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Psychosocial and Ergonomic Factors, and Their Relation to Musculoskeletal Complaints in the Swedish Workforce

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A random sample of 1 000 subjects (20–65 years old) from the national population of Sweden received a questionnaire; 70% (n *= 695) replied, of whom 532 were occupationally active. Female gender, working with neck and/or body bent forward, arms above shoulders, and precision work tasks were predictors of musculoskeletal symptoms. Neck, shoulder, and upper back symptoms were more common in a strained situation at work (high demands, low control) (adjusted odds ratios [adjOR] 2.76, 2.80, and 2.26, respectively). Among females, neck and shoulder symptoms were more common in an iso-strain situation (high demands, low control and low social support) (adjOR 4.43 and 3.69, respectively), and low back symptoms were more common at low social support combined with a passive work situation (adjOR 3.35). No associations were found between iso-strain model and symptoms among males. In conclusion, iso-strain work situation was associated with neck symptoms among females, even when controlling for ergonomic factors.*

gender demands–control iso-strain psychosocial work environment musculoskeletal symptoms ergonomic factors national population

1. INTRODUCTION

Musculoskeletal disorders have been a research focus for many decades; their prevalence is still high, leading to a risk for sick leave and disability [1, 2]. The origin of musculoskeletal symptoms is multifactorial. Possible risk factors are ergonomic, such as exposure to manual handling, repetitive and static work, vibrations and physical load [1, 2, 3, 4]; psychosocial, such as monotonous work, time pressure, poor work content, high demands and low support from colleagues and superiors [2, 5, 6]; high perceived work stress and nonwork-related stress [1, 5]; poorly experienced psychosocial work environment [7], or personal factors such as older age [2, 8, 9, 10, 11], female gender [4, 12, 13], low job satisfaction [6, 9, 14], low sense of coherence [15], and psychological and emotional problems [5].

Over the last few decades, more interest has been focused on psychosocial factors and their relation to musculoskeletal disorders [1]. To study the influence of psychosocial factors at work on musculoskeletal disorders the demands–control model (DC) has been applied [16]. Karasek and Theorell constructed the DC model to study the impact of psychosocial factors at work on different symptoms and illnesses [17]. They predicted a set of outcomes for "active workers", i.e., a high degree of control was supposed to counteract high psychological work demands. Low control has been associated with musculoskeletal symptoms

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[5, 7]. Psychosocial factors were only associated with part of the multidimensional spectrum of neck and back pain [9, 18]. Recently Bongers, IJmker, van den Heuvel, et al. found that high work demands or low control at work in many studies were associated with neck and upper limb problems, in both epidemiological cross-sectional and longitudinal studies [1]. Associations between psychosocial work situation and musculoskeletal symptoms are found mainly in the central body regions [19]. Different aspects of the DC model were associated with different musculoskeletal symptoms, e.g., high job demands were associated with symptoms from neck and low-back pain [5, 20].

Social support from superiors and co-workers is another important factor for the perception of psychosocial stress [21]. House suggested that social support could act as a main effect on work stress and health, and additionally as a buffer by reducing the importance of experienced stress; by tranquilizing the neuroendocrine system, thus making people less reactive to stress; and by facilitating healthful behaviour. Johnson added social support to the DC model and a three-dimensional model called iso-strain was thus created [17, 22]. An iso-strain work situation is characterized by high psychological demands, low control and low support. High demands means having too much to do in a short time and over a prolonged period. Low control means not having enough influence over the way in which the work should be performed, on a day-to-day basis. Low support means not having sufficient support from co-workers and superiors. It has been shown that an unbalanced psychosocial work situation increases the risk of cardiovascular disease, particularly a combination of high demands, lack of control and lack of social support from superiors or colleagues [17]. Using this model it has been shown that a poor psychosocial work situation results in higher reports of musculoskeletal disorders, such as pain in the neck/shoulders and upper/low back [23]. Low social support has been associated with neck [5, 14] and low back pain [5, 24].

To our knowledge there had been no study on the iso-strain model, musculoskeletal symptoms and ergonomic factors in general populations, hence this one.

