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Published in:
Applied Ergonomics

DOI:
10.1016/j.apergo.2015.09.004

2016

Document Version:
Peer reviewed version (aka post-print)

Link to publication

Citation for published version (APA):
Balogh, I., Ohlsson, K., Nordander, C., Björk, J., & Hansson, G.-Å. (2016). The importance of work organization on workload and musculoskeletal health - Grocery store work as a model. *Applied Ergonomics*, *53*(Part A), 143-151. https://doi.org/10.1016/j.apergo.2015.09.004

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The importance of work organization on workload and musculoskeletal health - grocery store work as a model

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Abstract

We have evaluated the consequences of work organization on musculoskeletal health. Using a postal questionnaire, answered by 1600 female grocery store workers, their main work tasks were identified and four work groups were defined (cashier, picking, and delicatessen work, and a mixed group, who performed a mix of these tasks). The crude odds ratios (ORs) for neck/shoulder complaints were 1.5 (95% CI 1.0–2.2), 1.1 (0.7–1.5) and 1.6 (1.1–2.3), respectively, compared to mixed work. Adjusting for individual and psychosocial factors had no effect on these ORs. For elbows/hands, no significant differences were found. Technical measurements of the workload showed large differences between the work groups. Picking work was the most strenuous, while cashier work showed low loads. Quantitative measures of variation revealed for mixed work high between minutes variation and the highest between/within minutes variation. Combining work tasks with different physical exposure levels increases the variation and may reduce the risk of musculoskeletal complaints.

Word: 150

Keywords: variation, physical exposure, job rotation

Highlights

The physical workload and musculoskeletal symptoms in grocery store workers are clarified

Single work tasks had higher risk for musculoskeletal complaints than mixed ones

Cashiers had the lowest physical loads but the highest level of musculoskeletal complaints

The low variation for cashiers may explain their high risk of neck/shoulder complaints

Combining work tasks with different workloads will improve the work situation

1. Introduction

A large number of recent studies show that work-related musculoskeletal disorders (WMSD) are still highly prevalent, more so in certain occupational settings (Buckle and Devereux, 2002; Bongers et al., 2006; Nordander et al., 2009; Farioli et al., 2014). There is an obvious need for preventive action (Hagberg et al., 2012). Many work settings are characterised by constrained postures and repetitive movements during continuous periods of long duration (Nordander et al., 2009). It has been suggested that variation between work tasks during the working day may reduce the risk of developing WMSD (Luger et al., 2014). However, Leider et al. (2015a) concluded that the evidence for the health benefits of job rotation is inconsistent, and that it may not be useful for all activities (Leider et al., 2015b). Bao et al. (2015) found that job rotation involved higher biomechanical stresses, while Keir et al. (2015) showed that there were beneficial effects on muscular loads. Obviously, workers rotating between jobs with different loads implies an exposure pattern of great complexity (de Oliviera Sato and Cote Gil Coury, 2009). Hence, as stated by Mathiassen (2006**)** further studies are still needed. Such studies must use quantitative measures of the variation which are derived from physical exposure data. It is also necessary to find occupations where musculoskeletal problems occur, and which involve a large number of work tasks with different exposure profiles. Such a work situation is found in grocery stores, which retain a large number of employees, particularly women (Johansson et al. 2015).

In a survey from Statistics Sweden (2003), 93% of the cashiers in grocery stores reported performing physically monotonous, repetitive work for at least half their work time. Cashiers in grocery stores therefore constitute a relevant group for studying the importance of how work is organised. A number of publications show a high prevalence of WMSD among supermarket cashiers (Niedhammer et al., 1998; Lundberg et al., 1999; Rissén et al., 2002; Bonfiglioli et al., 2007; Forcier et al., 2008). Many risk factors have been highlighted, such as the physical work conditions (Lehman et al., 2001; Kihlstedt and Hägg, 2011; Draicchio et al., 2012**)** and the psychosocial environment (Niedhammer et al., 1998; Lundberg et al., 1999)**.**

Recent recommendations from The Swedish Work Environment Authority state that: “If the checkout work is repetitive and closely controlled, it must be organised so that it does not normally exceed 4 hours/day and does not last for more than 2 hours at a time”. Thus changes need to be made to how cashier work is organised, possibly by alternating with other types of work.

However, to achieve a better work environment for the cashiers, it is important that these other forms of work truly comprise a different physical exposure. Thus, information about workloads in all the work tasks carried out in grocery stores is needed, along with information about how variation and musculoskeletal health are affected by the way in which the work is organised. To achieve this, a number of measures regarding postures and movements, as well as muscular loads in the relevant body regions, have to be applied. The aim of the present study is to collect such information and to test the hypothesis that variations in workload imply a decreased risk for WMSD.

2. Study design

All 110 grocery stores within a large store association in the southern part of Sweden were invited to participate. A majority, 98, agreed to do so, and provided us with a list of those of their employees who work at least 10 hours per week. All employees received a questionnaire, and written information about the study, which emphasised that participation was optional. If no response was received, two reminders were sent. In 13 of the stores, the data was augmented by performing a physical examination. Direct technical measurements of the physical workload were carried out in eight of these stores, taking into account different working days, the size of the stores, their location (town, city) and the three main work tasks identified from the questionnaire. In connection to the physical examination, the subjects were asked to participate in the measurements, and 1–5 were randomly selected for measurement. Four work groups were

formed from subjects working a minimum of 30 hours per week, divided according to the proportion their time spent on the main work tasks (see 3.1.). All work was performed during opening hours, 7 a.m. to 10 p.m.

