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Relationship Between Leisure Time Physical Activity, Weight, and the Onset and Persistence of Nonspecific Neck Pain: A Systematic Review

Neck pain is one of the leading causes of global disability, and leads to direct and indirect societal and economic costs.^{19,31,37} *Nonspecific* neck pain (NSNP) is “neck pain occurring in the absence of trauma, signs, or symptoms of major structural pathology, neurological signs or specific pathology,”⁶ without an identifiable source of pain.²⁹ Pain onset is associated with different biopsychosocial risk factors.^{5,6,28,45,47,60} NSNP is also characterized by a poor prognosis³⁸ and frequent recurrence, both in the general population¹⁵ and in

the working population.¹⁴ Almost half of patients with NSNP may develop persistent pain (>3 months).⁸³ Risk factors for persistent NSNP include a history

of other musculoskeletal disorders, age, and psychosocial factors.^{5,20,66,82} Some behavioral factors (eg, physical activity [PA], weight, stress, sleep, and diet) that increase the risk of the onset or the persistence of NSNP are potentially modifiable and could be targeted by health care professionals.⁴⁸

Physical activity can reduce morbidity and mortality in many chronic conditions.^{7,10,61} and can have an effect on pain in chronic pain populations^{4,27} through different, although poorly understood mechanisms.^{63,75} Physical activity is categorized as occupational (performed while one is working), transportation (to get from 1 place to another), household (done in or around one's home), and leisure time (not related to the other three, eg, going for a walk and sports participation) activities.⁶¹ Regular PA is consistently recommended for managing neck pain.^{20,46,50,60} However, the association between PA and the onset or the persistence of NSNP is unclear. Several systematic reviews have analyzed the association between physical (in)activity and neck or neck/shoulder pain in the adult general and working populations,^{39,41,44,45,55,58,73} with inconsistent findings. Only two of

• **OBJECTIVE:** To study the relationships between weight, leisure time physical activity (PA), and the onset and persistence of neck pain in adults with nonspecific neck pain (NSNP).

• **DESIGN:** Etiology and prognosis systematic review.

• **LITERATURE SEARCH:** Five databases (PubMed, Scopus, Embase, Cochrane Library, PsycINFO) were searched from January 2010 to November 2021.

• **STUDY SELECTION CRITERIA:** Case-control or cohort studies assessing the relationship between the onset and the persistence of NSNP, weight, and leisure time PA in healthy adults or adults with NSNP at baseline.

• **DATA SYNTHESIS:** Use of the “vote counting based on direction of effects” and qualitative synthesis.

• **RESULTS:** Nine articles were included (20 350 participants, range 86–11 391), four on the onset and five on the persistence of NSNP. Methodological quality varied from poor to good according to the Newcastle-Ottawa Scale. For the onset and the persistence of NSNP, there was very low certainty evidence for modest associations suggesting a decreased risk with higher levels of leisure time PA and an increased risk in people with overweight and obesity.

• **CONCLUSION:** The risk for onset and persistence of NSNP may be lower in more active people and higher in people with overweight and obesity. Results should be interpreted cautiously and should not be generalized to populations other than workers. *J Orthop Sports Phys Ther* 2022;52(12):777–791. Epub: 12 August 2022. doi:10.2519/jospt.2022.11137

• **KEY WORDS:** lifestyle, neck pain, physical activity, weight

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them^{55,73} specifically assessed the association with PA, but none exclusively focused on leisure time PA and on NSNP without any other associated painful areas (eg, shoulder).

Weight is usually classified based on body mass index (BMI): underweight (BMI < 18.5 kg/m²), normal weight (BMI between 18.5 and 24.9 kg/m²), overweight (BMI between 25 and 29.9 kg/m²), and obesity (BMI greater than or equal to 30 kg/m²).⁸⁶ Overweight and obesity are associated with the incidence of many comorbidities,³⁰ including chronic pain^{16,52,54} and musculoskeletal pain.⁸⁴ Similar to PA, systematic reviews analyzing the association between BMI and neck pain in adults^{39,45} have inconsistent results. However, none specifically investigated the association between BMI and NSNP.

To date, the question “Are weight and leisure time PA associated with the onset or the persistence of NSNP?” remains unanswered, as previous systematic reviews have shown inconsistent results. This lack of evidence hinders health care professionals from treating patients with NSNP using a comprehensive biopsychosocial approach. Thus, the aim of this systematic review was to synthesize evidence on the relationship between weight, leisure time PA, and the onset or the persistence of neck pain in adults with NSNP.

METHODS

THIS SYSTEMATIC REVIEW WAS PERFORMED in accordance with the Cochrane Handbook recommendations³³ and reported according to the updated Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement.⁵⁷ A protocol was registered in PROSPERO prior to completion of the initial search (registration number: CRD42020215409).

Search Strategy

Systematic searches were conducted in PubMed, Scopus, Cochrane Library, Embase, and PsycINFO to identify eligible studies published from January 2010

up until November 2020. An updated search was performed in November 2021. Comprehensive and exhaustive search equations were developed according to the PECO format (population, exposure, comparator, and outcomes) and validated by an experienced librarian at the Université catholique de Louvain (UCLouvain, Belgium). Search terms were related to *neck pain*, *physical activity*, *weight*, and their synonyms (chosen according to each database's syntax). Search equations are provided in **SUPPLEMENTAL APPENDIX 1**. In addition, we screened the reference list of each included study and similar reviews for any additional relevant papers that were missed in our search.

Study Selection

Studies available in full text that met the eligibility criteria were included. These criteria were case-control or cohort design, including adults (≥ 18 years) with NSNP and/or healthy participants, assessing the onset or the persistence of NSNP as outcomes, assessing leisure time PA or weight as exposures, including reported or extractable quantitative estimates of the risk of NSNP (onset or persistence), and published in French or English.

To avoid missing any relevant studies, we used no specific definition of NSNP. However, the neck pain had to occur in the *absence of trauma, signs, or symptoms of major structural pathology, neurological signs, or specific pathology*.⁶ Articles that reported NSNP in combination with pain in other body areas (eg, shoulder or arm) were excluded, unless separate data related to neck pain were reported. Symptoms in the shoulder may be the result of injuries in the neck and/or shoulder regions, and risk factors for neck and shoulder pain populations are not identical.^{22,78,81} Therefore, studies investigating neck and shoulder symptoms as a single region (or a mixed population with inclusion of one or the other) were excluded.

Outcomes were the onset (new reported episode of neck pain/symptoms irrespective of the duration or severity of

symptoms) and the persistence (episode for more than 3 months) of NSNP. There was no restriction on how these outcomes were assessed.

Only leisure time PA was evaluated in this review. Studies evaluating only occupational PA or a combination of occupational and leisure time PA without any subgroup analysis were not considered. There was no restriction on how these exposures were assessed.

We excluded studies of a mixed neck pain population (without subgroup analysis by type of neck pain) and/or studies that evaluated a combination of lifestyle factors.

Studies were selected according to the following process: import of citations in EndNote X9, removal of duplicates manually and via the EndNote process, screening on the basis of title and abstract, screening on the basis of full-text, and final inclusion in the review. All these steps were done independently by 2 reviewers (A.L. and F.A.). Disagreements were resolved through consensus. If not, a third reviewer (L.P.) made a final decision.

Data Extraction

The following data of each primary study were extracted independently by 2 reviewers (A.L. and F.A.) in a standardized form: eligibility criteria, study methods, participants, intervention, outcomes, results, and miscellaneous information. Details of extracted data are available in **SUPPLEMENTAL APPENDIX 2**. In cases of missing data or a need to specify information about the study, authors were contacted via email.

Methodological Quality Assessment

Two reviewers (A.L. and F.A.) independently assessed methodological quality using the Newcastle-Ottawa Scale (NOS) for cohort and case-control studies.⁸⁵ Quality assessment tables are separated by exposure (leisure time PA and weight). The total score of NOS ranged from 0 to 9 based on 3 domains: selection (0–4 stars), comparability (0–2 stars), and outcome (0–3 stars). The NOS scoring system was

applied; however, more weight was attributed for the “comparability” criterion (ie, controlling for confounders), which better reflects the risk of bias in the included studies. Disagreements were resolved through consensus. Criteria used for the methodological quality assessment of included studies are presented in **SUPPLEMENTAL APPENDIX 3**.