The main aim was to study associations between psychosocial work conditions and musculoskeletal symptoms in a randomly selected, occupationally active normal population in Sweden. Additional aims were to study differences between males and females in prevalence of musculoskeletal symptoms, ergonomic factors and psychosocial work situation, and to take into account both psychosocial and ergonomic work factors when testing for predictors for musculoskeletal symptoms.

2. MATERIAL AND METHODS

A random sample of 1 000 subjects, females and males aged 20–65 years was drawn in 1991 from the civil registration register in Sweden. They received a self-administrated postal questionnaire [25]. The subjects were randomized into four equal subgroups. The subgroups received the questionnaire once but during different seasons. Personal factors included age, gender and tobacco smoking. Occupational factors included psychosocial work conditions, measured with the iso-strain model, and ergonomic factors at work. Demographic factors included region, city size and educational level. Only the occupationally active (n = 532) were included in the subsequent analyses. The sample was representative for the working population in Sweden; 93.7% of the males and 57.6% of the females were working full-time.

2.1. Assessment of Musculoskeletal Symptoms, and Personal and Ergonomic Factors

Musculoskeletal symptoms were assessed with the standardized Nordic questionnaire for analyzing musculoskeletal symptoms [26]. It consists of questions on musculoskeletal pain or discomfort from nine body regions during the past 12 months. As we were primarily interested in analyzing associations between psychosocial factors and symptoms, we only used regions of the central body, i.e., the neck, shoulders, upper back and low back, in accordance with earlier findings [19]. Symptoms were dichotomized into *yes* or *no*. One question on current occupational activity (during the past 3 months) was used to define the occupationally active population. Moreover, there were questions on age, gender and smoking habits.

Ergonomic factors were assessed with a previously constructed questionnaire of 16 items on exposure during the last 3 months [25]. The eight most common exposures were included in subsequent analyses: often working with arms above shoulders, often working with neck bent forward, often working with body bent forward, often performing precision work tasks, often working with vibrating tools or vibrating chairs, and lifting 1 or 10 kg. Lifting was dichotomized: those who lifted 1 kg more than once every minute or 10 kg every 10 min were considered to be exposed, while those who lifted less were considered to be unexposed. The ergonomic factors were dichotomized as *yes* and *no*.

2.2. Assessment of Work Demands, Work Control, and Work Support

Both Karasek and Theorell's two-dimensional model DC and Johnson's iso-strain model were used [17, 22]. Two questionnaires were used. Researchers at the Swedish National Institute for Psychosocial Factors and Health designed and validated the questionnaires on the psychosocial work situation [27]. The first was the Swedish version of the questionnaire for the DC model [27, 28]. It consisted of five items for the psychological work demands index and six items for the control index with four possible answers, 1—*yes, often*; 2—*yes, sometimes*; 3—*no, seldom*; 4—*no, almost never*. The questions were, e.g., "Does your job make you work very hard?" and "Can you decide how your work will be done?" The second questionnaire involved the work social support index; Ahlberg-Hultén, Theorell and Sigala originally constructed it as two questionnaires (16 items), one with positive, the other with negative statements [29]. These were combined into one questionnaire with questions about contact with supervisors, colleagues and psychosocial climate, to which the same four answers were possible, 1—*yes, often*; 2—*yes, sometimes*; 3—*no, seldom*; 4—*no, almost never* [30]. The questionnaire on DC had been previously validity tested [20]. The validity and internal homogeneity were high for the psychological work demands index. The index for control was found to be well-suited for population studies involving a wide range of work tasks. The reliability of the indices for demands and control had been tested earlier (Cronbach's α .84 and .83, respectively) [30]. The reliability of the combined index for social support had been previously tested, too (Cronbach's α .79) [31]. Each of the three dimensions in the model was dichotomized as *high* and *low*, as used in a previous study [30]. The median values for the current population sample were used as cut-off points. High social support was defined as scoring 55–64, while low social support was defined as scoring 34–54 (no individuals scored lower than 34). High psychological demands were defined as 13–20, low demands as 5–12. High control was defined as 19–24 and low as 6–18 (Table 1).

