beaugrand, S., 2008. Supermarket workers: their work and their health, particularly their self-reported musculoskeletal problems and compensable injuries. Work 30, 493–510.

Gardner, L.I., Landsittel, D.P., Nelson, N.A., Pan, C.S., 2000. Misclassification of physical work exposures as a design issue for musculoskeletal intervention studies. Scand. J. Work Environ. Health 26, 406–413.

Grzywiński, W., Wandycz, A., Tomczak, A., Jelonek, T., 2016. The prevalence of self-reported musculoskeletal symptoms among loggers in Poland. Int. J. Ind. Ergon. 52, 12–17.

Hartvigsen, J., Bakketeig, L.S., Leboeuf-Yde, C., Engberg, M., Lauritzen, T., 2001. The association between physical workload and low back pain clouded by the "healthy worker" effect – population-based cross-sectional and 5-year prospective questionnaire study. Spine 26, 1788–1792.

Hignett, S., McAtamney, L., 2000. Rapid entire body assessment (REBA). Appl. Ergon. 31, 201–205.

Juul-Kristensen, B., Sogaard, K., Stroyer, J., Jensen, C., 2004. Computer users' risk factors for developing shoulder, elbow and back symptoms. Scand. J. Work Environ. Health 30, 390–398.

Kapellusch, J.M., Garg, A., Bao, S.S., Silverstein, B.A., Burt, S.E., Dale, A.M., Rempel, D.M., 2013. Pooling job physical exposure data from multiple independent studies in a consortium study of carpal tunnel syndrome. Ergonomics 56, 1021–1037.

Karasek, R.A., Theorell, T., 1990. Healthy Work: Stress Productivity and the Reconstruction of Working Life. Basic Books, New York.

Karhu, O., Kansi, P., Kuorinka, I., 1977. Correcting working postures in industry: a practical method for analysis. Appl. Ergon. 8, 199–201.

Keyserling, W.M., Wiggermann, N., Werner, R.A., Gell, N., 2010. Inter-worker variability in lower body postures during assembly line work: implications for exposure assessment. J. Occup. Environ. Hyg. 7, 261–271.

Kuorinka, I., Jonsson, B., Kilbom, Å., Vinterberg, H., Biering-Sørensen, F., Andersson, G., Jørgensen, K., 1987. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Appl. Ergon. 18, 233–237.

Lang, J., Ochsmann, E., Kraus, T., Lang, J.W.B., 2012. Psychosocial work stressors as antecedents of musculoskeletal problems: a systematic review and meta-analysis of stability-adjusted longitudinal studies. Soc. Sci. Med. 75, 1163–1174.

Major, M.E., Vezina, N., 2015. Analysis of worker strategies: a comprehensive understanding for the prevention of work related musculoskeletal disorders. Int. J. Ind. Ergon. 48, 149–157.

Margolis, W., Kraus, J.F., 1987. The prevalence of carpal-tunnel syndrome symptoms in female supermarket checkers. J. Occup. Environ. Med. 29, 953–956.

Merlino, L.A., Rosecrance, J.C., Anton, D., Cook, T.M., 2003. Symptoms of musculoskeletal disorders among apprentice construction workers. Appl. Occup. Environ. Hyg. 18, 57–64.

Messing, K., Tissot, F., Stock, S., 2008. Distal lower-extremity pain and work postures in the Quebec population. Am. J. Public Health 98, 705–713.

Miranda, H., Viikari-Juntura, E., Martikainen, R., Takala, E.P., Riihimaki, H., 2001. A prospective study of work related factors and physical exercise as predictors of shoulder pain. Occup. Environ. Med. 58, 528–534.

Moore, J.S., Garg, A., 1995. The Strain Index: a proposed method to analyze jobs for risk of distal upper extremity disorders. Am. Ind. Hyg. Assoc. J. 56, 443–458.

National Research Council – Institute of Medicine, 2001. Musculoskeletal Disorders and the Workplace. National Academy Press, Washington, DC.

NIOSH, 2009. National Occupational Research Agenda (NORA): National Wholesale and Retail Trade Agenda. Retrieved June 25, 2015, from:http://www.cdc.gov/niosh/nora/comment/agendas/wholrettrade/pdfs/WholRetTradeOct2009.pdf.

Nordander, C., Ohlsson, K., Akesson, I., Arvidsson, I., Balogh, I., Hansson, G.A., Skerfving, S., 2013. Exposure-response relationships in work-related musculoskeletal disorders in elbows and hands – a synthesis of group-level data on exposure and response obtained using uniform methods of data collection. Appl. Ergon. 44, 241–253.