Data Synthesis

A meta-analysis was precluded (see the “Differences Between the Protocol and Review” section). Instead, we used the Synthesis Without Meta-analysis (SWiM) reporting guidelines for the synthesis of quantitative data.¹³ Because narrative synthesis is characterized by a lack of transparency, making an assessment of the validity of its findings is difficult.¹² An alternative synthesis was chosen, when possible, as recommended by the SWiM guidelines. Our synthesis was based on the “vote counting based on direction of effects” method, which is considered acceptable when a meta-analysis could not be undertaken.⁵¹

To undertake vote counting, we first created a standardized binary metric by categorizing each effect estimate based on direction (“showing benefit” vs “showing harm”).⁵¹ Regardless of statistical significance or effect size, we counted and compared the number of effect estimates showing benefit and those showing harm. We calculated an estimate of the proportion of effects favoring the exposure (leisure time PA or weight) as follows: proportion (p) = u/n , where u = number of effects favoring the exposure, and n = number of studies.⁵¹ We also calculated a 95% confidence interval (CI) on this proportion using the Wilson interval method (in Stata version 17.0), as recommended by the Cochrane collaboration.⁵¹ Because of the high heterogeneity (clinical and methodological diversities), a qualitative (narrative) synthesis was used for the persistence of NSNP.

Studies were grouped by outcome (onset and persistence) and exposure (leisure time PA and weight). Effect measures, retrieved from the primary studies, were

odds ratio (OR) and hazard ratio (HR). Each effect estimate was presented with its corresponding 95% CI in the results section. When necessary, the leisure time PA or weight subgroups used in the primary studies were specified in subscript with the corresponding OR. Studies were heterogeneous in the way they presented leisure time PA exposure. Some studied associations between NSNP and lower activity levels, while others studied associations between NSNP and higher activity levels. The same applied to the exposure weight (underweight, normal weight, and overweight). To make this clear, we presented the risk estimates of exposures into 2 categories for leisure time PA (*being less active vs being more active*) and for weight (*underweight or normal weight vs overweight*).

A positive or negative effect estimate was considered irrespective of the statistical significance. Automatic use of a binary *significant vs nonsignificant* decision rule encourages raters to ignore potentially important observed differences.²⁶ Our approach avoids misinterpreting a moderate or large P value (eg, $>.05$) as evidence that the exposure has no effect on the outcome.⁶⁹ Inclusion of nonsignificant findings allows for a more nuanced evaluation. However, we specified the significance of effect estimates for completeness. In the absence of a recommended threshold for an important difference, we specified a threshold including effect estimates in the region of 1 (between 0.95 and 1.05) to indicate little or no effect. Multivariable adjusted associations were preferred over univariable associations for data synthesis because they usually reduce the impact of confounding.³²

Certainty of Evidence

The GRADE approach was used to assess the certainty of the synthesis findings for each outcome and each exposure.^{25,67} The certainty of evidence for each outcome ranges from very low to high. According to the GRADE approach, because of the observational design, assessment started with a *low* certainty of evidence.^{67,68} We

downgraded certainty when the body of evidence for an outcome was judged to be affected by risk of bias, inconsistent results, indirectness of evidence, imprecision, or publication bias.^{67,68} We upgraded certainty in case of large effects, dose-response associations, or residual confounding.^{67,68}

Differences Between the Protocol and Review

Given the high heterogeneity between studies and the risk of bias, we did not conduct a meta-analysis.²¹ Although subgroup analyses were planned for sex and age, they were not performed due to the paucity of studies. Data extraction was expanded to correspond to the Cochrane Handbook recommendations⁴⁹ by extracting more information about statistical analyses, methods used to prevent biases and to address missing data, and discussion information.

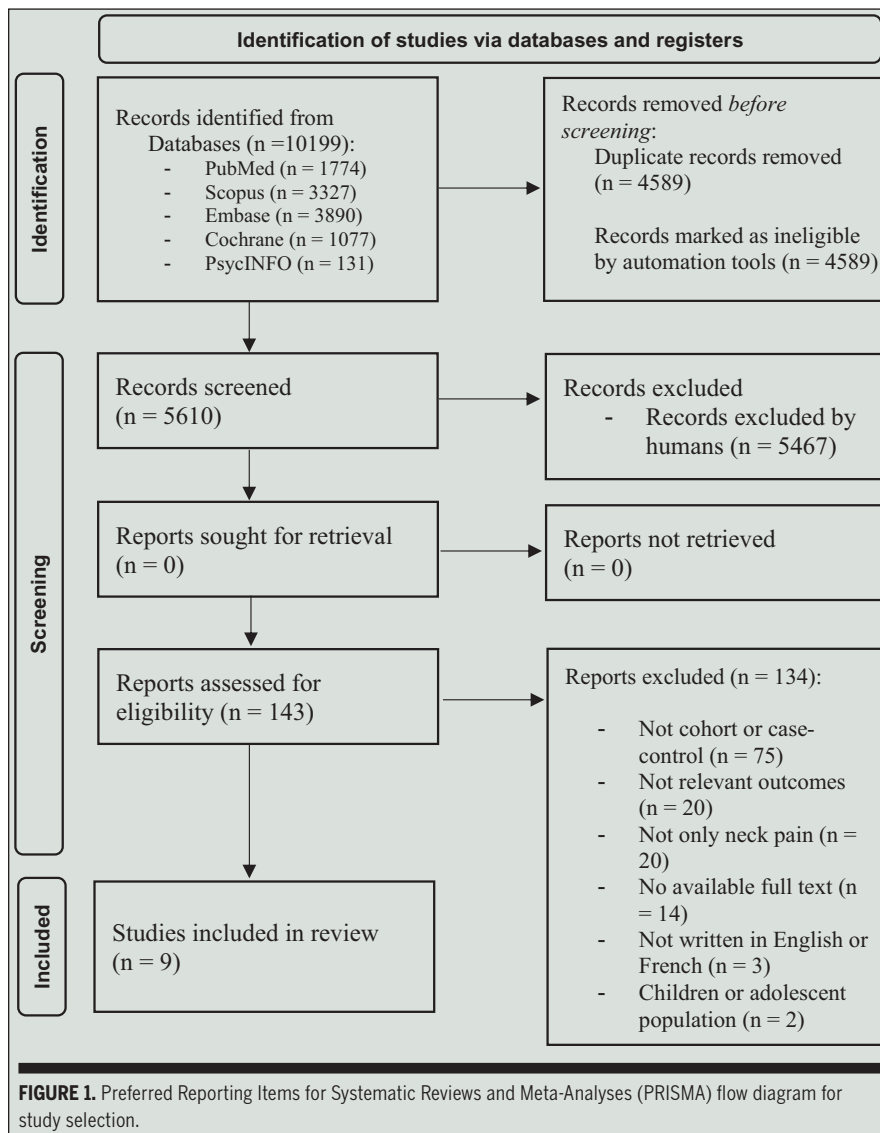
RESULTS

Study Selection

The initial search yielded 10 199 references. After removing duplicates, we screened the titles and abstracts of 5610 articles. After applying the selection criteria, 9 articles were included for qualitative synthesis. The updated search did not identify any new articles. Details are described in **FIGURE 1**.

Characteristics of Included Studies

Eight cohort studies and one case-control study were included in this systematic review, with a total of 20 350 participants (ranging from 86 to 11 391). Studies on the onset of NSNP included 1176 participants (**TABLE 1**), whereas studies of persistence included 19 174 participants (**TABLE 2**). Eight studies included workers (4 studies^{40,70-72} on white-collar workers, 3 studies^{42,43,59} on mixed white-collar and blue-collar workers, and 1 study⁹ on blue-collar workers), and 1 study⁶² included the general population of working age. Studies including mixed white-collar and blue-collar workers^{42,43,59} included a majority of white-collar workers.