TABLE 1. The Iso-Strain Model

Category	Demands		Control		Support
passive	low ≤ 12	and	low ≤ 18	and	low ≤ 54
strained[a]	high ≥ 13	and	low ≤ 18	and	low ≤ 54
relaxed	low ≤ 12	and	high ≥ 19	and	low ≤ 54
active	high ≥ 13	and	high ≥ 19	and	low ≤ 54
passive	low ≤ 12	and	low ≤ 18	and	high ≥ 55
strained	high ≥ 13	and	low ≤ 18	and	high ≥ 55
relaxed	low ≤ 12	and	high ≥ 19	and	high ≥ 55
active	high ≥ 13	and	high ≥ 19	and	high ≥ 55

Notes. Median values were used to dichotomize the variables; a—iso-strain.

2.3. Statistical Methods

Initially, bivariate analysis was applied using χ^2 test for 2 × 2 contingency tables. This test was used to assess differences between male and female subjects regarding musculoskeletal symptoms, and psychosocial and ergonomic factors.

Logistic regressions (enter mode) were used to assess the psychosocial factors of the two-dimensional DC model and the three-dimensional iso-strain model as predictors of the different musculoskeletal symptoms. The DC model categories were treated as a categorical variable. The different psychosocial situations were dichotomized (1—*in the category*, 0—*in another category*). The reference category was the theoretically best work situation. For the DC model this was low psychological work demands, high control, whereas for the iso-strain model high social support, low psychological work demands, high control. In the DC model males and females were analyzed together, with gender as a control variable. In the iso-strain model males and females were analyzed separately.

A stepwise regression (backward WALD) was used to assess the associations between the theoretically worst psychosocial situation (high demands, low control, low support) versus all other psychosocial work situations, personal factors, ergonomic factors and musculoskeletal symptoms. In this logistic regression analysis males and females were analyzed together. Again, the reference category was the theoretically best work situation: high social support, low psychological work demands, high control.

3. RESULTS

The overall response rate was 70% (*n* = 695), among which 532 subjects were occupationally active and thus included in the subsequent analyses (77%). The proportion of occupationally active was 81% among males and 73% among females. Responders (*n* = 695) were compared with nonresponders (*n* = 305) with respect to demographic data. The response rate was 68% among males and 71% among females, a nonsignificant difference. Mean age was 41 years (*SD* 13) among responders and 39 years (*SD* 13) among nonresponders, a nonsignificant difference.

3.1. Musculoskeletal Symptoms and Gender

There were significant differences between males and females for many musculoskeletal symptoms. Females reported more symptoms from the neck ($p < .001$), shoulders ($p < .001$) and upper back ($p < .001$) but there were no significant differences in symptoms from the low back (Table 2).

TABLE 2. Different Musculoskeletal Symptoms Among Occupationally Active Male and Female Participants (%) (*n* = 532)

Musculoskeletal Symptoms[a]	Males (*n* = 272)	Females (*n* = 260)	2-Tailed *p* Value[b]
Neck	21	38	<.001
Shoulders	21	44	<.001
Upper back	10	23	<.001
Lower back	34	41	*ns*

Notes. a—self-reported work-related musculoskeletal complaints; b—differences between males and females, calculated by χ^2 test (2 × 2 contingency tables).

3.2. Ergonomic Factors and Gender

There were several significant differences in ergonomic workload between males and females. Males worked more often with arms above shoulders, precision work tasks, vibrating chairs and tools and lifted repetitively up to 1 kg. The only ergonomic task that was more common among females was often working with the neck bent forward (Table 3).

3.3. Ergonomic Factors and Occupations

The highest prevalence of ergonomic factors in all occupations was working with the neck and/or the body bent forward. Most ergonomic factors were highly prevalent in three occupational classes: agriculture, production, and transport (Table 4).

