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**The joint association of musculoskeletal pain and domains of physical activity with sleep problems: cross-sectional data from the DPhacto study, Denmark**

**Running head: Musculoskeletal pain, physical activity and sleep problems**

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AUTHORS’ CONTRIBUTIONS

Study concept and design: All authors. Drafting of the manuscript: ESS. Critical revision of the manuscript: All authors. Statistical analysis: ESS, PJM, TILN, AH. Analysis and interpretation of data: All authors. Critical revision: All authors. Final approval: All authors.

ABSTRACT

Purpose: To investigate if occupational physical activity (OPA) and leisure time physical activity (LTPA) influence the association between musculoskeletal pain and sleep problems.

Methods: Cross-sectional study including 678 workers in the Danish PHysical ACTivity cohort with Objective measurements (DPhacto). Musculoskeletal pain was assessed by questionnaires, while OPA and LTPA were measured with accelerometers for up to six consecutive days. We used logistic regression to calculate odds ratios (ORs) with 95% confidence intervals (CIs) for self-reported insomnia symptoms and non-restorative sleep.

Results: Analyses of the joint association of musculoskeletal pain and OPA showed that workers with high pain and high OPA had ORs of 5.80 (95% CI 2.64-12.67) for insomnia symptoms and 2.50 (95% CI 1.37-4.57) for non-restorative sleep, compared to those with low pain and low OPA, whereas workers with high pain and low OPA had ORs of 4.67 (95% CI 2.17-10.07) for insomnia symptoms, and 2.67 (95% CI 1.46-4.89) for non-restorative sleep, respectively. Further, workers with high pain and high LTPA had ORs of 4.23 (95% CI 2.16-8.32) for insomnia symptoms and 1.95 (95% CI 1.09-3.48) for non-restorative sleep, compared to those with low pain and low LTPA, whereas workers with high pain and low LTPA had ORs of 3.34 (95% CI 1.66-6.70) for insomnia symptoms and 2.14 (95% CI 1.21-3.80) for non-restorative sleep, respectively.

Conclusions: Workers with high musculoskeletal pain who also conducted high levels of OPA or LTPA reported higher prevalence of insomnia symptoms.

Key terms: Physical work exposure, work demands, accelerometer, technical measurement, insomnia

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**Compliance with ethical standards**

**Ethical approval** The study was approved by the Ethics Committee for the Capital Region of Denmark and conducted in accordance with the Declaration of Helsinki.

**Informed consent** All workers who participated in the study signed an informed consent.

**Conflict of interest** The authors declare no conflicts of interest.

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INTRODUCTION

The prevalence of sleep problems is generally high in working populations (Yong et al. 2017), which may have substantial effects on work performance as well as increase the risk of sickness absence and adverse safety outcomes (Kessler et al. 2011; Lallukka et al. 2014; Uehli et al. 2014). Insomnia symptoms may also increase the risk of adverse health outcomes, such as cardiovascular disease, type 2 diabetes, hypertension and mental disorders (Anothaisintawee et al. 2015; Dew et al. 2003; Sivertsen et al. 2009; Vgontzas et al. 2009). Thus, the high prevalence and negative consequences of insomnia in working populations underscores the importance of identifying factors associated with sleep problems.

Several studies have reported that chronic musculoskeletal pain is a strong risk factor of insomnia symptoms (Skarpsno et al. 2018a; Tang et al. 2015; Ødegard et al. 2013), and non-restorative sleep is very common among people with chronic pain (Sayar et al. 2002). It is conceivable that the association between musculoskeletal pain and insomnia may depend on physical activity. Physically active people report less problems falling asleep, less nocturnal awakenings, less daytime sleepiness (Flausino et al. 2012; Loprinzi and Cardinal 2011; Soltani et al. 2012) and improvements in the feeling of sleep being restorative (King et al. 2008). Regular physical activity is therefore recommended as a non-pharmacological treatment of insomnia (Chennaoui et al. 2015). Accordingly, some studies have shown that leisure time physical activity (LTPA) may reduce the risk of insomnia in people with chronic musculoskeletal pain (Axen et al. 2017; Skarpsno et al. 2018a), although contrasting results have been reported (Andrews et al. 2014). However, for a large fraction of the population, the main domain for physical activity is at work (Holtermann et al. 2012) and a recent study has shown that workers with high occupational physical activity (OPA) have higher prevalence of insomnia symptoms and non-restorative sleep (Skarpsno et al. 2018b).