Nonspecific neck pain was self-reported in all studies, according to specific criteria decided by the authors (6 studies) or by using the Standardized Nordic Questionnaire (3 studies). Leisure time PA was assessed through open-ended and multiple choice questions in 4 studies, validated questionnaires in 2 studies (International Physical Activity Questionnaire and Baecke Physical Activity Index), and objectively via a pedometer in 1 study. Data for weight were self-reported in 3 studies and collected by an examiner in 2 studies.

Four studies investigated the association between exposures and the onset of

NSNP (three on leisure time PA and two on weight), whereas 5 studies investigated the association between exposures and the persistence of NSNP (four on leisure time PA and three on weight). Characteristics of the included studies are presented in **TABLES 1** and **2**.

Methodological Quality Assessment

Six studies were judged to have *good* methodological quality (three for leisure time PA and three for weight), two were judged *fair* (two for leisure time PA), two were judged *poor to fair* (one for leisure time PA and one for weight), and two were

judged *poor* (one for leisure time PA and one for weight). The most encountered limitations were the nonrepresentativeness of the exposed cohorts (volunteers or convenience samples), the ascertainment of exposures (mostly self-reports), and the assessment of outcomes (mostly self-reports). Detailed risk of bias assessments can be found in **SUPPLEMENTAL APPENDIX 4** (NOS for leisure time PA) and **SUPPLEMENTAL APPENDIX 5** (NOS for weight).

Summary of Results

Tabulation of the available effect estimates is shown in **TABLE 3** (onset of NSNP) and **TABLE 4** (persistence of NSNP). The GRADE assessment is shown in **TABLE 5**. **Association Between Leisure Time PA and Onset of NSNP** Three prospective cohort studies investigated the association between leisure time PA and the onset of NSNP. According to the vote counting based on direction of effects, 2 of 3 studies^{40,72} (67% [95% CI: 21% to 94%]; very low certainty evidence) found a decreased risk of NSNP with higher levels of activity (Jun et al⁴⁰: adjusted HR [95% CI] = 0.72 [0.60-0.87]; Sitthipornvorakul et al⁷²: adjusted OR [95% CI] = 0.86 [0.74-1.00]). Both studies were adjusted for some relevant confounders (eg, confounders giving a star in the NOS assessment, being age, sex, previous neck or back pain, lifestyle factors, physical factors, or psychosocial factors). The third study⁹ found little or no effect (unadjusted OR [95% CI] = 1.04 [0.69-1.57]) and was neither adjusted for relevant confounders nor statistically significant. One study⁴⁰ adjusted for relevant confounders, investigated the association between inactivity and the onset of NSNP and found a significant increased risk (adjusted HR [95% CI] = 1.04 [1.03-1.06]). Because the effect size did not exceed our threshold for clinical relevance, we considered this to reflect little or no effect.

Association Between Weight and Onset of NSNP One cohort⁹ and one case-control⁴³ study investigated the association between weight and the onset of NSNP.

TABLE 1

SUMMARY OF STUDIES ASSESSING THE ONSET OF NONSPECIFIC NECK PAIN

Authors	Study Design	Study Population	Sample Size (N)	Follow-up Duration Drop-out Rate (%)	Exposure + Measurement Tool or Scale	Outcomes Outcome Definition Measurement Tool or Scale	Statistical Model, Investigated Covariates
Jun et al (2020)	Prospective longitudinal cohort study	Subjects: Office workers from multiple organizations: universities, research center, management service, industrial-educational agency, and health service institution. Average age (SD): 37.3 (9.9) years Sex: 55.1% female Country: Australia (Brisbane) and South Korea (Daegu)	N = 214: Brisbane (N = 156), Daegu (N = 58) 191 participants included in the final analysis (including risk factors between cultures)	Follow-up: 12 months Drop-out rate: 2.7% at follow-up and 13.2% at risk factor analysis	Exposure: Physical activity Measurement tool: • Brisbane: IPAQ-SF • Daegu: IPAQ-SF (Korean version)	Outcome: Onset of neck pain Measurement tool: Self-report (closed questions) Definition: A new development of interfering neck pain in the 12 months following the baseline assessment Interfering neck pain = Symptoms severe enough to (1) interfere with daily activities, or (2) one has taken a sick leave or has sought health care advice or self-management	Multivariate HR adjusted for age, sex, BMI, coping strategy, social support, muscular strength, and endurance
Kanagalakshmi et al (2018)	Case-control study	Subjects: Support services staff including technicians, pharmacists, record keeping services, and administrative staff in hospitals Average age (SD): Cases: 39.14 (7.67) years Controls: 39.44 (7.80) years Sex: 40.7% female Country: India (Tamil Nadu)	N = 86 (included in the risk factor analysis for BMI)	Follow-up: Not applicable Drop-out rate: Not applicable	Exposure: Weight (BMI) Measurement tool: Measured by a health care professional	Outcome: Onset of neck pain Measurement tool: Self-administered questionnaire + evaluation of pain + physical examination Definition: Pain, ache, or discomfort in the neck and/or inter-scapular region between occiput and third thoracic vertebra in the last 3 months	Adjusted OR for age, sex, working more than 3 hours with computers, perception of job control, posture, repetitive nature of work

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TABLE 1

SUMMARY OF STUDIES ASSESSING THE ONSET OF NONSPECIFIC NECK PAIN (CONTINUED)

Authors	Study Design	Study Population	Sample Size (N)	Follow-up Duration Drop-out Rate (%)	Exposure + Measurement Tool or Scale	Outcomes Outcome Definition Measurement Tool or Scale	Statistical Model, Investigated Covariates
Sitthipornvorakul et al (2015)	Prospective cohort study	Subjects: Office workers from 4 large-scale enterprises (1 university and 3 ministry's head offices) Average age (% sample): 20-29 years (24.3%) 30-39 years (49.1%) 40-45 years (26.6%) Sex: 76.2% female Country: Thailand (Bangkok)	N = 387 (baseline) N = 367 (12-month follow-up) N = 362 (final analysis)	Follow-up: 12 months Drop-out rate: 5.2% at 12-month follow-up and 6.5% at final analysis	Exposure: Physical activity (daily walking steps) Measurement tool: Digi-walker Pedometer CW700s	Outcome: Onset of neck pain Measurement tool: Standardized Nordic Questionnaire Definition: Pain lasting for more than 1 day in the last month with intensity greater than 30 mm on a 100-mm visual analog scale, and no weakness or numbness in the upper or lower limbs	Adjusted OR for age, sex, history of neck pain, chair adjustability, physical job demands
Bovenzi et al (2015)	Prospective cohort study	Subjects: Male professional drivers employed in several industries (marble quarries, marble laboratories, dockyards, paper mills), and public utilities (garbage services, public transport) located in various Provinces of Italy Average age (SD): 41 (8.1) years Sex: 100% male Country: Italy	N = 598 (baseline) N = 537 (analyzed): 317 did the 2 follow-ups, 220 only did one.	Follow-up: 3 years Drop-out rate: 10.2% at one-year follow-up	Exposures: Physical activity and weight Measurement tool: • Physical activity: self-report (questionnaire) • Weight (BMI): self-report (questionnaire)	Outcome: Onset of neck pain Measurement tool: Modified version of the Nordic questionnaire on musculoskeletal symptoms Definition: At least 1 episode of pain lasting 1 day or more in the neck anatomical area	Univariate OR adjusted for time effect

Abbreviations: BMI, body mass index; HR, hazard ratio; IPAQ-SF, International Physical Activity Questionnaire – Short Form; OR, odds ratio; SD, standard deviation.

According to the vote counting based on direction of effects, both studies (100% [95% CI: 34% to 100%]; very low certainty of evidence) found an increased risk of NSNP in overweight people. The case-control study⁴³ was adjusted for relevant confounders (eg, age, sex, perception of job control, repetitive nature of work) and found a significant increased risk (adjusted OR [95% CI] = 2.44 [1.17-5.05]),

whereas the effect estimate in the cohort study⁹ was neither adjusted for relevant confounders nor statistically significant (unadjusted OR_{25-27 kg/m² vs <25 kg/m²} [95% CI] = 1.19 [0.66-2.16]; unadjusted OR_{>27 kg/m² vs <25 kg/m²} [95% CI] = 1.33 [0.71-2.48]).