Nordander, C., Ohlsson, K., Balogh, I., Hansson, G.A., Axmon, A., Persson, R., Skerfving, S., 2008. Gender differences in workers with identical repetitive industrial tasks: exposure and musculoskeletal disorders. Int. Arch. Occup. Environ. Health 81, 939–947.

Osorio, A.M., Ames, R.G., Jones, J., Castorina, J., Rempel, D., Estrin, W., Thompson, D., 1994. Carpal tunnel syndrome among grocery store workers. Am. J. Ind. Med. 25, 229–245.

Palmer, K.T., Reading, I., Linaker, C., Calnan, M., Coggon, D., 2008. Population-based cohort study of incident and persistent arm pain: role of mental health, self-rated health and health beliefs. Pain 136, 30–37.

Parot-Schinkel, E., Descatha, A., Ha, C., Petit, A., Leclerc, A., Roquelaure, Y., 2012. Prevalence of multisite musculoskeletal symptoms: a French cross-sectional working population-based study. BMC Musculoskelet. Disord. 13 (122).

Pensri, P., Janwantanakul, P., Chaikumarn, M., 2009. Prevalence of self-reported musculoskeletal symptoms in salespersons. Occup. Med. Oxford 59, 499–501.

Rodacki, A.L.F., Vieira, J.E.A., Okimoto, M.L.L.R., Fowler, N.E., Rodacki, C.D.L.N., 2006. The effect of handling products of different weights on trunk kinematics of supermarket cashiers. Int. J. Ind. Ergon. 36, 129–134.

Rodgers, S.H., 1992. A functional job evaluation technique. Occup. Med. 7, 679–711.

Ryan, G.A., 1989. The prevalence of musculoskeletal symptoms in supermarket workers. Ergonomics 32, 359–371.

Silverstein, B., Adams, D., 2007. Work-related Musculoskeletal Disorders of the Neck, Back, and Upper Extremity in Washington State, 1997-2005. SHARP Program, Olympia, WA.

Spielholz, P., Howard, N., Carcamo, E., Coulter, B., 2008. Field evaluation of a new grocery checkstand design. Appl. Ergon. 39, 87–91.

Stewart, W.F., Ricci, J.A., Chee, E., Morganstein, D., Lipton, R., 2003. Lost productive time and cost due to common pain conditions in the US workforce. JAMA J. Am. Med. Assoc. 290, 2443–2454.

Stock, S., Nicolakakis, N., Raiq, H., Messing, K., Lippel, K., Turcot, A., 2014. Under-reporting work absences for nontraumatic work-related musculoskeletal disorders to workers' compensation: results of a 2007–2008 survey of the Quebec working population. Am. J. Public Health 104, E94–E101.

Tak, S., Calvert, G.M., 2011. The estimated national burden of physical ergonomic hazards among US workers. Am. J. Ind. Med. 54, 395–404.

Takala, E.P., Pehkonen, I., Forsman, M., Hansson, G.A., Mathiassen, S.E., Neumann, W.P., Winkel, J., 2010. Systematic evaluation of observational methods assessing biomechanical exposures at work. Scand. J. Work Environ. Health 36, 3–24.

Thomas, M.J., Roddy, E., Zhang, W.Y., Menz, H.B., Hannan, M.T., Peat, G.M., 2011. The population prevalence of foot and ankle pain in middle and old age: a systematic review. Pain 152, 2870–2880.

Turner-Bowker, D.M., Bartley, P.J., Ware, J.E., 2002. SF-36 Health Survey & "SF" Bibliography. QualityMetric, Inc., Lincoln, RI.

Violante, F.S., Graziosi, F., Bonfiglioli, R., Curti, S., Mattioli, S., 2005. Relations between occupational, psychosocial and individual factors and three different categories of back disorder among supermarket workers. Int. Arch. Occup. Environ. Health 78, 613–624.

Ware, J.E., Kosinski, M., 2001. SF-36 Physical and Mental Health Summary Scales: a Manual for Users of Version 1. QualityMetric, Inc., Lincoln, RI.

Werner, R.A., Gell, N., Hartigan, A., Wiggermann, N., Keyserling, W.M., 2010. Risk factors for foot and ankle disorders among assembly plant workers. Am. J. Ind. Med. 53, 1233–1239.

Widanarko, B., Legg, S., Stevenson, M., Devereux, J., Eng, A., t Mannetje, A., Pearce, N., 2011. Prevalence of musculoskeletal symptoms in relation to gender, age, and occupational/industrial group. Int. J. Ind. Ergon. 41, 561–572.