Workers with high levels of OPA may perform strenuous work tasks characterized by awkward postures and heavy lifting often without sufficient periods of rest, which could lead to an overload response (Sluiter et al. 2000) increasing their risk for sleep problems (Miglis 2016). However, previous studies have not investigated the joint associations between OPA and pain with sleep problems. Further, pain may introduce differential misclassification in self-reported physical activity (Gupta et al. 2017), and it is therefore crucial to use technical measurements when investigating the influence of LTPA and OPA on the association between musculoskeletal pain and sleep problems. Moreover, although emerging evidence suggest that non-restorative sleep can occur without other insomnia symptoms such as difficulties initiating and maintaining sleep (Roth et al. 2010), few studies have investigated these symptoms separately (Skarpsno et al. 2018b).

The purpose of the current study was therefore to investigate the joint association of musculoskeletal pain and objectively measured LTPA and OPA with the occurrence of insomnia symptoms and non-restorative sleep.

METHODS

Study population and design

This study is based on data from the Danish PHysical ACTivity cohort with Objective measurements (DPhacto). Data were collected from spring 2012 until spring 2014 from 15 workplaces located in different regions all over Denmark and included three sectors (i.e., manufacturing, cleaning and transportation) with varying physical work demands. More information about the DPhacto study can be found elsewhere (Jørgensen et al. 2013).

The study included mainly blue-collar workers, but some white-collar workers in administrative and management positions were also included. A total of 1,119 workers of 2,107 invited consented to participate. Inclusion criteria were at least 20 working hours per week and being between 18-67 years of age. Exclusion criteria were pregnancy, having fever on the day of testing, band aid allergy, slipped disc, and current and past illness making the worker unable to participate in the measurements of physical activity. Objective measurements of OPA and LTPA were obtained from 755 workers. Out of these, 698 had valid accelerometer recordings at work and during leisure time. Furthermore, we excluded workers with missing information on body height and/or weight (13), smoking (3) and shift work (4). The analysis was therefore based on 678 workers (315 women and 363 men).

The study was approved by the Ethics Committee for the Capital Region of Denmark and conducted in accordance with the Declaration of Helsinki. All workers who participated in the study signed an informed consent.

*Procedure*

All workers were invited to information meetings where the objectives and procedures of the study were explained in detail. All participants were asked to wear accelerometers for continuous measurement of physical activity for up to six consecutive days and nights, including at least two working days and two leisure days. Research staff visited the workplace on the first day and the past day of measurements. The timing of the data collection was selected as an agreement between the research staff and the employers involved in the project. Measurements of height and weight were performed on the same day as mounting of the accelerometers for objective measurements of physical activity. The workers also completed a short computer-based questionnaire concerning age, sex, education, working hours, diet, smoking, alcohol consumption, physical activity, self-reported health, work ability, psychosocial work environment, and musculoskeletal pain. After completing the physical activity recordings, the workers returned a diary with information about working days, working hours, days off work, and periods without wearing the measuring devices.

*Insomnia symptoms*

Insomnia symptoms were assessed by two questions: “How often during the past month did you: 1) have difficulties falling asleep at night, and 2) wake up too early and couldn’t get back to sleep?”. The response options were: “never”, “rarely”, “sometimes”, “often”, and “always” on both questions. Participants answering “often” or “always” on one or both questions were considered to have symptoms of insomnia.

*Non-restorative sleep*

Non-restorative sleep was assessed by the question: “In the past month, how often have you felt that you were not rested when you woke up in the morning?”. The response options were: “never”, “rarely”, “sometimes”, “often”, and “always”. Participants answering “often” or “always” were considered to experience non-restorative sleep.

