Physical and mental strain at work: Relationships with onset and persistence of multi-site pain in a four-year follow up

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Running title: Mental and physical strain and multi-site pain

Abstract

This study evaluates whether physical and mental strain are associated with an onset and persistence of multi-site pain among younger and older employees in a four year of follow-up. A questionnaire survey was conducted in a food processing company twice, in 2005 and 2009 with the response from 734 employees in the age between 20 and 66 years (445 younger and 289 older; 65% female). Information on musculoskeletal pain during the preceding week and perceived mental and physical strain was obtained through a structured questionnaire. The association of onset and persistence of multi-site pain with mental and physical strain was estimated with log binomial regression analysis and stratified by age-group. Risk ratio (RR) with their 95% confidence intervals (CIs) are reported for the estimates. More than 56% of the employees reported multi-site pain at baseline. Among those who reported multi-site pain at baseline 70% reported persistence of multi-site pain and one third had new onset of multi-site pain at the follow-up. Mental strain at baseline strongly predicted persistence of multi-site pain among both younger and older employees (RR from for younger employees = 1.68, 95% CI = 1.01-2.83 and RR for older employees = 2.25, 95% CI 0 1.27-3.98). The high mental strain predicted the risk of persistence multi-site pain among both younger and older employees in a four year follow-up but not onset of multi-site pain.

Key words: musculoskeletal pain; multi-site pain; mental strain; physical strain

Highlights

- There is an increased attention to the relationship between work exposures and musculoskeletal disorders in recent research.
- Mental strain at baseline was strong predictor of persistence of multi-site pain musculoskeletal pain both among younger and older employees.
- Interventions in the workplaces focusing on the individual level would reduce physical and mental strain as a result lower the incidence of multi-site pain for both younger and older employees.

INTRODUCTION

Musculoskeletal pain in multiple body sites is frequent in the working population (Neupane et al, 2013a; Haukka et al, 2013; Herin et al, 2014). A large body of research however focused on a single body site. Association between certain physical (physical work load, repetitive task, awkward posture) and psychosocial exposures (high job demands, low job control, co-workers and supervisors support) at work and painful conditions at particular anatomical sites has been studied extensively. Evidence shows that pain in multiple body site is associated with decreased functioning and worse prognosis when compared to having pain in only one body site (Neupane et al, 2014; Haukka et al, 2013; Kamaleri et al, 2008; Miranda et al, 2010). However less is known about the relationship of multi-site musculoskeletal pain with mental and physical strain related work exposures.

The concept of strain in this study is based on the stress-strain model where the stress on a worker depends on environmental factors (both physical and psychosocial) acting upon the person, whereas strain denotes the effects of stress which differ by individual for a certain stress factor (Rutenfrantz, 1981; Cox et al, 2000). The stress and strain concept has been widely used in studies on the effects of physical work load on both the cardiovascular as well as the musculoskeletal system (Rutenfranz, 1981, Nygård et al, 1988). The model emphasizes the role of individual characteristics such as age, gender, health status and work ability as modifiers of the relationship between strain and musculoskeletal symptoms or pain.

Industrial workers are mostly exposed to physical strain (Nicot, 2007). The high strain is mostly due to the physical work environment in the industry. In a cross-sectional study among men and women employed in different occupations, physical strain was associated with musculoskeletal symptoms (Johansson, 1995). One earlier study among health care employees, mental strain was found to be a risk factor for musculoskeletal symptoms in a three year follow-up (Josephson et al, 1997). It also found that the risk was higher when it was combined with perceived high physical exertion. Psychological or mental strain has also been found to be linked to poor outcomes such as early retirement (Laine et al, 2008) and mortality (Kivimäki et al, 2002). In a 28 years of follow-up study, work strain (both mental and physical) during midlife among municipal employees was found to be strongly related to declined work ability in old age (von Bonsdorff et al, 2012) and stress symptoms in midlife predicted disability after 28 years (Kulmala et al, 2013).

Earlier studies have reported the relationship of strain and age with inconclusive findings. One study has shown that older employees experience higher strain than younger employees (Nygård et al., 1997). However, Pailhe (2005) reported that younger cohorts are exposed to physical strain more frequently than older cohorts. In this study of 4 years of prospective follow-up of industrial employees we evaluated whether physical and mental strain were associated with an onset and persistence of multi-site pain. We were also interested whether the association were different for younger and older employees.