The study was approved by The Regional Ethical Review Board in Lund.

3. Subjects and methods

3.1. Subjects

A questionnaire (see 3.2.1.) was answered by 1600 female (response rate 74%) and 445 male employees, respectively. Since only 6 male employees fulfilled the criteria for inclusion in the study (see below), all the males were excluded. Of the female employees, 989 fulfilled the inclusion criteria of working at least 30 hours per week. Based on information from the questionnaire, three main work tasks were identified, namely cashier work, picking work and delicatessen work, and therefore three work groups were formed. Cashier work involves registrations of provisions, handling payments (money or credit cards) and providing customers with tobacco. The work is performed either sitting or standing. Picking work involves fetching provisions from the storeroom, either by carrying or pulling/pushing a cart, and subsequently filling the shelves and the freezers. The provisions are handled one by one or in larger packages. Delicatessen work involves filling up the refrigerated display counters, as well as attending to customers buying food at the delicatessen counter.

The subjects were included in one of these groups if they performed the task during at least 80% of their working time. In addition, a fourth group, mixed work, was formed, comprised of those who perform a combination of these three work tasks during at least 80% of their working time. For this group, the proportion of the main work tasks was 45%, 42% and 13% for cashier, picking and delicatessen work respectively (mean values for the group). There were 828 participants who fulfilled the inclusion criteria. The cashier, picking, delicatessen, and mixed groups consisted of 185, 199, 164 and 280 subjects respectively. The mean age of the 828 included subjects was 42 (with a span of 18–66) years, and their employment time 11 (0.3–46)

years, there were no major differences in age or employment time between the four work groups. For all the individual factors, see Table 1.

Table 1. Individual factors for the female workers in the 98 grocery stores in the four work groups, as well as for the total sample population. Mean values and standard deviations (SD) are given, as well as fractions (%) for category scales.

	Cashier work N=185	Picking work N=199	Delicatessen work N=164	Mixed work N=280	Total N= 828
Age, years (SD)	42 (15)	42 (12)	43 (12)	40 (13)	42 (13)
Employment Time, years (SD)	11 (10)	13(11)	11(10)	9 (9)	11 (10)
BMI, kg/m^2 (SD)	25 (5)	25 (4)	26 (5)	25 (4)	25(5)
No. of children, (SD)	0.6 (0.9)	0.9 (1)	0.8 (1)	0.8 (1)	0.8 (1)
Smoking, %	31	29	21	26	26
Housekeeping, >10h/week, %	45	54	57	53	52
Recovery, >1h/day, %	63	64	65	56	61
Exercise, >once/week %	73	74	79	74	75

3.2. Methods

3.2.1. Questionnaire

The questionnaire included questions about individual factors, musculoskeletal complaints (pain, aches or discomfort) occurring in the neck and upper extremities during the previous seven days (Standardized Nordic Questionnaire; Kuorinka et al., 1987). In addition, information was requested regarding the main work tasks, and the proportion of time per week spent upon each task, The psychosocial work environment was estimated using responses to a Job Content Questionnaire (JCQ) (Karasek and Theorell, 1990; Karasek et al. 1998**)**.

3.2.2. Physical examination

In 13 of the stores, a physical examination of the neck and upper limbs (Ohlsson et al., 1994) was performed on all subjects, resulting in data from 212 female employees. In terms of their

individual factors, these subjects did not differ from the study group as a whole. Diagnoses were reached according to a set of predefined criteria (Ohlsson et al., 1994; Nordander, 2004; Nordander et al., 2009**)**.

3.2.3. Measurement of physical workload

Measurements were obtained for 22 female grocery store workers. Their mean age was 37 years (range 22–60 years), height 168 cm (range 156–178 cm) and weight 75 kg (range 55–95 kg). Seventeen of the workers performed both cashier work and picking work. The remaining five workers performed delicatessen work. These participants did not differ from the total group in terms of their individual factors or their muscular skeletal complaints. During the recordings the subjects were observed and the time of the beginning and end of the tasks was noted. This information was used to split the analysis into work tasks.

3.2.3.1. Muscular load

Bipolar surface electromyography (EMG) was recorded bilaterally for the descending part of the upper trapezius muscle, and for the forearm extensor muscles (m. carpi radialis longus and brevis) (Åkesson et al., 1997). Muscular activity was normalised to the EMG activity (MVE) recorded during maximal voluntary contractions. For the trapezius muscle, these were performed as attempted arm elevation against a resistance, with the arm elevated to 90° in the scapula plane, and for the forearm extensor muscles as a maximal hand grip test (for details see Nordander et al., 2004). Data were sampled at 1024 Hz using data loggers (Logger Teknologi HB, Åkarp, Sweden; Hansson et al., 2003). The signal was band pass (30–400 Hz) and notch (50, 100, 150, . . 400 Hz) filtered, and the root mean square value (RMS) was calculated for epochs of 0.125 s (Hansson et al., 1997). The subtraction of noise was performed in a power sense (Hansson, 2011). Muscular rest, i.e. the fraction of time with an EMG activity below 0.5% MVE (Veiersted et al., 1990; Hansson et al., 2000), and the 10^{th}, 50^{th} and 90^{th} percentiles of the amplitude distribution (Jonsson, 1982) were used to describe the muscle load.