Association Between Leisure Time PA and Persistence of NSNP Four cohort studies investigated the association between leisure time PA and the persistence

of NSNP (one of them⁶² investigated recovery from persistent NSNP). Overall, based on multivariable effect estimates, there was a trend for a decreased risk of persistent NSNP in more active people. Certainty of evidence was very low. Results are summarized qualitatively in **SUPPLEMENTAL APPENDIX 6**.

Association Between Weight and Persistence of NSNP Three cohort studies

TABLE 2

SUMMARY OF STUDIES ASSESSING THE PERSISTENCE OF NONSPECIFIC NECK PAIN

Authors	Study Design	Study Population	Sample Size (N)	Follow-up Duration Drop-out Rate (%)	Exposure + Measurement Tool or Scale	Outcomes Outcome Definition Measurement Tool or Scale	Statistical Model, Investigated Covariates
Kääriä et al (2012)	Prospective cohort study	Subjects: Middle-aged employees of the City of Helsinki (more than 200 different occupations) Age (% sample): 40 years (20.9%) 45 years (21.6%) 50 years (21.2%) 55 years (24.3%) 60 years (12%) Sex: 80% female Country: Finland (Helsinki)	N = 5277	Follow-up: 5-7 years Drop-out rate: 17%	Exposure: Physical activity and Weight Measurement tool: • Physical activity: self-report (opened question) • Weight (BMI): self-report of weight and height	Outcome: New onset of chronic neck pain Measurement tool: Self-report (closed question) Definition: Incident chronic neck pain (duration >3 months) was defined as not having had chronic neck pain at the baseline but reporting it at the follow-up.	Adjusted OR for age
Palmiöf et al (2016)	Prospective cohort study 2 subcohorts <i>Cohort 1</i> = risk cohort <i>Cohort 2</i> = prognostic cohort	Subjects: Swedish residents (18-65 years) from 24 out of 26 municipalities in Stockholm County <i>Cohort 1:</i> Individuals with no neck pain at baseline (during the last 6 months) <i>Cohort 2:</i> Individuals with occasional neck pain at baseline Average age (SD): <i>Cohort 1:</i> 44 (11) years <i>Cohort 2:</i> 42 (11) years Sex: <i>Cohort 1:</i> 40.3% female <i>Cohort 2:</i> 57.7% female Country: Sweden (Stockholm)	N = 11391 (analyzed) <i>Cohort 1:</i> N = 4639 <i>Cohort 2:</i> N = 6752	Follow-up: 5 years Drop-out rate: 20.4%	Exposure: Physical activity Measurement tool: Self-report (multiple choice question)	Outcome: Long duration troublesome neck pain Measurement tool: Self-report (closed question) Definition: Neck pain for at least 3 consecutive months in the last 5 years that is considerably bothering	Cohort 1: Adjusted OR for age, alcohol consumption, smoking, immigrant status, work under knee level, computer work, work above shoulder level Cohort 2: Adjusted OR for age, immigrant status, smoking, work over shoulder level, and computer work

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TABLE 2

SUMMARY OF STUDIES ASSESSING THE PERSISTENCE OF NONSPECIFIC NECK PAIN (CONTINUED)

Authors	Study Design	Study Population	Sample Size (N)	Follow-up Duration Drop-out Rate (%)	Exposure + Measurement Tool or Scale	Outcomes Outcome Definition Measurement Tool or Scale	Statistical Model, Investigated Covariates
Rasmussen et al (2013)	Prospective cohort study	Subjects: Residents (18 to 65 years) of Stockholm County, from each of 43 strata comprising 25 municipalities and 18 subregions of the municipality Average age: Not reported Sex: 71.4% female Country: Sweden (Stockholm)	N = 1730	Follow-up: 5 years Drop-out rate: 5.36%	Exposure: Physical activity and weight Measurement tool: • Physical activity: Self-report (multiple choice question) • Weight (BMI): Self-report of weight and height	Outcome: Recovery from persistent neck pain Measurement tool: Self-report (closed questions) Definition: • Persistent neck pain = pain in the neck or upper back, every day during the previous 6 months • Recovery from neck pain = no neck pain during the past 5-year period for at least 3 consecutive months (or at least 7 consecutive days but less than 3 consecutive months) that was considerably bothering	Adjusted OR for age, smoking, alcohol, back pain the previous 6 months, chronic illness or handicap, socioeconomic class, current occupation, marital status, country of birth, time with housework per day, main physical workload the previous 12 months, sick leave the last 12 months, time spent at computer per day, psychological well-being, and BMI
Shahidi et al (2015)	Prospective cohort study	Subjects: Office workers (18-65 years) from Denver metropolitan area Average age: 30 years Sex: 79.5% female Country: United States of America (Denver)	N = 167	Follow-up: 12 months Drop-out rate: 2.3%	Exposure: Physical activity Measurement tool: Baecke Physical Activity (BPA) Index	Outcome: Chronic interfering neck pain Measurement tool: Self-report Definition: Either persistent (≥ 3 consecutive months) or episodic (≥ 3 nonconsecutive months) interfering pain at any point during the 12-month follow-up	Adjusted OR for age, sex, BMI
Sihawong et al (2016)	Prospective cohort study	Subjects: Office workers from 9 large-scale enterprises in Bangkok Average age (SD): 35.7 (8.3) years Sex: 74.9% female Country: Thailand (Bangkok)	N = 669 (baseline) N = 609 (analysis)	Follow-up: 12 months Drop-out rate: 9%	Exposure: Weight (BMI) Measurement tools: • Body weight: electronic digital scale • Body height: wall-mounted stadiometer • Waist circumference: tape measure	Outcome: Chronic neck pain Measurement tool: Standardized Nordic questionnaire Definition: • Incident neck pain = neck pain lasting >24 h in the past month, intensity >30 mm on a 100-mm VAS and no weakness or numbness in the upper or lower limbs • Chronic neck pain = incident neck pain for at least 3 months in any 6 months during the 1-year follow-up	Adjusted OR for age, sex, initial pain intensity, and initial disability level

Abbreviations: BMI, body mass index; OR, odds ratio; SD, standard deviation; VAS, visual analogue scale.

investigated the association between weight and the persistence of NSNP (one of them⁶² investigated recovery from persistent NSNP). Overall, based on multivariable effect estimates, there was a

trend for an increased risk of persistent NSNP in people with overweight and obesity. Certainty of evidence was very low. Results are summarized qualitatively in SUPPLEMENTAL APPENDIX 6.

DISCUSSION

WE INVESTIGATED THE RELATIONSHIP between leisure time PA, weight, and NSNP (onset and

TABLE 3

EFFECT OF LEISURE TIME PHYSICAL ACTIVITY AND WEIGHT ON THE ONSET OF NONSPECIFIC NECK PAIN (RESULTS AND VOTE COUNTING)^a

Authors (NOS Assessment)	Exposure	Outcomes	Results	Being Less Active	Being More Active
Jun et al (2020) ("Fair" quality)	Leisure time physical activity (total METs/week derived from the IPAQ) Inactivity (per hour of sitting during weekdays, according to the IPAQ)	Onset of interfering neck pain	Adjusted ^b HR: 0.72 (0.60-0.87) Adjusted ^b HR: 1.04 (1.03-1.06)	0	—*
Sitthipornvorakul et al (2015) ("Good" quality)	Leisure time physical activity (per 1000 daily walking steps, measured by a pedometer)	Onset of neck pain	Adjusted ^b OR: 0.86 (0.74-1.00)		—
Bovenzi et al (2015) ("Poor" quality)	Leisure time physical activity (self-reported weekly frequency) → <3 times a week vs ≥3 times a week	At least 1 episode of neck pain	Unadjusted OR: 1.04 (0.69-1.57)		0
Kanagalakshmi et al (2018) ("Good" quality)	Overweight (BMI ≤25 vs >25 kg/m ²)	Onset of neck pain	Adjusted ^b OR: 2.44 (1.17-5.05)	Underweight or normal weight	Overweight
Bovenzi et al (2015) ("Poor" quality)	BMI (calculated based on self-reported height and weight) → BMI 25-27 vs <25 kg/m ² // BMI >27 vs <25 kg/m ²	At least 1 episode of neck pain	Unadjusted OR _{25-27 vs <25} : 1.19 (0.66-2.16) Unadjusted OR _{>27 vs <25} : 1.33 (0.71-2.48)		+ +

Abbreviations: BMI, body mass index; HR, hazard ratio; IPAQ, International Physical Activity Questionnaire; MET, metabolic equivalent task; NOS, Newcastle-Ottawa Scale; OR, odds ratio.