METHODS

This study is based on questionnaire surveys conducted among all employees of one of the leading food industries in Finland (1985 employees) in spring 2005 and spring 2009. The questionnaires were distributed at the workplaces to every employee (response rate 60%). It was possible to reply anonymously or to sign the consent for individual follow-up of the surveys and for linking to the personnel registers of the company including information on age, gender occupational status, workplace and duration and interruptions of the job contract. The replies were placed in sealed envelopes which were collected and forwarded to the researchers. As the question forms were not addressed to individual employees, no reminders could be sent. The study was approved by the ethical committee of Pirkanmaa Hospital District.

Measurement of variables

A modification of the validated Nordic Musculoskeletal questionnaire (Kuorinka et al. 1987) was used to assess musculoskeletal pain. It included a question regarding whether the employee had felt pain, aching or numbness in four anatomical areas (hands or upper extremities; neck or shoulders; lower back; and feet or lower extremities) during the preceding week, with the reply scale being from 0 (not at all) to 10 (very much). The variables were dichotomised at the median (less than median: 0= mild; more than median: 1= severe). The cut-off values for upper extremities, neck and shoulder, lower back and lower extremities were 4, 5, 2 and 2, respectively. The dichotomised variables were summed up into a variable expressing the number of areas with severe pain (from zero to four) (Neupane et al. 2013a; Neupane et al. 2013b). The summed variable was further

categorized into two, leaving zero and one as ‘no multi-site pain’ and ‘multi-site pain’ by combining two, three and four sites pain.

Mental strain

Perceived mental strain was assessed by a modified version of the occupational stress questionnaire (Elo et al., 1992), using a single question (“Stress means a situation in which a person feels excited, apprehensive/concerned, nervous or distressed or she/he cannot sleep because of the things on her/his mind. Do you feel this kind of stress nowadays?”) (Elo et al., 1992), with the reply scale from 0 (not at all) to10 (very much). For this analysis, mental strain was categorized into low (0-2), medium (3-6) and high (7-10) by their tertile values.

Physical strain

Perceived physical strain was elicited with the rating of perceived exertion (RPE) with the question “How physically hard/ exhausting do you feel your job is in a normal work day?” on a scale from 6 (not at all) to 20 (very much) (Borg, 1970). Physical strain in this study was categorized into three low (6-11), medium (12-15) and high (16-20) based on the tertile values.

Covariates:

Work ability was assessed with one question from the work ability index as a subjective assessment of current work ability compared with a person’s self-identified lifetime best (i.e. with the question “Assume that your work ability at its best has a value of 10 points.

What score would you give your current work ability?"). Work ability was categorized into excellent (score 10), good (score 9), moderate (score 8) and poor (scores 0-7) work ability in this study (Gould et al, 2008).

Body mass index (BMI) was calculated using workers' self-reported weight (kg) and height (m). The level of physical exercise during the last month was elicited on a scale from 0 (not at all) to 7 (strenuous physical activity for more than 3 hours a week).

Statistical Analysis

Descriptive statistics of the study population was presented first in the form of frequencies and percentages in total stratified by age group (<45 years 'younger' and ≥45 'older'). Log binomial regression analysis was performed to examine whether baseline mental and physical strain were associated to multi-site pain after four years of follow-up. Risk ratios (RR) with their 95% confidence intervals (CI) are presented. The analyses were conducted separately for those who had multi-site pain at baseline ('persistence of multi-site pain') and those with no multi-site pain at baseline ('onset of multi-site pain'). And again both analyses were stratified by age group in order to see the difference between age group. The models were built up in 3 steps: Model I: crude risk ratios, Model II: adjusted for gender and occupational status and lastly Model III: includes gender, occupational status, physical exercise, BMI and baseline work ability. All the analyses were carried out with the statistical package SPSS version 21.0.

RESULTS

Table 1 shows the descriptive characteristics of the study population at baseline. Within the total of 734 study population, 60% were less than 45 years of old. About two third of the study population were female and more than 70% were blue-collar employees. There were more male and blue-collar employees in the younger age group and more female and white-collar employees in the older age. One third of the study population had high physical exercise which not much differed between age groups. A little more than one fifth of the people had BMI $\geq$ 29.0 Kg/m^2 and almost 30% of the younger employees had low (<23.0 kg/m^2) BMI and 25% of the older employees had high ($\geq$ 29.0 Kg/m^2) BMI. About 15% of the study population had poor work ability at baseline and about the same number (16%) had reported excellent work ability. Within the age group, almost one fifth of younger employees had excellent work ability compared to 11% in their older counterparts. Physical strain was comparatively high (30% vs. 27%) among younger employees while mental strain was high among older employees (30% vs. 21%). More than 56% of the employees reported multi-site pain at baseline. Comparatively younger employees reported multi-site pain more often than their older counterparts.