3.2.3.2 Postures and movements and variation of the head and upper arms

Inclinometers, based on triaxial accelerometers were used for recording flexion/extension of the head and elevation of the upper arms (Hansson et al., 2001, 2006). The inclinometers were fixed on the forehead, and on the lateral part of the upper arms just distal to the insertion of the middle part of the deltoid muscle. The reference postures of the head (0° forward/backward inclination) was recorded with the subject standing in an upright posture, looking straight ahead. The reference posture (0° elevation) of the upper arm was recorded with the subject seated, with the side of the body leaning towards the armrest of the chair, and the arm hanging perpendicular while holding a 2 kg weight in their hand. One data logger (Logger Teknologi HB, Åkarp, Sweden) with a sampling frequency of 20 Hz was used. For the head inclination, positive angles denote forward inclination and negative angles backward. The 1^{st}, 50^{th} and 90^{th} percentiles were presented. The 1^{st} percentile represents "backward inclination", the 50^{th} percentile "median inclination" and the 90^{th} percentile "forward inclination". The median forward/backward inclination angular velocity was used to describe head movements. For the upper arms the 99^{th} percentile, and the percentage of time with an elevation above 90°, were used to describe arm elevation, and the 50^{th} percentile of the generalised angular velocity was used to describe the movements (Hansson et al., 2001).

The within-minutes (WMV) and between-minutes variation (BMV) was calculated as the mean and standard deviation, respectively, of the time-series of the minute-by-minute calculated 90% width (95^{th}–5^{th} percentile) of the angular distributions (Arvidsson et al., 2012). The between- to within-minutes variation ratio (BWR), i.e. the coefficient of variation, was also derived.

3.2.3.3 Postures and movements of the wrists

Biaxial electrogoniometers (SG75, accuracy ±2° over ±90°; Biometrics Ltd., Gwent, UK) were used for recording the flexion/extension angles of both the right and left wrist (Hansson et al., 1996, 2004; Balogh et al., 2009**)**. The reference posture (0° flexion/extension) was defined as the

wrist angle obtained when the subject was standing and the arms and hands were hanging relaxed beside the body. Positive angles denote flexion and negative angles extension. A data logger (Logger Teknologi HB, Åkarp, Sweden) with a sampling frequency of 20 Hz was used. The 10th, 50th and 90th percentiles of the angular distribution were used to describe the extended, median and flexed postures, respectively. The 50th percentile of the angular velocity, and the fraction of time with the hand held still (<1 °/s for consecutive periods ≥ 0.5 s) were used to describe the movements (Hansson et al., 1996).

3.2.4 Calculation of physical workload

For mixed work) the mean values were for all exposure measures (except BMV and BWR; see below) calculated by straightforward time weighting according to the mixed work group average fraction of time spent with cashier work (t_C = 45%), picking work (t_P = 42%) and delicatessen work (t_D = 13%) (see above) and the loads in these tasks,:

$$Mean_{EXP}(Mixed) = t_C \cdot Mean_{EXP}(Cashier) + t_M \cdot Mean_{EXP}(Picking) + t_D \cdot Mean_{EXP}(Delicatessen).$$

The corresponding variance (Var_{EXP}) and standard deviation ($\sqrt{Var_{EXP}}$) of these measures were calculated based on the time-weighted variance contributions of the three tasks and the covariance between each pair of tasks:

$$Var_{EXP}(Mixed) = t_C^2 \cdot Var_{EXP}(Cashier) + t_P^2 \cdot Var_{EXP}(Picking) + t_D^2 \cdot Var_{EXP}(Delicatessen) + 2t_C t_P \cdot CoVar_{EXP}(Cashier, Picking) + 2t_C t_D \cdot CoVar_{EXP}(Cashier, Delicatessen) + 2t_P t_D \cdot CoVar_{EXP}(Picking, Delicatessen),$$

where the covariance ($CoVar_{EXP}$) between two tasks X_1 and X_2 was obtained from the correlation ($Corr_{EXP}$) and variance of the two tasks:

$$CoVar_{EXP}(X_1, X_2) = Corr_{EXP}(X_1, X_2) \cdot \sqrt{Var_{EXP}(X_1)} \cdot \sqrt{Var_{EXP}(X_2)}.$$

Since a correlation could only be derived between cashier and picking work, this value was used for calculation of the covariance between the other two pairs.

For BMV and BWR, the calculations were performed differently. Since BMV^2 (BMV squared) is a variability measure on a variance scale, we denote

$$Var(Cashier) = Mean_{BMV}(Cashier)^2.$$

$$Var(Picking) = Mean_{BMV}(Picking)^2.$$

$$Var(Delicatessen) = Mean_{BMV}(Delicatessen)^2.$$

Standard formulas for calculation of the variance in pooled samples from different populations can be applied to obtain mean BMV for the mixed work group. Hence, the variance in the pooled (mixed work group) sample is the sum of two variance components (VCs),

$$Var = VC_1 + VC_2.$$

where VC_1 is the contribution of the variance within each task assessed as time-weighted average:

$$VC_1 = t_C \cdot Var(Cashier) + t_P \cdot Var(Picking) + t_D \cdot Var(Delicatessen).$$

and VC_2 is the time-weighted variance contribution stemming from differences in means (i.e. of the WMV) across tasks:

$$VC_2 = t_C t_P \cdot (Mean_{WMV}(Cashier) - Mean_{WMV}(Picking))^2$$
$$+ t_C t_D \cdot (Mean_{WMV}(Cashier) - Mean_{WMV}(Delicatessen))^2$$
$$+ t_P t_D \cdot (Mean_{WMV}(Picking) - Mean_{WMV}(Delicatessen))^2.$$

Thus,

$$Mean_{BMV}(Mixed) = \sqrt{Var} = \sqrt{VC_1 + VC_2}.$$

BWR was then calculated as the BMV/WMV ratio. The standard deviations for BMV and BWR were not estimated.