^a(—*) significant decreased risk; (+*) significant increased risk; (—) nonsignificant decreased risk; (+) nonsignificant increased risk; (0) no effect.

^bAdjusted for at least age and sex.

persistence). There were modest associations, and overall, very low certainty evidence of a relationship between NSNP and both exposures.

For the onset of NSNP, 2 of 2 studies reported an increased risk in people with overweight or obesity, and 2 of 3 studies reported a decreased risk for more active people. For the persistence of NSNP, most studies' multivariable ORs reported a decreased risk with increased leisure time PA and an increased risk with overweight or obesity (with less consistent findings for men). Sex differences are well-known in neck pain,⁶⁵ female sex being a risk factor for NSNP,^{6,44,58} which may explain the differences between men and women observed in this study. However, this needs to be investigated in future studies.

Leisure time PA seemed to protect against NSNP, which contradicts previous systematic reviews.^{55,73} Sitthipornvorakul et al⁷³ found limited evidence for no association between leisure time PA and neck pain in workers. However, their con-

clusion was based on 1 study including an adult working population with neck-shoulder symptoms.⁷³ Therefore, it may not generalize to a neck pain population. Øverås et al⁵⁵ found that inactivity at work may protect against neck pain, while an increase in PA may increase the risk of neck pain. These findings are different to ours, and may reflect differences in the study population. Øverås et al⁵⁵ mostly included blue-collar workers, who are usually more physically active at work than white-collar workers.⁵⁵ In addition, because Øverås et al⁵⁵ investigated both occupational and leisure time PA, a possible explanation for their findings is the PA paradox, which states that more occupational PA could be detrimental to health (effort of too low intensity or too long duration, elevation of 24-hour heart rate and blood pressure, in sufficient recovery time, low worker control, increased level of inflammation, prolonged postures, or repetitive tasks)^{17,18,34-36} and, thus, could increase the risk of neck pain. Another explanation is that occupa-

tional and leisure time PA elicit distinct biomechanical loadings and physiological responses, which over time, have differential impact on various health outcomes, including musculoskeletal health.⁵⁵ Neither of these studies^{55,73} investigated the persistence of NSNP. Based on these results, leisure time PA appears to protect against the onset and persistence of NSNP, whereas occupational PA appears to promote NSNP. This is very important to consider when helping patients with NSNP, as the type of PA may have opposing effects and consequences on NSNP.

To date, 2 systematic reviews^{39,45} on risk factors for NSNP have included studies that assessed weight and showed inconsistent results. Discrepancies between them and our review may be explained by the fact that we specifically focused on weight, whereas it was one of multiple risk factors in the other systematic reviews. Previous reviews did not investigate the persistence of NSNP. However, the link between overweight or obesity

TABLE 4

EFFECT OF LEISURE TIME PHYSICAL ACTIVITY AND WEIGHT ON THE PERSISTENCE OF NONSPECIFIC NECK PAIN (RESULTS AND VOTE COUNTING)^a

Authors (NOS Assessment)	Exposure	Outcomes	Results	Being Less Active	Being More Active
Kääriä et al (2012) ("Poor to fair" quality)	Leisure time physical activity (4 grades of intensity exemplified with common activities that people often do) → Classification into 4 groups based on METs hours/week (inactive, moderate, vigorous, conditioning)	Chronic neck pain	Men (n = 1057): Unadjusted OR Vigorous vs conditioning: 0.84 (0.44-1.60) Moderate vs conditioning: 1.18 (0.64-2.20) Inactive vs conditioning: 1.05 (0.55-2.00)	Men	
			Women (n = 4220): Unadjusted OR Vigorous vs conditioning: 1.05 (0.76-1.46) Moderate vs conditioning: 1.26 (0.94-1.69) Inactive vs conditioning: 0.98 (0.71-1.36)		
				–	
				+	
				0	
				Women	
				0	
				+	
				0	
Palmiöf et al (2016) ("Good" quality)	Leisure time physical activity ("How much have you been physically active in your leisure time during the past 12 months?") → Sedentary, moderate physical activity, moderate regular physical activity, high regular physical activity	Cohort 1: Onset of long- duration troublesome neck pain (healthy participants at baseline)	Both sexes: Adjusted ^b OR Moderate level vs sedentary: 0.7 (0.4-1.0) Moderate or high regular level vs sedentary: 0.6 (0.4-0.9) Men (n = 2772): Adjusted ^b OR Moderate level vs sedentary: 0.8 (0.4-1.6) Moderate or high regular level vs sedentary: 0.6 (0.3-1.2) Women (n = 1867): Adjusted ^b OR Moderate level vs sedentary: 0.5 (0.2-1.0) Moderate or high regular level vs sedentary: 0.6 (0.3-1.1)		Both sexes
					–
					–*
					Men
					–
					–
					Women
					–
					–
	Leisure time physical activity ("How much have you been physically active in your leisure time during the past 12 months?") → Sedentary, moderate physical activity, moderate regular physical activity, high regular physical activity	Cohort 2: Onset of chronic neck pain (occasional neck pain participants at baseline)	Both sexes: Adjusted ^b OR Moderate level vs sedentary: 1.0 (0.8-1.3) Moderate or high regular level vs sedentary: 0.9 (0.7-1.1) Men (n = 2924): Adjusted ^b OR Moderate level vs sedentary: 1.2 (0.8-1.7) Moderate or high regular level vs sedentary: 0.8 (0.5-1.1) Women (n = 3891): Adjusted ^b OR Moderate level vs sedentary: 0.9 (0.6-1.2) Moderate or high regular level vs sedentary: 0.9 (0.7-1.2)		Both sexes
					0
					–
					Men
					+
					–
					Women

Table continues on next page.

TABLE 4

EFFECT OF LEISURE TIME PHYSICAL ACTIVITY AND WEIGHT ON THE PERSISTENCE OF NONSPECIFIC NECK PAIN (RESULTS AND VOTE COUNTING)^a (CONTINUED)

Authors (NOS Assessment)	Exposure	Outcomes	Results	Being Less Active	Being More Active
Rasmussen et al (2013) ("Good" quality)	Leisure time physical activity level (PAL) ("During the previous 12 months, how physically active have you been during leisure time? If your activity differs between, eg, summer and winter, please estimate the average activity") → Sedentary, low, moderate, high	Recovery from persistent neck pain	Men (n = 495): Adjusted ^b OR Active PAL vs sedentary: 0.9 (0.6-1.5) Women (n = 1235): Adjusted ^b OR Active PAL vs sedentary: 1.5 (1.0-2.4)		Men – Women +
Shahidi et al (2015) ("Fair" quality)	Leisure time physical activity (BPA Index - Leisure)	Chronic interfering neck pain	Adjusted ^b OR: 0.79 (0.46-1.37)		–
Kääriä et al (2012) ("Poor to fair" quality)	BMI (kg/m ² , calculated based on self-reported height and weight) → Normal weight, overweight, obese	Chronic neck pain	Men (n = 1057): Unadjusted OR Overweight vs normal weight: 0.60 (0.38-0.96) Obese vs normal weight: 1.11 (0.61-2.02) Women (n = 4220): Adjusted ^b OR Overweight vs normal weight: 1.22 (1.00-1.48) Obese vs normal weight: 1.39 (1.08-1.80)	Underweight or normal weight	Men –* + Women + +*
Rasmussen et al (2013) ("Good" quality)	BMI (kg/m ² , calculated based on self-reported height and weight) → Underweight, normal weight, overweight	Recovery from persistent neck pain	Men (n = 495): Adjusted ^b OR 18-24.9 vs <18 and >25: 1.2 (0.7-1.9) Women (n = 1235): Adjusted ^b OR 18-24.9 vs <18 and >25: 1.0 (0.8-1.3)		Men + Women 0
Sihawong et al (2016) ("Good" quality)	BMI (kg/m ² , calculated based on weight (digital scale) and height (wall-mounted stadiometer))	Chronic neck pain	Adjusted ^b OR: 1.10 (1.02-1.19)		+*

Abbreviations: BMI, body mass index; BPA, Baecke Physical Activity; MET, metabolic equivalent task; NOS, Newcastle-Ottawa Scale; OR, odds ratio; PA, physical activity; PAL, physical activity level.