3.4. Psychosocial Models and Gender

There were no significant gender differences in the DC model, but the iso-strain model showed some gender differences. Among those with

TABLE 3. Ergonomic Factors Among Occupationally Active Male and Female Participants (%) (*n* = 532)

Ergonomic Factors	Males (*n* = 272)	Females (*n* = 260)	2-Tailed *p* Value[a]
Often arms above shoulders	21.8	10.9	.001
Often neck bent forward	49.6	62.7	.002
Often body bent forward	47.2	53.9	*ns*
Often precision work tasks	43.9	25.1	<.001
Often use of vibrating tools	24.4	4.3	<.001
Often use of vibrating chairs	8.2	1.2	<.001
Lifting 1 kg more than once/minute	14.5	8.0	.042
Lifting 10 kg more than once/10 min	20.4	14.3	*ns*

Notes. a—differences between males and females, calculated by χ^2 test (2 × 2 contingency tables).

TABLE 4. Prevalence of Different Ergonomic Factors Among Different Occupations (*n* = 532)

	Occupation							
Ergonomic Factors	Technical (*n* = 102)	Health (*n* = 87)	Adminis-trative (*n* = 78)	Sales (*n* = 51)	Agricul-tural (*n* = 15)	Transport (*n* = 32)	Produc-tion (*n* = 114)	Service (*n* = 40)
Often arms above shoulders	6	6	1	15	36	16	37	28
Often neck bent forward	46	49	51	67	57	48	64	70
Often body bent forward	42	60	30	48	57	42	61	63
Often precision work tasks	35	22	18	27	50	47	57	26
Often use of vibrating tools	4	5	1	0	57	10	47	5
Often use of vibrating chairs	0	0	0	2	50	26	8	0
Lifting 1 kg more than once/minute	4	5	1	14	29	13	28	3
Lifting 10 kg more than once/10 min	8	7	4	21	46	10	38	15
Males	50	13	39	51	87	69	83	43
Females	50	87	61	49	13	31	17	57

Notes. Occupations, *n* = 519, 13 missing.

low social support, males were more common in both the passive (p = .040) and the active group (p = .007). Among those with high social support, females were more common in the active group (p = .040).

3.5. Psychosocial Factors Related to Musculoskeletal Symptoms

First a logistic regression analysis was made to test the associations between the DC model and symptoms for the whole population. In the total material, there were no associations between age, smoking and symptoms. The neck, shoulders and upper back symptoms were more common among those with a strained work situation (high demands, low control) and among females only. For low back pain, there were no significant associations (Table 5).

A logistic regression analysis followed to test the associations between the iso-strain model and symptoms. In an iso-strain situation there were associations with neck, shoulders and upper back

TABLE 5. Logistic Regression Between the Demands–Control Model and the Different Musculoskeletal Symptoms controlled for Age, Gender, and Smoking for Males and Females (n = 532)

Variable		Neck OR (95% CI)		Shoulder OR (95% CI)		Upper Back OR (95% CI)		Lower Back OR (95% CI)	
Demands–control	passive	1.04	(0.58–1.87)	1.56	(0.88–2.74)	1.29	(0.65–2.58)	1.45	(0.86–2.41)
	strained	2.76***	(1.56–4.86)	2.80***	(1.58–4.96)	2.26*	(1.16–4.39)	1.66	(0.98–2.84)
	relaxed[a]	1		1		1		1	
	active	0.97	(0.55–1.70)	1.13	(0.64–1.97)	0.95	(0.47–1.93)	1.10	(0.67–1.87)
Age (older)		1.01	(0.99–1.03)	1.02	(1.00–1.04)	0.98	(0.96–1.00)	1.01	(0.99–1.02)
Gender (female)		2.22***	(1.46–3.37)	2.71	(1.80–4.09)	2.90***	(1.72–4.88)	1.21	(0.83–1.76)
Smoking		1.35	(0.83–2.19)	1.21	(0.75–1.95)	0.89	(0.48–1.64)	1.27	(0.81–1.97)

Notes. OR—odds ratio; CI—confidence interval; a—reference category; $^*p < .05$, $^{***}p < .001$.