For the other work groups, which on average spent 95-98% of the time in their particular work, we assigned the exposure measures for the relevant work.

3.3. Psychosocial exposure

From the 26 JCQ items the scales job demand, job control and job support were calculated as the means of the items, in accordance with Karasek et al. (1998). For each scale, results were dichotomized, based on the median value of the response data from all the subjects, to define high and low values for each individual. A combination of low job demands and high job control was denoted “relaxed”, high job demands and high job control was denoted “active”; low job demands and low job control as “passive”; and high job demands and low job control as “job strain”.

3.4. Statistics

All statistical analyses were conducted in SPSS 18.0 (SPSS, Chicago, IL, USA), and p-values below 0.05 considered as statistically significant. Individual factors for the participants were summarized using the mean and standard deviation (SD) for continuous values, and with the relative frequency of the most common category for categorical variables. Direct comparisons between groups were made for continuous values using a t-test. The proportion of the variance in the physical exposures attributed to a job task was estimated for each exposure as 1 – ICC, where ICC is the interclass correlation coefficient obtained from a two-way mixed effects regression model. Here, data for cashier work was limited to subjects chosen from the n=17 subjects from whom individual exposure measurements had been taken, reducing the total number of subjects to n=786. The proportion of the variance in the psychosocial aspects attributed to each work task was estimated for each aspect as an adjusted R^2 from a linear regression model, with job task as a fixed factor.

Logistic regression analysis was used to investigate associations between the work task and musculoskeletal complaints, with adjustment for individual-level factors. As a first step, unadjusted odds ratios (ORs) for complaints in the neck/shoulders and elbows/hands were estimated. In the second step, individual-level factors exhibiting univariate associations (with a threshold p-value <=0.2) with a musculoskeletal complaint in a specific region were included as adjustment variables in that particular regression model, “partly adjusted”. The third step, “fully adjusted”, also included those individual variables which, irrespective of p-value, were considered a priori to be risk factors for musculoskeletal complaints. Finally, dichotomised psychosocial factors were added to the fully adjusted models in order to assess the effects on the risk estimates.

4. Results

4.1. Physical workload

As could be expected, for cashier, picking, and delicatessen work, velocities were generally higher for the right than the left side, both for the upper arms and the wrists. The relative

differences were similar, being on average 40% (not in table). For picking work, the upper arm elevation was also higher for the right than the left side (99th percentile: 107° vs. 96°; above 90°: 4.1 vs. 1.8 % of time). Only data for the right side are presented below.

Cashier work showed significantly lower muscular load (for both the trapezius muscle and the forearm extensors), less backward or forward inclination of the head, less arm elevation, lower velocities for head, upper arm and wrist, and lower WMV and BMV than picking work. Delicatessen work showed intermediate values for all except two of these measures (Table 2). Wrist extension did not differ significantly between the work tasks. Cashier work showed a more extended median posture and less wrist flexion than picking work, while delicatessen work showed intermediate values.

Table 2. (140513) Muscular load, head and upper arm postures, movements and variation, and wrist postures and movements, recorded for 17 female grocery store workers, performing both cashier work (mean recording duration 89 min) and picking work (duration 81 min), and 5 female workers performing delicatessen work (duration 241 min). Data for mixed work, derived by time weighting of the load for cashier, picking, and delicatessen work (see text), are also shown. For muscular load, the percentile values are normalized to the maximal voluntary EMG activity (% MVE). For head inclination, positive angles denote forward inclination and negative angles backward. For wrist flexion/extension positive angles denote flexion and negative angles extension.

Region		Work			
Load		Cashier (n=17)	Picking (n=17)	Delicatessen (n=5)	Mixed
Measure		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Right trapezius					
Muscular rest (% time)		18.0 (14.9) [A, B]	3.7 (3.2) [A]	4.2 (2.3) [B]	10.2 (7.8)
Percentile (% MVE)	10th	0.8 (1.0) [A]	1.5 (0.9) [A]	1.3 (0.6)	1.1 (0.7)
	50th	4.4 (2.7) [A]	7.1 (3.2) [A]	6.4 (2.8)	5.8 (2.5)
	90th	10.9 (4.5) [A, B]	20.1 (6.8) [A]	18.3 (4.6) [B]	15.7 (4.6)
Right forearm extensors *					
Muscular rest (% time)		8.8 (7.6) [A]	4.2 (3.2) [A]	4.2 (3.6)	6.3 (4.1)
Percentile (% MVE)	10th	1.0 (0.9) [A]	2.0 (1.3) [A]	1.6 (1.3)	1.5 (0.8)
	50th	8.5 (4.0) [A]	13.3 (8.4) [A]	9.9 (4.5)	10.7 (5.5)
	90th	24.7 (11.6) [A]	35.1 (17.6) [A]	24.4 (7.8)	29.0 (13.4)
Head					
Inclination (°)					
Percentile	1st	-13 (5) [A]	-26 (7) [A, D]	-15 (4) [D]	-19 (4)
	50th	11 (7) [B]	14 (7) [D]	24 (5) [B, D]	14 (6)
	90th	25 (8) [A, B]	44 (11) [A]	46 (2) [B]	36 (7)
Velocity (°/s)					
Percentile	50th	11.4 (2.8) [A, B]	20.6 (4.0) [A, D]	14.4 (2.6) [B, D]	15.7 (3.0)
Variation					
Within-minutes (°)		32 (4) [A, B]	54 (7) [A, D]	46 (3) [B, D]	43 (4)
Between-minutes (°)		8 (2) [A, B]	15 (2) [A, D]	12 (3) [B, D]	16
Between/Within-minutes		0.26 (0.05)	0.28 (0.05)	0.27 (0.06)	0.37
Right upper arm					