^a(–*) significant decreased risk; (+*) significant increased risk; (–) nonsignificant decreased risk; (+) nonsignificant increased risk; (0) no effect.

^bAdjusted for at least age and sex.

and NSNP would not be surprising, because obesity is associated with musculoskeletal disorders⁸⁴ and is considered a risk factor for low back pain.⁸⁷

A possible explanation for the inconsistent findings throughout the literature may be that only weight or leisure time PA is not sufficient to clearly influence the onset or the persistence of NSNP. Some recent reviews demonstrated the relationships between other lifestyle fac-

tors (eg, smoking, stress, nutrition, sleep, and alcohol intake) and musculoskeletal pain.^{1,2,11,24,53,79,80} When combined, lifestyle factors ("lifestyle behavior") may have a greater impact on NSNP. Indeed, 2 recent prospective cohort studies^{8,74} suggest that adhering to a healthy lifestyle behavior decreases the risk of long-duration troublesome neck pain. However, the paucity of studies prevents firm conclusions, and further research on the impact

of a healthy lifestyle behavior on NSNP is needed.

Overall, our results reflect the current international guidelines promoting a healthy weight and regular leisure time PA to foster good health^{10,23} and suggest that this also applies to NSNP.

Limitations

This is the first systematic review focusing on the relationship between these 2

TABLE 5

GRADING OF RECOMMENDATIONS ASSESSMENT, DEVELOPMENT, AND EVALUATION (GRADE) SUMMARY OF FINDINGS

Number of Studies	Study Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Certainty of Evidence
Leisure Time Physical Activity on Onset of Nonspecific Neck Pain							
3	Observational studies	Not serious	Not serious	Serious ^a	Not serious	Likely ^b	Very low ⊕○○○
Weight on Onset of Nonspecific Neck Pain							
2	Observational studies	Some concerns ^c	Not serious	Serious ^d	Serious ^e	Likely ^b	Very low ⊕○○○
Leisure Time Physical Activity on Persistence of Nonspecific Neck Pain							
4	Observational studies	Not serious	Not serious	Serious ^f	Serious ^g	Likely ^b	Very low ⊕○○○
Weight on Persistence of Nonspecific Neck Pain							
3	Observational studies	Not serious	Not serious	Serious ^f	Serious ^g	Likely ^b	Very low ⊕○○○

^aOne study did not use a validated assessment of leisure time physical activity and most studies included specific populations.

^bSome studies tended to report and analyze only significant factors, and the search strategy did not cover every database and unpublished literature (thus, relevant studies with different effect estimates may have been missed).

^cLimitations may lower confidence in the estimate of effect (1 “good” quality study and 1 “poor” quality study).

^dSubjective assessment of weight and various populations.

^eLow number of events (<400 events); large confidence intervals (crossing 1.0) for 1 study.

^fMost studies used self-reports, 1 study investigated recovery rather than chronicity, mixed populations investigated.

^gMost effect estimates crossing 1.0.

exposures and the onset or the persistence of NSNP. Thanks to specific selection criteria, we could offer a better view of the association between leisure time PA, weight, and NSNP. Including mainly prospective cohort studies allowed to better assess the causation between exposures and NSNP.⁷⁶ To consider every effect estimate notwithstanding the statistical significance, as recommended by the Cochrane collaboration⁵¹ to avoid ignoring potentially important observed differences, and interpreting effect estimates between 0.95 and 1.05 as null (not clinically relevant) allowed to better reflect the associations observed in primary studies. Using the Cochrane recommendations, the SWiM guidelines, and the GRADE approach makes this a rigorous systematic review.

Only English or French published articles were screened in some of the available databases, implying a risk for publication and language biases. The synthesis method used for the onset of NSNP is recommended when a meta-analysis cannot be undertaken,^{13,51} but it contains some

disadvantages: has no information on the magnitude of effects, does not account for differences in the relative sizes of the studies, and is less powerful than methods used to combine *P* values.⁵¹ The synthesis for the persistence of NSNP is also a limitation because descriptive (narrative) synthesis is characterized by a lack of transparency and makes the assessment of the validity of its findings difficult.¹² The presence of modest and sometimes inconsistent associations, as well as the paucity of studies and the specific population studied (white-collar and blue-collar workers), also represent limitations that decrease the generalizability of the findings and the certainty of the evidence.

Recommendations for Future Research

Most studies included workers (white-collar workers,^{40,70-72} mixed white-collar and blue-collar workers,^{42,43,59} blue-collar workers⁹), sometimes using a convenience sample, preventing the generalization of the results to a general population. Future studies should investigate these relationships in a general population.

To avoid biases induced by residual and unmeasured confounding,⁷⁷ future studies should control for relevant confounders that are related to the onset or the persistence of NSNP, such as individual factors (eg, age, sex, history of neck pain, or other musculoskeletal disorders), psychosocial factors (eg, anxiety, depression, high job demands, social or work support), and lifestyle factors (eg, stress, sleep, smoking, occupational PA).^{5,6,17,28,45,47,60}

Because studies with long-term follow-up could have recall bias, regular follow-ups are preferred. Self-reports of leisure time PA and weight could also introduce reporting bias due to overestimation or underestimation,³ so the use of validated objective measurements is recommended. Body mass index may not be sufficient to assess the risks associated with abdominal adiposity, so adding a measure of waist circumference should be performed⁶⁴ in future studies investigating weight as an exposure.

Several studies were subject to nonreporting and underreporting data due to nonsignificance, which implies totally or

partially missing results.⁵⁶ Because missing results can lead to biases, authors recommend reporting and performing multivariable analyses for all results (significant or not).

Clinical Implications

Leisure time PA and weight may play a role in the onset and persistence of NSNP, identifying these exposures as potential risk factors. Thus, clinicians may need to consider these factors when assessing and treating NSNP, to reduce the risk of new or persistent painful episodes. This could prevent or reduce the burden and disability of their patients, as well as the costs associated with NSNP by avoiding recurrence or persistence of pain.

When assessing PA behavior, clinicians should take care to distinguish between occupational and leisure time PA, as they may have opposing effects on NSNP. Therefore, clinicians should investigate both aspects and make different recommendations depending on the type of PA (eg, decrease occupational PA and/or increase leisure time PA).

CONCLUSION

MODEST AND SOMETIMES INCONSISTENT associations suggest that the risk of NSNP (onset and persistence) may be lower in more active people and higher in people with overweight and obesity. However, the certainty of evidence is very low for all associations, which means that they may exist, but it is very uncertain. In addition, due to the specific population studied, results should not be generalized to populations other than workers. ●

KEY POINTS

FINDINGS: Leisure time physical activity tends to decrease the risk of the onset and the persistence of NSNP. Overweight and obesity tend to increase the risk of the onset and the persistence of NSNP.

IMPLICATIONS: These findings synthesize the most recent evidence about the re-

lationship between NSNP, weight, and leisure time physical activity. Clinicians may need to consider their patients' leisure time physical activity behavior and body mass index within a comprehensive assessment and management planning approach to NSNP.

CAUTION: Due to the very low certainty of evidence and the specific population studied, results should be interpreted cautiously and should not be generalized to populations other than workers.