*Musculoskeletal pain*

Intensity and extent of musculoskeletal pain was assessed by the question: “During the past 3 months, what have been your worst pain in the following body regions on a scale from 0 to 10?”. Body regions included “neck/shoulders”, “elbows”, “wrists/hands”, “low back”, “hips”, “knees”, and “ankles/feet”. Based on these answers, we constructed a new variable using number of pain sites and pain intensity to categorize participants into “low pain” if they answered ≤5 on pain intensity for all pain sites and “high pain” if they answered ≥6 on intensity for one or more pain sites.

*Objective measurements of physical activity*

Physical activity was recorded with two accelerometers (Actigraph GT3X+, Actigraph LLC, Florida, USA) attached by tape (3M, Hair-Set, double sided adhesive tape, and Fixomull, BSN medical) on the thigh and the upper back. Actigraph is a compact water resistant device (19x34x45 mm, weight 19 g), which measures tri-axial acceleration with a frequency of 30 Hz, a dynamic range of ±6 G (1 G = 9.81 m/s2), and a precision of 12 bit. The accelerometers were first initialized using the Actilife software version 5.5 (ActiGraph LLC, Pensacola, FL, USA) and data were processed off-line using the Acti4 software (Skotte et al. 2014). More information about this procedure and detailed description of the placement of the accelerometers has been reported elsewhere (Skotte et al. 2014).

Different types of physical activity were detected from the processed accelerometer signals, and the total time (min/day) with physical activity, i.e., walking, running, cycling and walking stairs was summed up separately during work and leisure time. OPA was then expressed as minutes of physical activity at work, and LTPA was expressed as minutes of physical activity during leisure time. OPA and LTPA were then dichotomized to obtain two exposure groups: ‘low’ and ‘high’ (median cut offs OPA: 76.1 min, median cut offs LTPA: 52.0 min). The mean time with OPA was 47.4 min/day for the low group and 106.8 min/day for the high group. The corresponding mean time for LTPA was 37.0 min/day for the low group and 76.0 min/day for the high group. In the analyses of joint associations of musculoskeletal pain and OPA, one variable with four combined categories was made: 1) low pain and low OPA 2) high pain and low OPA, 3) low pain and high OPA, and 4) high pain and high OPA. The corresponding variable of LTPA and musculoskeletal pain was: 1) low pain and low LTPA 2) high pain and low LTPA, 3) low pain and high LTPA, and 4) high pain and high LTPA.

*Assessment of covariates*

Age was determined from the worker’s Danish civil registration number (CPR-number). Body mass index (BMI, kg/m2) was calculated using objectively measured height (m) and body mass (kg). Smoking was determined from the question: “Do you smoke?” with four response options: “yes, daily”, “yes, sometimes”, “used to smoke, but not anymore”, and “I have never smoked”. The response options were further categorized into two groups: “yes” (yes, daily and yes, sometimes), and “no” (used to smoke, but not anymore and I have never smoked). Medication for depression was assessed by two questions: “Have you in the past three months been taking prescription medication?”, with response options: “yes” and “no”. If “yes”, the participants were asked about type of medication, with anti-depressives as a response option. Based on the participant’s work place, we categorized workers into three sectors: cleaning, manufacturing and transportation. Shift work was assessed by the question: “At which time of the day do you usually work in your main occupation?”, with the following response options: “Fixed day work”, “Night, varying working hours with night”, and “Other”. Number of working hours per week was assessed by the following question: “How many hours per week do you work in your main occupation?”.