Elevation					
Percentile (°)	99th	69 (11) [A, B]	107 (14) [A, D]	89 (3) [B, D]	87 (9)
Above 90° (% time)		0.2 (0.3) [A, B]	4.1 (3.5) [A]	1.0 (0.2) [B]	1.9 (1.5)
Velocity (°/s)					
Percentile	50th	30.9 (11.0) [A, B]	65.3 (12.9) [A, D]	50.9 (8.3) [B, D]	48.0 (9.9)
Variation					
Within-minutes (°)		29 (4) [A, B]	55 (6) [A, D]	42 (4) [B, D]	42 (4)
Between-minutes (°)		10 (3) [A, B]	21 (4) [A]	17 (2) [B]	20
Between/within-minutes		0.35 (0.08)	0.38 (0.06)	0.40 (0.07)	0.48
Right wrist **					
Flexion/extension (°)					
Percentile	10th	-40 (7)	-37 (7)	-42 (12)	-39 (7)
	50th	-17 (6) [A]	-6 (5) [A]	-13 (10)	-12 (6)
	90th	14 (6) [A]	24 (7) [A]	16 (9)	18 (6)
Velocity (°/s)					
Rest (<1 °/s; % time)		3.5 (3.5) [A, B]	0.5 (0.7) [A]	0.8 (0.7) [B]	1.9 (1.7)
Percentile	50th	18.8 (7.3) [A]	28.5 (6.2) [A]	22.4 (4.7)	23.4 (4.5)

Missing data due to technical reasons: * cashier 1 subject, picking 1 subject; ** cashier 4 subjects, picking 4 subjects.
Significant differences ($p<0.05$): [A] cashier vs. picking; [B] cashier vs. delicatessen; [D] picking vs. delicatessen.

For all measures except BMV and BWR, mixed work showed values in-between those for cashier and picking work (Table 2). This is a consequence of the characteristics of the majority of the measures, i.e. that they can be derived by straightforward time-weighting of the tasks involved in the mixed work, combined with the fact that cashier and picking work make up about equal parts of the mixed work, and delicatessen work only a minor part. However, for BMV and BWR, the relations between the tasks became quite different. For BMV, mixed work showed, compared to the other work groups, the highest value for the head. For the upper arm, BMV had a high value (20°), close to the value for picking (21°), rather than an intermediate value between picking and cashier (10°). BWR revealed even more prominent differences between the work groups: for the head, mixed work showed a high value (0.37), compared to cashier, picking and delicatessen work, which had lower values which were all close to each other (0.26, 0.28, 0.27, respectively). The pattern was the same for the upper arm (Table 2).

Between 11 and 91% of the variance was attributed to the work groups which had the highest values for wrist movements and lowest for wrist postures (cashier and picking work). Regarding the specific measures for variation, the figures were 68–99%.

4.2. Psychosocial exposure

There were substantial, statistically significant differences in the psychosocial work conditions between the work groups (Table 3). Cashier work had the lowest scores for job demand and job control, but similar scores for job support, compared to the other three work groups. Median values for job demand, job control and job support were 2.66, 2.59 and 2.63 respectively (not in table).

Table 3. Psychosocial factors for the female grocery store workers in different work groups. The mean scores and standard deviation (SD) are shown, as well as the distribution over the four aspects: relaxed, active, passive, and strain.

	Cashier work N=174	Picking work N=191	Delicatessen work N=155	Mixed work N=266	Total N= 786
Job demands, score (SD)	2.60[ABC] (.43)	2.69[A] (.39)	2.75[B] (.37)	2.70[C] (.40)	2.68 (.40)
Job control, score (SD)	2.22[ABC] (.48)	2.86[ADE] (.44)	2.74[BDF] (.45)	2.58[CEF] (.48)	2.60 (.52)
Job support, score (SD)	2.64 (.46)	2.68[D] (.45)	2.57[D] (.46)	2.64 (.49)	2.64 (.47)
Relaxed, %	11[ABC]	35[ADE]	24[BD]	24[CE]	24
Active, %	10[ABC]	37[AE]	39[BF]	21[CEF]	26
Passive, %	50[ABC]	14[AE]	14[BF]	25[CEF]	26
Strain, %	30[A]	15[AE]	22	31[E]	25

Significant differences ($p<0.05$): [A] cashier vs. picking; [B] cashier vs. delicatessen; [C] cashier vs. mixed; [D] picking vs. delicatessen; [E] picking vs. mixed; [F] delicatessen vs. mixed.