TABLE 6. Logistic Regression Between the Iso-Strain Model and the Different Musculoskeletal Symptoms. Controlled for Age, Gender and Smoking (n = 532)

Iso-Strain		Neck OR (95% CI)		Shoulder OR (95% CI)		Upper Back OR (95% CI)		Lower Back OR (95% CI)	
Low support	passive	1.58	(0.71–3.55)	1.15	(0.54–2.47)	2.33	(0.91–5.99)	1.72	(0.84–3.52)
	strained	3.42**	(1.64–7.14)	2.31*	(1.16–4.62)	3.00*	(1.24–7.28)	1.76	(0.90–3.47)
	relaxed	1.61	(0.74–3.54)	0.62	(0.28–1.38)	1.73	(0.68–4.61)	0.94	(0.46–1.94)
	active	1.20	(0.58–2.51)	0.95	(0.48–1.87)	1.05	(0.40–2.74)	1.18	(0.62–2.26)
High support	passive	0.91	(0.39–2.10)	1.21	(0.58–2.52)	1.12	(0.39–3.20)	1.11	(0.54–2.28)
	strained	3.22*	(1.33–7.82)	2.11	(0.90–4.95)	3.14*	(1.10–8.96)	1.41	(0.60–3.31)
	relaxed[a]	1		1		1		1	
	active	0.94	(0.39–2.29)	0.77	(0.34–1.76)	1.46	(0.50–4.25)	1.01	(0.47–2.19)

Notes. OR—odds ratio; CI—confidence interval; a—reference category; $^*p < .05$, $^{**}p < .01$.

TABLE 7. Logistic Regression Between the Iso-Strain Model and the Different Musculoskeletal Symptoms Among Female Participants. Controlled for Age and Smoking (n = 260)

Iso-Strain		Neck OR (95% CI)		Shoulder OR (95% CI)		Upper Back OR (95% CI)		Lower Back OR (95% CI)	
Low support	passive	2.39	(0.75–7.65)	1.77	(0.58–5.39)	2.71	(0.78–9.45)	3.35*	(1.09–10.30)
	strained	4.43**	(1.61–12.99)	3.69**	(1.38–9.87)	2.61	(0.88–7.81)	1.99	(0.76–5.18)
	relaxed	1.79	(0.63–5.05)	0.54	(0.19–1.58)	2.09	(0.66–6.67)	1.28	(0.46–3.54)
	active	2.49	(0.91–6.80)	1.30	(0.50–3.41)	1.25	(0.37–4.18)	1.90	(0.71–5.09)
High support	passive	0.80	(0.28–2.32)	1.27	(0.50–3.21)	1.28	(0.40–4.10)	1.38	(0.53–3.59)
	strained	2.44	(0.80–7.44)	1.79	(0.61–5.23)	2.92	(0.85–10.07)	2.77	(0.92–8.34)
	relaxed[a]	1		1		1		1	
	active	1.17	(0.41–3.38)	0.97	(0.36–2.60)	1.27	(0.50–4.28)	1.35	(0.50–3.67)

Notes. OR—odds ratio; CI—confidence interval; a—reference category; $^*p < .05$, $^{**}p < .01$.

symptoms, and there were also associations with a strained work situation combined with high social support and symptoms from the neck and upper back (Table 6).

3.6. Psychosocial Factors Related to Musculoskeletal Symptoms Stratified for Gender

A crosstabs analysis was performed stratified for gender. Females with low social support at work had significantly more often symptoms from the neck (p = .001) and shoulders (p = .000). No associations were found between social support and symptoms among males.

When a logistic regression analysis was performed stratified for gender, no significant associations were found for males in the iso-strain model. For females there were significantly higher risks for neck and shoulder symptoms in an iso-strain work situation, and for low back pain in a passive situation with low support (Table 7).