Risk ratios and their 95% CI for multi-site pain at follow-up due to physical and mental strain among the cohort with no multi-site pain at baseline are presented in Table 2. One third of the study population had new onset of multi-site pain. High physical strain was found to be associated with onset of multi-site pain among all in the crude model (RR = 1.48, 95% CI = 1.01-2.18) but significance association was lost when adjusted in model II and model III. Although not significant, the employees with high mental strain had higher risk of having new onset of multi-site pain in the four year follow-up. Employees with high

physical strain had higher risk of reporting onset of multi-site pain among both younger and older age group. However the associations were not found to be significant.

Table 3 presented risk ratio with their 95% CI for persistence of multi-site. More than 70% of the employees had continuation of multi-site pain at the follow-up. High physical strain was associated with persistence of multi-site pain among all who had multi-site pain already at baseline. However it lost a significant association when adjusted for gender, occupational status, physical exercise, BMI and work ability in Model III. Medium to high mental strain was strongly associated with persistence of multi-site pain (RR = 1.90, 95% CI = 1.30-2.78). Among younger employees high physical strain was associated with persistence of multi-site pain up to model II but no significant association was found in final model. However mental strain was found to significantly associate with persistence of multi-site pain among younger employees (RR from final model = 1.68, 95% CI = 1.01-2.83). Physical strain was not associated with persistence of multi-site pain among older employees. However mental strain significantly predicted persistence of multi-site pain among older employees. The association was consistently significant in each adjustment (RR from final model = 2.25, 95% CI 0 1.27-3.98).

DISCUSSIONS

Our study provides strong evidence that mental strain predicted persistence of multi-site pain both among younger and older employees but not the onset of multi-site pain after four years of follow-up. The association mental strain with multi-site pain was particularly

stronger among older employees. Physical strain was also associated with persistence of multi-site pain only among younger employees but when controlled for gender, occupational status, physical exercise, BMI and work ability at baseline the effect of physical strain was decreased and turned out to be insignificant. Due to the limited number of earlier studies studying the association of mental and physical strain with musculoskeletal pain in multiple locations, a meaningful comparison with the results of the present study is warrant.

This is the first report where perceived mental and physical strain has been observed as an independent risk factor for development of onset and persistence of multi-site pain in a prospective design. The current findings should be replicated in other industrial populations with a similar design, more power and longer follow-up. Although physical strain was associated neither with onset nor persistence of multi-site pain, strong significant association of multi-site pain was found with physical strain when using all subjects (data not shown). Based on the current findings we argue that interventions may be designed to lower the perceived mental and physical strain and as a result lower the incidence of multi-site pain for both younger and older employees. There may be a need for interventions in the workplaces more specifically focused to the individual than to the workplace, since the perception of musculoskeletal pain arise from both workplace factors and individual factors. Ergonomic solutions at individual level in the work place to match the demands with the capacity of the workers are essential.

Interestingly, in this study perceived physical or mental strain did not predict onset of multi-site pain in four year of follow-up although almost one third of the employees who did not have multi-site pain at baseline had new onset or incidence of multi-site pain at the follow-up. Among the employees who had multi-site pain at baseline, a very large proportion, 70%, had persistence or continuation of multi-site pain at the follow-up. Similarly, nearly one third of the employees reported high physical strain and 24% reported high mental strain, which is considered to be high. It was also found that physical strain was comparatively high among younger and mental strain was high among older employees within the same cohort. However we did not find an interaction between mental strain and physical strain in relation to multi-site pain in our study.