Half of the subjects performing cashier work reported passive work conditions, twice as many as those with mixed work and three times as many as those with picking work or delicatessen work. One third of the cashiers reported strain, almost as many as those with mixed work, but significantly higher than picking or delicatessen work. Picking work showed the highest score for job control, followed by delicatessen work. Mixed work showed the most even distribution over the four aspects.

The proportions of the variance in the psychosocial aspects attributed to work groups were low: demand 1%, control 19% and support 0%.

4.3. Musculoskeletal disorders

4.3.1. Complaints

The prevalence of neck/shoulder complaints during the previous seven days varied between 44–56%, mixed work being the lowest, picking work somewhat higher, while cashier and delicatessen work showed significantly higher values (Table 4).

Table 4. Prevalence (%) of musculoskeletal complaints during the previous 7 days among the female employees, according to their main work task, and for the total.

Complaints during previous 7 days	Cashier work N=185	Picking work N=199	Delicatessen work N=164	Mixed work N=280	Total N=828
Neck/Shoulder %	55	46	56	44	49
Neck %	42	33	40	30	35
One or two shoulders	45	41	48	42	44
%	36	35	33	32	34
Elbows/hands %	14	13	11	12	12
One or two elbows %	34	28	30	27	29
One or two hands %					

For elbows/hands, the prevalence of complaints was lower, and the differences between the types of work were smaller (Table 4).

4.3.2. Diagnosed disorders

The physical examination of the 212 subjects showed that 28% had one or more diagnosable neck/shoulder disorders, these being most prevalent among subjects performing cashier work (33%, not in table). The most common diagnosis was tension neck syndrome (14%), most prevalent among subjects with cashier work 21%, and least prevalent among subjects with picking work, 9%. Other common diagnoses were right shoulder tendinitis, m. biceps (8.8%), m. supraspinatus (7.0%) and m. infraspinatus (4.7%).

The prevalence of diagnosed disorders in elbows/hands was lower, at 8%, varying between 6–11%. These disorders were most prevalent among subjects performing picking work and least prevalent among subjects with cashier work (not in table). The most frequent diagnoses were carpel tunnel syndrome for the left side (2%), lateral epicondylitis for the right side (2%) and overused hand syndrome 1% for both sides.

4.4. Association between exposure and disorders

For neck/shoulder complaints, subjects with cashier work and delicatessen work showed elevated ORs compared to subjects with mixed work (Table 5). In relation to mixed work, the crude ORs for cashier, picking and delicatessen work were 1.5 (95% CI 1.0–2.2), 1.1 (0.7–1.5) and 1.6, (1.1–2.3) respectively (Table 5). Partial and full adjustments had only a marginal effect on the ORs. No such difference in ORs was found for subjects with picking work. For elbows/hands complaints, no significant differences were found between subjects with different tasks, neither with crude nor adjusted values (Table 5).

Table 5. Odds ratios (ORs) and 95% confidence intervals (95% CI) for the risk of neck/shoulder and elbow hand complaints for cashier work, picking work and delicatessen work compared to mixed work. ORs were estimated from three different logistic regression models, unadjusted and fully adjusted.

	Neck/shoulder complaints				Elbow/hand complaints			
	Unadjusted		Fully adjusted*		Unadjusted		Fully adjusted*	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Work groups								
Cashier	1.5	1.0–2.2	1.5	1.0–2.3	1.2	0.8–1.8	1.2	0.7–1.8
Picking	1.1	0.7–1.5	1.0	0.7–1.5	1.1	0.8–1.7	1.2	0.8–1.8
Delicatessen	1.6	1.1–2.3	1.6	1.0–2.5	1.1	0.7–1.6	1.1	0.7–1.7
Mixed	Ref		Ref		Ref		Ref	
Individual factors								
Smoking								
No			Ref				Ref	
Yes			1.6	1.1–2.3			1.1	0.8–1.6
Recovery								
<=1 h/day			1.6	1.2–2.2			2.1	1.5–3.0
>1 h/day			Ref				Ref	
Housekeeping								
<10 h/week			Ref				Ref	
>=10 h/week			1.0	0.8–1.4			0.9	0.6–1.3
BMI								
<18.9			Ref				Ref	
>=18.9–<24.9			1.2	0.5–2.8			1.9	0.7–5.3
>=25			1.0	0.4–2.4			2.2	0.8–6.4
Age								
<35 years			Ref				Ref	
>=35–<50 years			1.4	0.9–2.1			1.9	1.2–2.9
>=50 years			1.5	0.9–2.3			4.5	2.8–7.3

Employment time							
<5 years		Ref				Ref	
>=5–<10 years		1.4	1.0–2.1			1.0	0.7–1.6
>=10 years		1.0	0.6–1.5			1.0	0.6–1.5

* Adjusted for smoking, recovery, housekeeping, BMI, age and employment time.

The psychosocial factors displayed an association with neck/shoulder complaints during the previous 7 days, i.e. the OR for high job demand was 1.5 and for low job support 1.7, both of which were statistically significant (Table 6). For low job control, the OR was 1.3, however this was not statistically significant. Similar figures were found for the elbow/hands (Table 6). Including these three factors in an extended model had virtually no effect on the risk estimates for the work groups, neither for neck/shoulder, nor for elbow/hands.