*Statistical analysis*

Logistic regression was used to calculate odds ratios (ORs) for insomnia symptoms and non-restorative sleep associated with categories of musculoskeletal pain, OPA and LTPA. The precision of the associations was assessed by 95% confidence intervals (CIs). Participants with high OPA or high LTPA were compared with the reference group of participants with low OPA or low LTPA, respectively. Further, we estimated the joint associations of musculoskeletal pain and OPA with insomnia symptoms and non-restorative sleep. Corresponding joint associations were estimated for LTPA. Participants with the combination of low OPA and low pain, or low LTPA and low pain served as the reference group in these analyses. All associations were adjusted for sex, age (continuous), BMI (continuous), use of anti-depressives (yes, no), smoking (yes, no), shift work (fixed day work, night/varying working hours, other) and work type (cleaning, manufacturing, transportation). Association of LTPA was additionally adjusted for pain (low, high) and OPA (low, high), and the association of musculoskeletal pain was additionally adjusted for OPA (low, high) and LTPA (low, high). Moreover, the analyses of the joint association of musculoskeletal pain and LTPA were further adjusted for OPA, whereas the joint associations of musculoskeletal pain and OPA were adjusted for LTPA.

Potential effect modification between musculoskeletal pain and LTPA, and between musculoskeletal and OPA, was assessed as departure from additive effects. Interaction on an additive scale was calculated as the relative excess risk due to interaction (RERI), but modified to reflect our use of ORs: RERI = ORhigh musculoskeletal pain and high OPA - ORlow musculoskeletal pain and high OPA - ORhigh musculoskeletal pain and low OPA + 1 (Andersson et al. 2005), i.e., RERI>0 indicates a synergistic association beyond an additive association. The same RERI estimate was assessed for the joint association between pain and LTPA.

To test the robustness of the results, we conducted supplementary analyses where we investigated whether the same associations remained with adjustment for additional covariates. Working hours are a known risk factor of sleep problems (Virtanen et al. 2009), and a sensitivity analysis was therefore conducted including working hours as a covariate in the multi-adjusted model. Moreover, we also conducted a sensitivity analysis where we used physical activity defined as percentage of total work time instead of total time in minutes. Finally, we conducted two sensitivity analyses using either higher (≥7) or lower (≥5) cutoffs of to indicate high musculoskeletal pain.

All statistical analyses were performed using Stata for Windows, version 13.1 (StataCorp LP, College Station, Texas).

RESULTS

Table 1 presents the characteristics of the study population stratified by pain level. Of the 678 workers who participated in the study, 98 (14.5%) reported insomnia symptoms, while 117 (17.2%) reported non-restorative sleep. The mean time with OPA during work hours was 77 min, while the mean time with LTPA during leisure-time was 57 min. The daily average with OPA consisted of 95.3% (74 min) walking, 4.0% (3 min) walking stairs, 0.3% (14 sec) running, and 0.4% (19 sec) cycling, whereas LTPA consisted of 85.6% (48 min) walking, 5.1% (3 min) walking stairs, 2.6% (1 min 30 sec) running, and 6.7% (4 min) cycling.

(TABLE 1)

Table 2 shows the associations for musculoskeletal pain, OPA, LTPA with insomnia symptoms and non-restorative sleep. Workers with high pain had ORs of 4.80 (95% CI: 2.86-8.04) for insomnia symptoms and 2.52 (95% CI: 1.64-3.87) for non-restorative sleep compared to workers with low pain. The associations of OPA and LTPA with insomnia symptoms and non-restorative sleep were weak and imprecise, i.e., workers with high OPA had an OR of 1.22 (95% CI: 0.76-1.94) for insomnia symptoms compared to workers with low OPA, whereas workers with high LTPA had an OR of 0.78 (95% CI: 0.52-1.19) for non-restorative sleep compared to the reference group with low LTPA.

(TABLE 2)

Table 3 shows the joint association for musculoskeletal pain and OPA with insomnia symptoms. Compared to the reference group with low pain and low OPA, workers with high pain had an OR of 5.80 (95% CI: 2.64-12.67) if they had high OPA and an OR of 4.67 (95% CI: 2.17-10.07) if they had low OPA. However, there was no strong evidence of interaction between pain and OPA on an additive scale (RERI = 0.80, 95% CI: -2.10-3.68).

(TABLE 3)

Table 4 shows the joint association of musculoskeletal pain and LTPA with insomnia symptoms. Compared to the reference group with low pain and low LTPA, workers with high pain had an OR of 4.23 (95% CI: 2.16-8.32) if they had high LTPA and an OR of 3.34 (95% CI: 1.66-6.70) if they had low LTPA. This difference in association corresponds to a RERI estimate of 1.20 (95% CI: -0.82-3.23).