3.7. Psychosocial, Personal, and Ergonomic Factors Related to Musculoskeletal Symptoms Among Males and Females

Stepwise logistic regression analyses (backward WALD) were performed to assess whether relationships between the iso-strain model had an impact on musculoskeletal symptoms when ergonomic and personal factors were introduced. For neck symptoms, an iso-strain work situation was significantly associated with symptoms among females (OR 4.33, 95% CI 1.42–13.22) but not among males. For shoulder, upper back and low back symptoms, there were no associations with iso-strain. Working with the neck bent forward was often associated with symptoms from the neck, shoulders and upper back for females, and with neck and upper back symptoms for males. Older age was associated with symptoms from the shoulders among females, whereas younger age was associated with symptoms from the upper back among males. Working with the body bent forward was often associated with symptoms from the low back for females and with symptoms from the upper back for males. Working with arms above the shoulders was associated with symptoms from the upper back for males, and having precision work tasks were often associated with symptoms from the low back for males (Table 8).

4. DISCUSSION

In this Swedish community-based study of an occupationally active population, a psychosocially strained work situation and female gender were associated with symptoms from the neck, shoulders and upper back. A strained work situation in combination with low social support was associated with neck and shoulder symptoms only among females. When controlling for ergonomic factors and age, an iso-strain work situation remained a high risk factor for neck symptoms among females.

TABLE 8. Stepwise Logistic Regression (backward WALD) Between the Different Musculoskeletal Symptoms, Personal, Ergonomic and Iso-Strain Variables. Occupationally Active Females (n = 260) and Males (n = 272).

Musculoskeletal Symptoms	Ergonomic, Personal and Iso-Strain Factors	Females OR (95% CI)		Males OR (95% CI)	
Neck	iso-strain	4.33**	(1.42–13.22)		
	often neck bent forward	2.03*	(1.05–3.90)	2.73**	(1.30–5.73)
Shoulders	age (older)	1.03*	(1.00–1.05)		
	often neck bent forward	3.16***	(1.71–5.81)		
	often body bent forward			2.08*	(1.10–3.92)
Upper back	often neck bent forward	3.23*	(1.53–6.85)	5.44**	(1.49–19.84)
	age (younger)			0.94**	(0.90–0.99)
	often arms above shoulders			3.15*	(1.24–7.99)
Lower back	often neck bent forward	2.11*	(1.17–3.82)		
	often precision work tasks			1.78*	(1.01–3.13)

Notes. OR—odds ratio; CI—confidence interval; *p < .05, **p < .01, ***p < .001. Variables in the initial model: (age, smoking, often arms above shoulders, often neck bent forward, often body bent forward, often precision work tasks, lifting 1 kg more than once/minute, lifting 10 kg more than once/10 min, iso-strain model). The iso-strain variable was used as categorical with the theoretically best situation “low demands, high control” as the reference category. All other variables except age were dichotomized.

Our findings that only a strained work situation was associated with symptoms from the neck, shoulders and upper back are partly in step with Smith, Silverstein, Fan, et al.'s [32] findings; in a prospective study they found that not only a strained work situation but also a passive one was associated with an incidence of shoulder symptoms during a one-year follow-up, similar to our findings. Also, Bongers et al. [1] in their review on the epidemiology of work-related neck and upper limb problems found that most studies on the effect of a combination of high demands and low control (i.e., a strained situation) reported a relationship between these working conditions and neck and shoulder symptoms.

When social support was added to the DC model, in the iso-strain model there was no additional effect of social support of musculoskeletal symptoms among males. Females, however, had higher odds ratios for neck and shoulder symptoms in an iso-strain situation and for low back symptoms in a passive work situation with low support. In contrast, in a Danish nationwide follow-up survey, Feveile, Jensen and Burr found that both low and high social support were associated with neck/shoulder symptoms among males but not among females [33]. In contrast to these findings we found strong associations between low social support at work and symptoms from the neck and shoulders among females. Our findings are also not consistent with recent findings in Macfarlane, Pallewatte, Paudyal, et al.'s review, who did not find any associations between social support and neck/shoulder pain [6]. However, our findings are consistent with those of Bongers, de Winter, Kompier, et al. [5].