STUDY DETAILS

AUTHOR CONTRIBUTORS: A.L., F.A., C.D., and L.P. designed the review. A.L. and F.A. developed and completed the search, determined eligible papers for inclusion, completed the quality appraisal of included papers, and completed the data extraction. A.L., F.A., and G.B. completed the data analysis and synthesis. All authors contributed to the interpretation and discussion of the results and to the writing of the final manuscript. All authors approved the final version of the manuscript.

DATA SHARING: All data relevant to the study are included in the article or are available as supplementary files.

PATIENT AND PUBLIC INVOLVEMENT: There was no patient or public involvement in the completion of this study.

REFERENCES

1. Abate M, Vanni D, Pantalone A, Salini V. Cigarette smoking and musculoskeletal disorders. *Muscles Ligaments Tendons J*. 2013;3:63-69. <https://doi.org/10.32098/mltj.02.2013.03>
2. Al-Bashaireh AM, Haddad LG, Weaver M, Kelly DL, Chengguo X, Yoon S. The effect of tobacco smoking on musculoskeletal health: a systematic review. *J Environ Public Health*. 2018;2018:4184190. <https://doi.org/10.1155/2018/4184190>
3. Althubaiti A. Information bias in health research: definition, pitfalls, and adjustment methods. *J Multidiscip Healthc*. 2016;9:211-217. <https://doi.org/10.2147/JMDH.S104807>
4. Belavy DL, Van Oosterwijck J, Clarkson M, et al. Pain sensitivity is reduced by exercise training: evidence from a systematic review and meta-analysis. *Neurosci Biobehav Rev*. 2021;120:100-108. <https://doi.org/10.1016/j.neubiorev.2020.11.012>
5. Bier JD, Scholten-Peeters WGM, Staal JB, et al. Clinical practice guideline for physical therapy assessment and treatment in patients with non-specific neck pain. *Phys Ther*. 2018;98:162-171. <https://doi.org/10.1093/ptj/pzx118>
6. Blanpied PR, Gross AR, Elliott JM, et al. Neck Pain: Revision 2017. *J Orthop Sports Phys Ther*. 2017;47:A1-A83. <https://doi.org/10.2519/jospt.2017.0302>
7. Blond K, Brinkløv CF, Ried-Larsen M, et al. Association of high amounts of physical activity with mortality risk: a systematic review and meta-analysis. *Br J Sports Med*. 2020;54:1195-1201. <https://doi.org/10.1136/bjsports-2018-100393>
8. Bohman T, Holm LW, Hallqvist J, Pico-Espinosa OJ, Skillgate E. Healthy lifestyle behaviour and risk of long-duration troublesome neck pain among men and women with occasional neck pain: results from the Stockholm public health cohort. *BMJ Open*. 2019;9:e031078. <https://doi.org/10.1136/bmjopen-2019-031078>
9. Bovenzi M. A prospective cohort study of neck and shoulder pain in professional drivers. *Ergonomics*. 2015;58:1103-1116. <https://doi.org/10.1080/00140139.2014.935487>
10. Bull FC, Al-Ansari SS, Biddle S, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br J Sports Med*. 2020;54:1451-1462. <https://doi.org/10.1136/bjsports-2020-102955>
11. Buscemi V, Chang WJ, Liston MB, McAuley JH, Schabrun SM. The role of perceived stress and life stressors in the development of chronic musculoskeletal pain disorders: a systematic review. *J Pain*. 2019;20:1127-1139. <https://doi.org/10.1016/j.jpain.2019.02.008>
12. Campbell M, Katikireddi SV, Sowden A, Thomson H. Lack of transparency in reporting narrative synthesis of quantitative data: a methodological assessment of systematic reviews. *J Clin Epidemiol*. 2019;105:1-9. <https://doi.org/10.1016/j.jclinepi.2018.08.019>
13. Campbell M, McKenzie JE, Sowden A, et al. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. *BMJ*. 2020;368:l6890. <https://doi.org/10.1136/bmj.l6890>
14. Carroll LJ, Hogg-Johnson S, Côté P, et al. Course and prognostic factors for neck pain in workers: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *J Manipulative Physiol Ther*. 2009;32(2 Suppl):S108-S116.
15. Carroll LJ, Hogg-Johnson S, van der Velde G, et al. Course and prognostic factors for neck pain in the general population: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine (Phila Pa 1976)*. 2008;33:S75-S82. <https://doi.org/10.1097/BRS.0b013e31816445be>
16. Chin SH, Huang WL, Akter S, Binks M. Obesity and pain: a systematic review. *Int J Obes (Lond)*. 2020;44:969-979. <https://doi.org/10.1038/s41366-019-0505-y>