(TABLE 4)

Table 5 shows the joint association of musculoskeletal pain and OPA with non-restorative sleep. Compared to the reference group with low pain and low OPA, workers with high pain and high OPA had an OR of 2.50 (95% CI: 1.37-4.57). Further, workers with low pain and high OPA had an OR of 1.10 (95% CI: 0.56-2.18), and workers with high pain and low OPA had an OR of 2.67 (95% CI: 1.46-4.89). There was no clear interaction between pain and OPA on an additive (RERI) scale (-0.27, 95% CI: -1.80-1.31).

(TABLE 5)

Table 6 shows the joint association of musculoskeletal pain and LTPA with non-restorative sleep. Workers with low pain and high LTPA had an OR of 0.63 (95% CI: 0.31-1.27), compared to the reference group with low pain and low LTPA. Furthermore, workers with high pain and low LTPA had an OR of 2.14 (95% CI: 1.21-3.80), while workers with high pain and high LTPA had an OR of 1.95 (95% CI: 1.09-3.48). There was no clear interaction between pain and OPA on the association with non-restorative sleep on an additive (RERI) scale (0.18, 95% CI: -1.03-1.37).

(TABLE 6)

Sensitivity analyses

When we included working hours as a covariate in the model or conducted analyses where we used physical activity defined as percentage of total work time or leisure time, the results remained essentially unchanged. In the sensitivity analysis using a higher cutoff to indicate high musculoskeletal pain (≥7), similar, but somewhat weaker associations were found (e.g., workers with high pain and high OPA had an OR for insomnia symptoms of 3.51 [95% CI: 1.32-4.93], while workers with high pain and low OPA had an OR of 2.52 [95% CI: 1.87-6.60]). Further, using a lower cutoff to indicate high musculoskeletal pain (≥5) showed similar association between OPA, LTPA and insomnia symptoms. However, somewhat stronger associations were found between LTPA and non-restorative sleep (e.g., workers with high pain had an OR of 2.90 [95% CI: 1.52-5.53] if they performed low LTPA and 2.50 [95% CI: 1.29-4.84] if they performed high LTPA).

DISCUSSION

The main findings of the current study were that workers with the combination of high musculoskeletal pain and high OPA reported higher prevalence of insomnia symptoms. Further, workers with the combination of high pain and high LTPA reported more insomnia symptoms than workers with low LTPA and the same pain level. The present study therefore suggests that both OPA and LTPA to some extent increase the prevalence of insomnia symptoms in workers with high pain.

Previous studies have reported that physical activity at work (Skarpsno et al. 2018b; Wennman et al. 2014; Åkerstedt et al. 2002) and pain (Skarpsno et al. 2018a; Ødegard et al. 2013) are independently and positively associated with sleep problems. However, to the best of our knowledge, no previous studies have investigated the joint association of musculoskeletal pain and OPA with sleep problems, and the possibility for comparison with findings of other studies is therefore limited. Although the confidence intervals in the analyses of additive interaction were wide, the current study shows that workers with the combination of high musculoskeletal pain and OPA report more insomnia symptoms. Thus, these results provide novel and important information about the possible interplay between musculoskeletal pain, physical work demands and sleep problems.