Table 6. Odds ratios (ORs) and 95% confidence intervals (95% CI) for the risk of neck/shoulder and elbow/hand complaints during the previous 7 days. These are given for the subjects who answered the psychosocial questions, separated according to cashier work, picking work and delicatessen work, in a fully adjusted and an extended model.

	Neck/shoulder				Elbow/hands			
	Modified Fully adjusted (N=638)*		Extended model (N=638)		Modified Fully adjusted (N=638)*		Extended model (N=638)	
	OR	(95%)	OR	95% CI	OR	(95%)	OR	95% CI
Main work task								
Cashier (N=146)	1.7	1.1–2.7	1.7	1.1–2.8	1.3	0.8–2.2	1.4	0.9–2.3
Picking (N=161)	1.0	0.7–1.6	1.1	0.7–1.7	1.2	0.8–2.0	1.3	0.8–2.1
Delicatessen (N=117)	1.7	1.1–2.8	1.7	1.1–2.8	1.0	0.6–1.7	0.9	0.5–1.6
Mixed (N=214)	Ref		Ref		Ref		Ref	
Psychosocial exposure								
Job demand (ref=low)			1.5	1.0–2.1			1.6	1.1–2.4
Job control (ref=high)			1.3	0.9–1.8			1.1	0.7–1.6
Job support (ref=high)			1.7	1.2–2.4			1.9	1.3–2.7

* Modified according to the number of subjects providing psychosocial exposure factor data

Since the physical exposure was assessed using the group mean, these factors cannot be included and evaluated in an extended model, unlike the psychosocial factors.

5. Discussion

The main result of the study was that mixed work involved more variation than the other tasks, with high between minute variation and the highest between minute/within minute variation ratio. Hence, the positive effect of variation may have counteracted the expected adverse effect of the established measures of physical workload.

The mixed work comprised three different work tasks. Our data show clear differences between the work groups in terms of their physical and psychosocial workload. Cashier work showed substantially lower loads than picking work for all measured parameters of the physical exposure. Interestingly, the prevalence of musculoskeletal complaints was not consistent with the established measures of physical workload: mixed work and picking work showed the highest physical workloads, but significantly fewer neck/shoulder complaints than delicatessen or cashier work.

Job demands, as well as job control, were lower for cashier work than for any of the other work groups. However, adjusting for the psychosocial factors had no effect on the ORs in regard to the association between complaints and type of work.

5.1. Methodological issues

To ensure that store design, organization culture, and professional training were as similar as possible, we chose to perform the study within a specific grocery store organization in the southern part of Sweden. These stores varied in size, and served cities, towns and rural areas. In this way, we have reduced the influence of some dependent factors, and still retained generalizability. The response rate was relatively high, and we have no reason to believe that the proportion of non-responders would differ between the groups. Hence, the risk estimates can be considered to be reliable.

To certify that the musculoskeletal complaints were related to work, we chose subjects performing a minimum of 30 working hours per week. To detect any effect of work organization, such as job rotation, we considered it crucial to establish well-defined work groups performing either a single task or with a mix of tasks. To accomplish this, we decided a minimum of 80% of the subject's time should be spent on a particular task in order to define the individual tasks. As the results of the study are based on the occurrence and duration of work tasks, it is essential that this data should be valid and reliable. Because the subjects worked according to individual schedules, we consider that the information is indeed reliable.

5.2. Measurements of physical workload

The methods used for assessing the physical exposure have proven to be precise (Nordander et al., 2004; Hansson et al., 2006; Balogh et al., 2009). Since we used 22 subjects for the measurements on different days and in different circumstances, the mean values for the specific work tasks can be considered as reliable. To ascertain the variation in work postures and movements we have also calculated the mean of within minute posture range for the upper arm

(95^{th}–5^{th} percentile) over the work day (the within minute variation) and the standard deviation over these means (the between minutes variation, Arvidsson et al., 2012) as well as the ratio between these two. These measures obviously also reflect other aspects of the workload.

The high BMV values for mixed work are due to the fact that this measure not only considers the variation within the included tasks, but also includes the variation due to differences between these tasks. Thus, BMV for mixed work exceeds the highest value of any of the individual tasks for head postures. This property of discrimination between tasks was even more pronounced for BWR.

The homogeneity of the single-task work groups is lower than indicated by the SDs from Table 2. This is because subjects included in these groups were those who spend at most 20% of their time on other work tasks, including tasks other than the main tasks identified here. The homogeneity can be even lower in the mixed group since, in addition to the above-described effect, the proportion of the three main work tasks differs between the subjects in this work group. These conditions may have diminished chances of detecting contrasts between the groups.

Comparing our data with previous measurements of other occupations using identical methods (Hansson et al., 2009, 2010), cashier and picking work differ considerably, also in relation to the wide range of exposure within the group of "repetitive industrial work". For all main exposures, cashier work showed generally low loads, while the loads for picking work were in the high range of "repetitive industrial work".

Sandsjö et al. (2000) found that muscular rest exceeded 25 % time and that the 90^{th} percentile was about 10% MVE for the right trapezius muscles during cashier work, which is well in accordance with our data. Also, Rissén et al. (2000) evaluated a combination of cashier and other work, and found similar muscular loads on the dominant trapezius as for the mixed work group in our study.