One recent study showed that moderate and strenuous physical exertion at work increases the risk of long-term sickness absence among healthcare workers (Andersen et al, 2012). In one earlier study, job strain (mostly physical) was a predictor for neck, shoulder and wrist symptoms among Chinese workers (Yu et al, 2013). The combination of high job strain and high perceived muscular tension was associated with higher risk of developing neck pain among VDU users in Sweden (Wahlström et al, 2004). Another 6 month follow-up study from USA reported that workers with perceived high job strain were more likely to develop neck-shoulder symptoms (Hannan et al, 2005). High risk of musculoskeletal pain was reported when job strain was combined with perceived high physical exertion among nursing personnel in Sweden (Josephson et al, 1997). Another study from Finland showed that stress symptoms and musculoskeletal disorders are reciprocally related to each other (Leino et al, 1989). However perceived physical exertion or physical strain in our

study was not as strong as mental strain to predict onset and persistence of multi-site pain when controlling for several possible confounders. Some explanations may be suggested for the results. Firstly, rearrangements of the ergonomic working conditions may have been more common in the workers with multi-site pain and high occurrence of physical strain. Age programs was implemented in the company (Siukola et al. 2011) and occupational health care management were active in individual level interventions when recognizing signs of reduced work ability. Such interventions may have inflated the association in the high exposure groups. Secondly, the healthy-worker effect may have affected our result in this, as well as in any, prospective workplace study. It may have levelled off the pain differences between the exposure groups through selection of employees with low and high physical strain to tasks with lower workload or out of the workforce.

Our study had the advantage of a prospective longitudinal design, allowing us to examine baseline predictors of multi-site pain at four years for those with and without multi-site pain at baseline. Response rates for both surveys were satisfactory. However, we cannot rule out the possibility that selection due to differential participation at baseline or at follow-up affected our results. Selection out of the workforce is more likely to occur among the workers with most health problems, as well as the highest exposure levels, leaving the healthiest workers at the workplaces and being selected in cohort studies as ours. In our study workers who were exposed to high mental or physical strain and had multi-site pain in the baseline were lost to follow-up. Such biases deflate the associations between workplace exposures and health outcomes. We also can't rule out that the measurement tool for mental strain was enough to capture all psychosocial aspects of work.

The subjects were asked to report pain that had occurred during the past seven days. This timeframe increases the likelihood that pain had truly occurred at multiple body sites concurrently and also decreases the likelihood of recall bias. The perception of musculoskeletal pain, mental and physical strain was assessed by questionnaire, i.e. no objective measurements were carried out. However, a self-report method appears to be the best (and practically only) way of assessing pain in epidemiological studies because of its complex and subjective nature (Crombie et al. 1999; Natvig et al. 2001). In addition the whole study was stratified by age groups in order to see the difference between younger and older employees.

CONCLUSION

The current study suggest that after controlling for potential confounders, a high mental strain predicted the risk of persistence multi-site pain but not the onset among neither younger nor older employees in a four year follow-up. Surprisingly, physical strain was not significantly related to both onset and persistence of multi-site pain when controlling for potential confounders.

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CONFLICT OF INTEREST

None declared

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Table 1: Baseline characteristics of the study population

Characteristics	All		Younger (<45 years)		Older (≥45 years)	
	N=734	%	N=445	%	N=289	%
Gender						
Male	255	34.7	173	38.9	82	28.4
Female	479	65.3	272	61.1	207	71.6
Occupational status						
Blue-collar	518	70.6	327	73.5	191	66.1
White-collar	216	29.4	118	26.5	98	33.9
Physical exercise						
Less	322	44.1	193	43.6	129	44.9
Moderate	162	22.2	94	21.2	68	23.7
High	246	33.7	156	35.2	90	31.4
BMI						
<23.0	180	24.5	129	29.0	51	17.6
23.0-25.9	230	31.3	136	30.6	94	32.5
26.0-28.9	153	20.8	82	18.4	71	24.6
≥29.0	171	23.3	98	22.0	73	25.3
Work ability						
Poor	106	14.5	63	14.3	43	14.9
Moderate	235	32.1	130	29.4	105	36.3
Good	274	37.5	165	37.3	109	37.7
Excellent	116	15.9	84	19.0	32	11.1
Physical strain						
Low	247	33.7	140	31.5	107	37.2
Medium	273	37.3	169	38.1	104	36.1
High	212	29.0	135	30.4	77	26.7
Mental Strain						
Low	267	36.4	166	37.4	101	34.9
Medium	288	39.3	186	41.9	102	35.3
High	178	24.3	92	20.7	86	29.8
Musculoskeletal pain						
No multi-site	321	43.7	191	42.9	130	45.0
Multi-site pain	413	56.3	254	57.1	159	55.0