Contrary to OPA, regular LTPA has been found to improve sleep (Kubitz et al. 1996), and it has been suggested that LTPA is a promising intervention in people with chronic pain (Geneen et al. 2017). Still, few studies have investigated if LTPA influences the association between musculoskeletal pain and insomnia symptoms (Axen et al. 2017; Skarpsno et al. 2018a). A large prospective cohort study suggested that LTPA may reduce the risk of insomnia in pain-afflicted individuals (Skarpsno et al. 2018a). Further, this is supported by a study of mainly male workers showing that low levels of physical activity in combination with previous or present low back- and neck pain increased the risk of insomnia (Axen et al. 2017). However, none of these latter studies used objective measurements of physical activity. Our study showed that workers with the combination of low pain and high LTPA tended to have a lower prevalence of both insomnia symptoms and non-restorative sleep. However, workers with high pain who also conducted high LTPA tended to report more insomnia symptoms. Notably, the joint analysis of musculoskeletal pain and LTPA showed that workers with high pain had slightly higher prevalence of insomnia if they also conducted high LTPA, although the difference was weak and imprecise. Although the explanation for these findings is unclear, this is in line with a previous study done on pain patients showing that high-intensity LTPA was associated with longer periods of wakefulness at night (Andrews et al. 2014), and may be explained by a delayed exaggeration in pain after a period of physical activity (Geisser et al. 1995) leading to poorer sleep the following night. Interestingly, the same trend was not observed with non-restorative sleep among workers with high pain, possibly explained by the improved sleep quality seen in physically active people (King et al. 2008). These latter results are not surprising considering that non-restorative sleep can occur without other insomnia symptoms (Roth et al. 2010). Thus, these results may therefore indicate that LTPA may influence insomnia symptoms and non-restorative sleep differently among workers with high pain. However, it should be noted that the study population consisted of workers with substantial pain. As such, it is therefore possible that the somewhat higher prevalence of insomnia symptoms in workers with high LTPA applies to individuals with very high levels of pain. It should also be noted that previous studies have shown that LTPA benefits sleep when exceeding low levels of LTPA, with no further effect of increasing active time (Skarpsno et al. 2018a; Skarpsno et al. 2018b). Unfortunately, we were not able to include more than two groups of LTPA and musculoskeletal pain, and future studies should therefore aim to investigate the effect of other levels of both pain and LTPA.

 Strengths of the current study include the objective measurements of OPA and LTPA, allowing precise exposure estimates and minimizing the potential bias associated with self-reported measurements of physical activity (Gupta et al. 2016; Gupta et al. 2017; Koch et al. 2016). However, we cannot exclude the possibility that up to six consecutive days with measurements do not capture the average amount of physical activity among the workers. Furthermore, we had available information on several covariates. Notably, the main results remained essentially unchanged after sensitivity analyses with working hours included as a covariate, a known risk factor of sleep problems (Virtanen et al. 2009). Some limitations should be considered in the interpretation of the results. First, the cross-sectional design precludes the possibility to make causal inferences about the associations between OPA, LTPA, musculoskeletal pain and sleep. It should be noted that the objective measurements in the current study did not assess other physically strenuous work characteristics that include forceful work such as lifting, pushing or pulling. Furthermore, it is likely that workers with high levels of OPA experience other exposures at work (e.g., psychosocial stressors) that could potentially influence both musculoskeletal pain and sleep. Further, we had few cases of insomnia in the group with low musculoskeletal pain. Especially the reference group of low pain and low OPA had few cases of insomnia symptoms. Furthermore, because of the limited sample size we were not able to include more than two groups of OPA and LTPA. Insomnia symptoms were assessed by self-report rather than clinical diagnosis, and the DPhacto study lack information about insomnia symptoms beyond one month. No information was available on repeated awakening during the night and daytime sleepiness, and the two questions used in DPhacto do not fulfil the DSM-V criteria for insomnia diagnosis (American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. American Psychiatric Publishing, Washington DC, 2013 (fifth edition) 2013).

 In conclusion, the current study show that workers with high musculoskeletal pain who also conduct high levels of OPA report more insomnia symptoms. Further, high LTPA may increase the prevalence of insomnia symptoms in workers with high musculoskeletal pain. However, high musculoskeletal pain appears to be the main driver in these associations.