We found no associations between low back pain and the psychosocial work situation. Contrary to the present study, IJzelenberg and Burdorf found associations between low back pain, high job strain and low social support in a population of industrial workers [2]. Furthermore, in the neck/upper extremity they found associations between high job strain and symptoms, but no associations between social support and those symptoms. Hannan, Monteilh, Gerr, et al. found in a prospective study among the staff of several large employers in metropolitan Atlanta, GA, USA, that high job strain but not social support was associated with neck/shoulder symptoms [13]. In this study, iso-strain was a risk factor for symptoms from the neck/shoulder/upper back regions among females. The differences might at least be partly due to the fact that the aforementioned studies were about specific work populations while the present study is a national survey study.

There seems to be a difference in factors at work associated with musculoskeletal symptoms between males and females. This could have several explanations, e.g., (a) males and females are not equally distributed in occupational groups [34], (b) males and females have different physical conditions [34], (c) males and females differ in their performance of work tasks [35], (d) there may be differences in social support between males and females, as in this study or (e) the socioeconomic situations of males and females may differ. Our results support the hypothesis that stratifying by gender is important in studying associations between exposure factors and musculoskeletal disorders, as suggested by Messing, Tissot, and Stock [36]. However, in a recent study, Hooftman, van der Beek, Bongers, et al. could not explain the gender difference in musculoskeletal symptoms among workers [37].

There was an association between shoulder pain and increasing age for females, which is in step with earlier findings [8, 10, 36, 38]. Our one unusual finding was that younger age was associated with more symptoms from the upper back among males, for which we had no explanation.

Methodological Considerations

Since the study was conducted on a random sample drawn from the entire Swedish population aged 20–65, and the sampling was evenly spread over all seasons, the study should have good external validity. It was performed as a postal inquiry and the response rate was acceptable. Demographic data for participants and nonparticipants could be compared. The response rate was higher in small municipalities as compared to middle-sized towns and large cities. This could introduce selection bias, but the magnitude of the difference was relatively small, and there were no associations between medical symptoms and municipality size. No other significant differences between participants and nonparticipants were found. A number of statistical tests were performed, but similar results were obtained in both bivariate and multivariate statistical analyses. Therefore, the study would be expected to have sufficient internal validity and generalizability and not be seriously hampered by selection bias, chance findings or the selection of a particular statistical model.

An important issue is whether self-reports can provide valid and reliable information about the work situation and symptoms. The instruments for assessing the DC and iso-strain models have been widely used and are shown to be reliable and useful in assessing work psychosocial factors [16, 22, 27, 30, 32, 39], which supports the use of them in the present study.

Earlier studies showed good validity at the dichotomous level of self-reported physical load but not when duration or frequency were quantified in greater detail [40, 41]. Torgén, Alfredsson, Köster, et al. found the test–retest reliability of a questionnaire for assessing present and past physical load acceptable [42], whereas Booth-Jones, Lemasters, Succop, et al. found the same for questionnaires on musculoskeletal symptoms [43]. The risk for dependent misclassification of exposure due to severe musculoskeletal pain has been discussed [41]. Other authors found no such dependent misclassifications [44, 45]. The Nordic questionnaire for musculoskeletal disorders has been extensively used and is considered as a valid instrument [26, 46]. We, therefore, believe that all questionnaires used in the study are of acceptable validity and reliability.

The cross-sectional design of our study, which does not allow making cause–effect associations, is a drawback. The distribution of the different occupations was uneven and some occupational groups were very small, so that the analysis of associations could not be performed on an occupational level. Since ergonomic exposure differs considerably among occupations there could also be differences in associations with symptoms for different occupations. Since this was a nationwide study it was not possible to assess observations of exposure and tests for musculoskeletal symptoms, which is another drawback of the study. Furthermore, the size of the study population was modest, which makes the statistical power weaker for less common exposures.

In conclusion, the iso-strain model can predict musculoskeletal symptoms from the neck even when controlling for personal and ergonomic factors, but only in females. There are indications that different exposure factors are associated with musculoskeletal symptoms for males and females. Female gender was associated with symptoms.

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