5.3. Psychosocial work environment

When analysing the psychosocial factors job demand, job control, and job support, we found relations to neck/shoulder as well as for elbows/hands complaints. However, introducing these factors in the fully adjusted model had virtually no influence on the ORs. This is consistent with the fact that the variance in the psychosocial aspects, attributed to work group was low, (0–19%). Thus, the differences between the work groups in the ORs for complaints cannot be explained by psychosocial work factors.

5.4 Musculoskeletal disorders

Our data on the prevalence of musculoskeletal symptoms in grocery store work compared to other occupations are in accordance with repetitive and/or constrained work such as light assembly work and dental hygienist work (Nordander et al., 2009). This is true of the neck/shoulder and the elbow/hand regions.

Most studies concerning work in grocery stores have focused on the prevalence of musculoskeletal disorders among cashiers (Rissén et al., 2002; Bonfiglioli et al., 2007; di Pedre et al., 2011; Kihlstedt and Hägg, 2011; Sansone et al., 2014). Only a few have studied other work tasks in grocery stores (Forcier et al., 2008). Unfortunately, direct comparisons with these studies are hampered by use of different case definitions.

The work presented here also included a physical examination, with a definition of diagnoses (Ohlsson et al., 1994; Nordander, 2004; Nordander et al., 2009). The number of subjects was too small for statistical calculations between the different work groups, but one of our most common diagnoses was carpel tunnel syndrome, which has also been shown to be frequent in other studies, along with other nerve entrapments, especially among cashiers (Panzone et al., 1996; Bonfiglioli et al., 2007; di Pede et al., 2011).

5.5 Relation between physical exposure and musculoskeletal disorders

The data on physical exposure showed clear differences between the work groups. For all the established measures, picking work had considerably higher exposures than cashier work. Also,

cashier work showed low exposures in comparison with a variety of other occupations, while picking work had high exposures (Hansson et al 2009, 2010). This may seem surprising, since cashier work is regarded as strenuous, with a high risk of developing musculoskeletal disorders (Bonfiglioli et al., 2007; Barbieri et al., 2013: Sansone et al., 2014), and indeed, the OR for neck/shoulders complaints was 1.7 for cashier work but 1.0 for picking work when compared to mixed work. However, one characteristic aspect of cashier work is the restricted work pattern, i.e. the work takes place within a limited area. There is a need for a relevant exposure measure to describe these aspects of the work (Mathiassen, 2006; Wells et al., 2007). A combination of different descriptions, such as cycle time, number of actions, duty time, low range of motion, and low velocities, has been used to assess such aspects. Moreover, methods to describe exposure-time variation have been developed (Mathiassen and Winkel, 1991; Arvidsson et al., 2012). In our opinion, measures of variation expressed as BMV and BWR offer a useful description of this aspect. Regarding BMV, picking work and mixed work showed the same value, twice as high as for cashier work. For BWR, the relative variation, there were no significant differences between cashier, picking and delicatessen work, while the numerical values for mixed work were considerably higher. Thus, BWR reflects another aspect of variation, and in this material it discriminates between work with a single task and shifting between tasks. Hence it is a suitable measure to quantify job rotation between tasks with different exposure levels.

In summary, we believe that the higher prevalence of complaints among subjects performing cashier work than among those with picking work or mixed work can be explained by a higher variation in the latter tasks.

It is obvious that organizing the work so that the employees shift between different work tasks with diverse loads, will lead to a sum of loads which is intermediate. Hence, for some individuals who experience lower loads changing to such a shifting arrangement will involve higher loads. This may seem contradictory, as higher loads are usually associated with unfavourable conditions. However, some studies point out that this is beneficial, especially in monotonous work (Strake and Mathiassen, 2009). Our study implies that when subjects belonging to the

cashier work group are transferred to the mixed work group, they will work at higher loads concerning muscular activities, postures and movements. However, they will also obtain a higher degree of variation regarding both BMV and BWR, which may decrease the prevalence of musculoskeletal disorders in the long term. Subjects in the picking work group will have decreased amplitudes, virtually without any decrease in BMV, and with an increase in BWR. Thus, the entire work group will achieve a more beneficial workload by shifting between work tasks. Such an argument has also been made by Yung et al. (2012). Organizing the work as described could be regarded as a natural form of "job rotation".

6. Conclusions

By combining work tasks with different physical exposure levels, an increased variation in workload can be achieved. The measures BMV and BWR proved to be useful in elucidating this variation. Mixed work, as described in this study, was proven to be beneficial. Furthermore, organizing the work in this way fulfilled the requirements demanded by the Swedish Work Environment Authority.

This finding may be applied in other work settings where it is possible to rotate between work tasks which differ in load. The risk of musculoskeletal complaints may be reduced by this kind of intervention.

7. Acknowledgements

This study was supported by the Swedish Council for Work Life and Social Research, Lund University Medical Faculty, and the County Councils of Southern Sweden. Skillful technical assistance was given by Ms Lothy Granquist, Ms Anita Olsson and Camilla Dahlqvist. Valuable contributions to the data collections were made by Ms Ingrid Åkesson, Ms Inger Arvidsson, Ms Monica Hansson and Ms Josefin Lindfors. We are also grateful for the valuable cooperation with all the employers and employees who participated in the study, as well as the trade union.

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