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Table 1: Characteristics of the study population

|  |  |
| --- | --- |
|  | Musculoskeletal pain |
|  | Lowa | Highb |
| No. of persons | 337 | 341 |
| Females, % | 42.7 | 50.2 (171) |
| Age, mean (SD) | 44.8 (9.7) | 45.2 (9.8) |
| Body mass index, mean (SD) | 26.9 (4.9) | 27.5 (4.6) |
| Current smokers, % | 24.9 | 20.9 (102) |
| Sleep problems, % |  |  |
| Insomnia symptoms | 6.2 | 22.6 |
| Non-restorative sleep | 11.0 | 23.5 |
| Blue-collar workers | 68.7 | 73.4 |
| Shift work | 11.9 | 8.5 |
| Sector, % |  |  |
| Cleaning | 17.5 | 19.9 |
| Manufacturing | 75.1 | 73.3 |
|  Transportation | 7.4 | 6.7 |
| Total measured hours, mean (SD) |  |  |
| Work | 8.0 (1.2) | 7.9 (1.2) |
| Leisure time | 9.0 (1.6) | 9.2 (1.5) |
| Physical activity, mean (SD) |  |  |
| OPA (min/day) | 77.6 (40.0) | 76.7 (32.7) |
| LTPA (min/day) | 57.1 (281) | 56.0 (23.4) |

Abbreviations: SD, standard deviation

a ≤5 on pain intensity for all pain-sites (on a scale from 0 to 10)

b ≥6 on pain intensity for one or more pain sites (on a scale from 0 to 10)

Table 2. Association between musculoskeletal pain, occupational physical activity, leisure time physical activity, and insomnia-symptoms and non-restorative sleep.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Insomnia symptoms |  | Nonrestorative sleep |
|  | No. of persons | No. of cases | Age-adjusted, ORa | Multi-adjusted, OR (95% CI)b |  | No. of persons | No. of cases | Age-adjusted, ORa | Multi-adjusted, OR (95% CI)b |
| Musculoskeletal painc |  |  |  |  |  |  |  |  |  |
| Low | 337 | 21 | 1.00 | 1.00 (reference) |  | 337 | 37 | 1.00 | 1.00 (reference) |
| High | 341 | 77 | 4.53 | 4.80 (2.86-8.04) |  | 341 | 80 | 2.68 | 2.52 (1.64-3.87) |
| Physical activity |  |  |  |  |  |  |  |  |  |
| Occupational physical activityd |  |  |  |  |  |  |  |  |  |
| Low | 341 | 42 | 1.00 | 1.00 (reference) |  | 341 | 58 | 1.00 | 1.00 (reference) |
| High | 337 | 56 | 1.42 | 1.22 (0.76-1.94) |  | 337 | 59 | 1.04 | 0.97 (0.63-1.48) |
| Leisure time physical activitye |  |  |  |  |  |  |  |  |  |
| Low | 342 | 47 | 1.00 | 1.00 (reference) |  | 342 | 64 | 1.00 | 1.00 (reference) |
| High | 336 | 51 | 1.12 | 1.05 (0.68-1.64) |  | 336 | 53 | 0.83 | 0.78 (0.52-1.19) |

a Adjusted for age (continuous)

b Adjusted for age (continuous, 20-67), sex, BMI (continuous, 16-45), smoking (yes, no), sector (cleaning, manufacturing, transportation), shift work (fixed day work, night/varying working hours, other) and use of anti-depressives (no, yes). The analysis of leisure-time physical activity was additionally adjusted for pain (low pain, high pain) and occupational physical activity (low, high), and the analysis of musculoskeletal pain was additionally adjusted for occupational (low, high) and leisure-time physical activity (low, high).

c Low pain ≤5 on pain intensity for all pain-sites (on a scale from 0 to 10), high pain ≥6 on pain intensity for one or more pain sites

d Occupational physical activity: Low <76 minutes/day, high ≥76 minutes/day

e Leisure time physical activity: Low <52 minutes/day, high ≥52 minutes/day

Table 3. The joint association of occupational physical activity and musculoskeletal pain with insomnia symptoms

|  |  |
| --- | --- |
|  | Occupational physical activitya |
|  | Low |  | High |
| Musculoskeletal painb | No. of persons | No. of cases | Multi-adjustedORc (95% CI) |  | No. of persons | No. of cases | Multi-adjustedORc (95% CI) |
| Low | 176 | 9 | 1.00 (reference) |  | 161 | 12 | 1.33 (0.53-3.28) |
| High | 165 | 33 | 4.67 (2.17-10.07) |  | 176 | 44 | 5.80 (2.64-12.67) |

a Occupational physical activity: Low <76 minutes/day, high ≥76 minutes/day

b Low pain ≤5 on pain intensity for all pain-sites (on a scale from 0 to 10), high pain ≥6 on pain intensity for one or more pain sites (on a scale from 0 to 10)

c Adjusted for age (continuous), sex, BMI (continuous), smoking (yes, no), work type (cleaning, manufacturing, transportation), shift work (fixed day work, night/varying working hours, other), leisure-time physical activity (low, high) and use of anti-depressives (no, yes)