Table 2: Risk ratios (RR) and 95% confidence interval (CI) for multi-site pain in relation to physical and mental strain at work among the cohort with no multi-site pain at baseline (N=108), younger and older employees

	RR and 95% CI for multi-site pain		
	Model I	**Model II**	**Model III**
All			
Physical strain			
Low	1.0	1.0	1.0
Medium	1.12 (0.81-1.55)	1.02 (0.70-1.48)	1.09 (0.74-1.60)
High	**1.48 (1.01-2.18)**	1.29 (0.83-2.00)	1.38 (0.87-2.18)
Mental Strain			
Low	1.0	1.0	1.0
Medium	1.22 (0.89-1.67)	1.27 (0.92-1.75)	1.14 (0.82-1.60)
High	1.19 (0.80-1.78)	1.28 (0.85-1.94)	1.23 (0.80-1.88)
Younger			
Physical strain			
Low	1.0	1.0	1.0
Medium	1.20 (0.79-1.82)	1.16 (0.71-1.91)	1.40 (0.82-2.41)
High	1.39 (0.80-2.41)	1.34 (0.72-2.47)	1.69 (0.88-3.25)
Mental Strain			
Low	1.0	1.0	1.0
Medium	1.14 (0.76-1.71)	1.17 (0.78-1.77)	1.05 (0.68-1.62)
High	0.90 (0.49-1.66)	0.99 (0.53-1.87)	1.08 (0.56-2.10)
Older			
Physical strain			
Low	1.0	1.0	1.0
Medium	1.11 (0.65-1.87)	0.93 (0.52-1.65)	0.91 (0.50-1.66)
High	1.53 (0.89-2.64)	1.18 (0.62-2.24)	1.12 (0.57-2.20)
Mental Strain			
Low	1.0	1.0	1.0
Medium	1.31 (0.79-2.17)	1.38 (0.82-2.30)	1.28 80.74-2.21)
High	1.36 (0.77-2.40)	1.46 (0.82-2.61)	1.39 (0.75-2.55)

Model I: Crude risk ratio

Model II: Adjusted for gender and occupational status

Model III: Adjusted for model II + physical exercise, BMI and work ability at baseline

Table 3: Risk ratios (RR) and 95% confidence interval (CI) for multi-site pain in relation to physical and mental strain at work among the cohort with multi-site pain at baseline (N=291), younger and older employees

	RR and 95% CI for multi-site pain		
	Model I	**Model II**	**Model III**
All			
Physical strain			
Low	1.0	1.0	1.0
Medium	1.02 (0.74-1.41)	1.05 (0.73-1.50)	0.97 (0.66-1.42)
High	**1.46 (1.04-2.04)**	**1.52 (1.02-2.24)**	1.28 (0.85-1.94)
Mental Strain			
Low	1.0	1.0	1.0
Medium	**1.44 (1.07-1.95)**	**1.45 (1.07-1.97)**	**1.40 (1.01-1.93)**
High	**2.07 (1.47-2.92)**	**2.24 (1.57-3.20)**	**1.90 (1.30-2.78)**
Younger			
Physical strain			
Low	1.0	1.0	1.0
Medium	1.00 (0.65-1.53)	1.03 (0.64-1.67)	0.97 (0.58-1.62)
High	**1.57 (1.03-2.41)**	**1.63 (1.00-2.73)**	1.40 (0.81-2.42)
Mental Strain			
Low	1.0	1.0	1.0
Medium	1.37 (0.93-2.01)	1.37 (0.93-2.01)	1.21 (0.80-1.84)
High	**1.96 (1.24-3.10)**	**2.15 (1.33-3.45)**	**1.68 (1.01-2.83)**
Older			
Physical strain			
Low	1.0	1.0	1.0
Medium	1.04 (0.64-1.71)	1.07 (0.62-1.83)	0.92 (0.51-1.65)
High	1.25 (0.72-2.17)	1.30 (0.70-2.41)	1.00 (0.52-1.93)
Mental Strain			
Low	1.0	1.0	1.0
Medium	1.54 (0.94-2.53)	1.56 (0.94-2.56)	1.63 (0.96-2.78)
High	**2.24 (1.33-3.77)**	**2.42 (1.41-4.15)**	**2.25 (1.27-3.98)**

Model I: Crude risk ratio

Model II: Adjusted for gender and occupational status

Model III: Adjusted for model II + physical exercise, BMI and work ability at baseline