Table 4. The joint association of leisure time physical activity and musculoskeletal pain with insomnia symptoms

|  |  |
| --- | --- |
|  | Leisure-time physical activitya |
|  | Low |  | High |
| Musculoskeletal painb | No. of persons | No. of cases | Multi-adjustedORc (95% CI) |  | No. of persons | No. of cases | Multi-adjustedORc (95% CI) |
| Low | 172 | 12 | 1.00 (reference) |  | 165 | 9 | 0.69 (0.28-1.70) |
| High | 170 | 35 | 3.34 (1.66-6.70) |  | 171 | 42 | 4.23 (2.16-8.32) |

a Leisure time physical activity: Low <52 minutes/day, high ≥52 minutes/day

b Low pain ≤5 on pain intensity for all pain-sites (on a scale from 0 to 10), high pain ≥6 on pain intensity for one or more pain sites (on a scale from 0 to 10)

c Adjusted for age (continuous), sex, BMI (continuous), smoking (yes, no), work type (cleaning, manufacturing, transportation), shift work (fixed day work, night/varying working hours, other), occupational physical activity (low, high) and use of anti-depressives (no, yes)

Table 5. The joint association of occupational physical activity and musculoskeletal pain with non-restorative sleep.

|  |  |
| --- | --- |
|  | Occupational physical activitya |
|  | Low |  | High |
| Musculoskeletal painb | No. of persons | No. of cases | Multi-adjustedORc (95% CI) |  | No. of persons | No. of cases | Multi-adjustedORc (95% CI) |
| Low | 176 | 19 | 1.00 (reference) |  | 161 | 18 | 1.10 (0.56-2.18) |
| High | 165 | 39 | 2.67 (1.46-4.89) |  | 176 | 41 | 2.50 (1.37-4.57) |

a Occupational physical activity: Low <76 minutes/day, high ≥76 minutes/day

b Low pain ≤5 on pain intensity for all pain-sites (on a scale from 0 to 10), high pain ≥6 on pain intensity for one or more pain sites (on a scale from 0 to 10)

c Adjusted for age (continuous), sex, BMI (continuous), smoking (yes, no), work type (cleaning, manufacturing, transportation), shift work (fixed day work, night/varying working hours, other), leisure-time physical activity (low, high), and use of anti-depressives (no, yes)

Table 6. The joint association of leisure time physical activity and musculoskeletal pain with non-restorative sleep.

|  |  |
| --- | --- |
|  | Leisure-time physical activitya |
|  | Low |  | High |
| Musculoskeletal painb | No. of persons | No. of cases | Multi-adjustedORc (95% CI) |  | No. of persons | No. of cases | Multi-adjustedORc (95% CI) |
| Low | 172 | 23 | 1.00 (reference) |  | 165 | 14 | 0.63 (0.31-1.27) |
| High | 170 | 41 | 2.14 (1.21-3.80) |  | 171 | 39 | 1.95 (1.09-3.48) |

a Leisure time physical activity: Low <52 minutes/day, high ≥52 minutes/day

b Low pain ≤5 on pain intensity for all pain-sites (on a scale from 0 to 10), high pain ≥6 on pain intensity for one or more pain sites (on a scale from 0 to 10)

c Adjusted for age (continuous), sex, BMI (continuous), smoking (yes, no), work type (cleaning, manufacturing, transportation), shift work (fixed day work, night/varying working hours, other), occupational physical activity (low, high) and use of anti-depressives (no, yes)