17. Coenen P, Huysmans MA, Holtermann A, et al. Do highly physically active workers die early? a systematic review with meta-analysis of data from 193 696 participants. *Br J Sports Med.* 2018;52:1320-1326. <https://doi.org/10.1136/bjsports-2017-098540>
18. Coenen P, Huysmans MA, Holtermann A, et al. Towards a better understanding of the 'physical activity paradox': the need for a research agenda. *Br J Sports Med.* 2020;54:1055-1057. <https://doi.org/10.1136/bjsports-2019-101343>
19. Côté P, van der Velde G, Cassidy JD, et al. The burden and determinants of neck pain in workers: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine (Phila Pa 1976).* 2008;33(4 Suppl):S60-S74. <https://doi.org/10.1097/BRS.0b013e3181643f24>
20. Côté P, Wong JJ, Sutton D, et al. Management of neck pain and associated disorders: a clinical practice guideline from the Ontario Protocol for Traffic Injury Management (OPTIMA) Collaboration. *Eur Spine J.* 2016;25:2000-2022. <https://doi.org/10.1007/s00586-016-4467-7>
21. Deeks JJ, Higgins JPT, Altman DG. Analysing data and undertaking meta-analyses. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, eds. *Cochrane Handbook for Systematic Reviews of Interventions.* version 6.2 (updated February 2021). London, UK: Cochrane; 2021.
22. Djade CD, Porgo TV, Zomahoun HTV, Perrault-Sullivan G, Dionne CE. Incidence of shoulder pain in 40 years old and over and associated factors: a systematic review. *Eur J Pain.* 2020;24:39-50. <https://doi.org/10.1002/ejp.1482>
23. Durrer Schutz D, Busetto L, Dicker D, et al. European practical and patient-centred guidelines for adult obesity management in primary care. *Obes Facts.* 2019;12:40-66. <https://doi.org/10.1159/000496183>
24. Elma Ö, Yilmaz ST, Deliens T, et al. Do nutritional factors interact with chronic musculoskeletal pain? A systematic review. *J Clin Med.* 2020;9:702. <https://doi.org/10.3390/jcm9030702>
25. Furlan AD, Malmivaara A, Chou R, et al. 2015 updated method guideline for systematic reviews in the Cochrane back and neck group. *Spine (Phila Pa 1976a).* 2015;40:1660-1673. <https://doi.org/10.1097/BRS.0000000000001061>
26. Gelman A, Stern H. The difference between "significant" and "not significant" is not itself statistically significant. *Am Stat.* 2006;60:328-331. <https://doi.org/10.1198/000313006X152649>
27. Geneen LJ, Moore RA, Clarke C, Martin D, Colvin LA, Smith BH. Physical activity and exercise for chronic pain in adults: an overview of Cochrane Reviews. *Cochrane Database Syst Rev.* 2017;1:CD011279. <https://doi.org/10.1002/14651858.CD011279.pub2>
28. Green BN, Johnson CD, Haldeman S, et al. A scoping review of biopsychosocial risk factors and co-morbidities for common spinal disorders. *PLOS One.* 2018;13:e0197987. <https://doi.org/10.1371/journal.pone.0197987>
29. Gross A, Forget M, St George K, et al. Patient education for neck pain. *Cochrane Database Syst Rev.* 2012;CD005106. <https://doi.org/10.1002/14651858.CD005106.pub4>
30. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. *BMC Public Health.* 2009;9:88. <https://doi.org/10.1186/1471-2458-9-88>
31. Herman PM, Broten N, Lavelle TA, Sorbero ME, Coulter ID. Health care costs and opioid use associated with high-impact chronic spinal pain in the United States. *Spine (Phila Pa 1976).* 2019;44:1154-1161. <https://doi.org/10.1097/BRS.0000000000003033>
32. Higgins JPT, Li T, Deeks JJ. Chapter 6: Choosing effect measures and computing estimates of effect. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, eds. *Cochrane Handbook for Systematic Reviews of Interventions.* version 6.2 (updated February 2021). London, UK: Cochrane; 2021.
33. Higgins JPT, Thomas J, Chandler J, et al. *Cochrane Handbook for Systematic Reviews of Interventions.* version 6.2 (updated February 2021). London, UK: Cochrane; 2021. Available from www.training.cochrane.org/handbook.
34. Holtermann A, Hansen JV, Burr H, Sjøgaard K, Sjøgaard G. The health paradox of occupational and leisure-time physical activity. *Br J Sports Med.* 2012;46:291-295. <https://doi.org/10.1136/bjism.2010.079582>
35. Holtermann A, Krause N, van der Beek AJ, Straker L. The physical activity paradox: six reasons why occupational physical activity (OPA) does not confer the cardiovascular health benefits that leisure time physical activity does. *Br J Sports Med.* 2018;52:149-150. <https://doi.org/10.1136/bjsports-2017-097965>
36. Holtermann A, Stamatakis E. Do all daily metabolic equivalent task units (METs) bring the same health benefits?. *Br J Sports Med.* 2019;53:991-992. <https://doi.org/10.1136/bjsports-2017-098693>
37. Hoy D, March L, Woolf A, et al. The global burden of neck pain: estimates from the global burden of disease 2010 study. *Ann Rheum Dis.* 2014;73:1309-1315. <https://doi.org/10.1136/annrheumdis-2013-204431>
38. Hush JM, Lin CC, Michaleff ZA, Verhagen A, Refshauge KM. Prognosis of acute idiopathic neck pain is poor: a systematic review and meta-analysis. *Arch Phys Med Rehabil.* 2011;92:824-829. <https://doi.org/10.1016/j.apmr.2010.12.025>
39. Jahre H, Grotle M, Smedbråten K, Dunn KM, Øiestad BE. Risk factors for non-specific neck pain in young adults. A systematic review. *BMC Musculoskelet Disord.* 2020;21:366. <https://doi.org/10.1186/s12891-020-03379-y>
40. Jun D, Johnston V, McPhail SM, O'Leary S. A longitudinal evaluation of risk factors and interactions for the development of nonspecific neck pain in office workers in two cultures. *Hum Factors.* 2020;63:663-683. <https://doi.org/10.1177/0018720820904231>
41. Jun D, Zoe M, Johnston V, O'Leary S. Physical risk factors for developing non-specific neck pain in office workers: a systematic review and meta-analysis. *Int Arch Occup Environ Health.* 2017;90:373-410. <https://doi.org/10.1007/s00420-017-1205-3>
42. Kääriä S, Laaksonen M, Rahkonen O, Lahelma E, Leino-Arjas P. Risk factors of chronic neck pain: a prospective study among middle-aged employees. *Eur J Pain.* 2012;16:911-920. <https://doi.org/10.1002/j.1532-2149.2011.00065.x>
43. Kanagalakshmi V, Muliylil DE, Alex R, Kirupakaran H, David JA, John J. Prevalence and risk factors for neck pain among support staff of tertiary care centre. *Indian J Comm Health.* 2018;30:377-380. <https://doi.org/10.47203/IJCH.2018.v30i04.012>
44. Keown GA, Tuchin PA. Workplace factors associated with neck pain experienced by computer users: a systematic review. *J Manipulative Physiol Ther.* 2018;41:508-529. <https://doi.org/10.1016/j.jmpt.2018.01.005>
45. Kim R, Wiest C, Clark K, Cook C, Horn M. Identifying risk factors for first-episode neck pain: a systematic review. *Musculoskelet Sci Pract.* 2018;33:77-83. <https://doi.org/10.1016/j.msksp.2017.11.007>
46. Kjaer P, Kongsted A, Hartvigsen J, et al. National clinical guidelines for non-surgical treatment of patients with recent onset neck pain or cervical radiculopathy. *Eur Spine J.* 2017;26:2242-2257. <https://doi.org/10.1007/s00586-017-5121-8>
47. Kraatz S, Lang J, Kraus T, Münster E, Ochsmann E. The incremental effect of psychosocial workplace factors on the development of neck and shoulder disorders: a systematic review of longitudinal studies. *Int Arch Occup Environ Health.* 2013;86:375-395. <https://doi.org/10.1007/s00420-013-0848-y>
48. Lewis J, O'Sullivan P. Is it time to reframe how we care for people with non-traumatic musculoskeletal pain? *Br J Sports Med.* 2018;52:1543-1544. <https://doi.org/10.1136/bjsports-2018-099198>
49. Li T, Higgins JPT, Deeks JJ. Chapter 5: Collecting data. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, eds. *Cochrane Handbook for Systematic Reviews of Interventions.* version 6.2 (updated February 2021). London, UK: Cochrane; 2021.
50. Lin I, Wiles L, Waller R, et al. What does best practice care for musculoskeletal pain look like? Eleven consistent recommendations from high-quality clinical practice guidelines: systematic review. *Br J Sports Med.* 2020;54:79-86. <https://doi.org/10.1136/bjsports-2018-099878>
51. McKenzie JE, Brennan SE. Chapter 12: Synthesizing and presenting findings using other methods. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, eds. *Cochrane Handbook for Systematic Reviews of Interventions.* version 6.2 (updated February 2021). London, UK: Cochrane; 2021.
52. McVinnie DS. Obesity and pain. *Br J Pain.* 2013;7:163-170. <https://doi.org/10.1177/2049463713484296>

53. Nijs J, D'Hondt E, Clarys P, et al. Lifestyle and chronic pain across the lifespan: an inconvenient truth? *PMR*. 2020;12:410-419. <https://doi.org/10.1002/pmrj.12244>
54. Okifuji A, Hare BD. The association between chronic pain and obesity. *J Pain Res*. 2015;8:399-408. <https://doi.org/10.2147/JPR.S55598>
55. Øverås CK, Villumsen M, Axén I, et al. Association between objectively measured physical behaviour and neck- and/or low back pain: a systematic review. *Eur J Pain*. 2020;24:1007-1022. <https://doi.org/10.1002/ejp.1551>
56. Page MJ, Higgins JPT, Sterne JAC. Assessing risk of bias due to missing results in a synthesis. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, eds. *Cochrane Handbook for Systematic Reviews of Interventions*. version 6.2 (updated February 2021). London, UK: Cochrane; 2021.
57. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. <https://doi.org/10.1136/bmj.n71>
58. Paksaichol A, Janwantanakul P, Purepong N, Pensri P, van der Beek AJ. Office workers' risk factors for the development of non-specific neck pain: a systematic review of prospective cohort studies. *Occup Environ Med*. 2012;69:610-618. <https://doi.org/10.1136/oemed-2011-100459>
59. Palmlof L, Holm LW, Alfredsson L, et al. The impact of work related physical activity and leisure physical activity on the risk and prognosis of neck pain – a population based cohort study on workers. *BMC Musculoskelet Disord*. 2016;17:219. <https://doi.org/10.1186/s12891-016-1080-1>
60. Parikh P, Santaguida P, Macdermid J, Gross A, Eshtiaghi A. Comparison of CPGs for the diagnosis, prognosis and management of non-specific neck pain: a systematic review. *BMC Musculoskelet Disord*. 2019;20:81. <https://doi.org/10.1186/s12891-019-2441-3>
61. Physical Activity Guidelines Advisory Committee. 2018 Physical Activity Guidelines Advisory Committee Scientific Report. U.S. Department of Health and Human Services. Washington, DC; 2018.
62. Rasmussen-Barr E, Bohman T, Hallqvist J, Holm LW, Skillgate E. Do physical activity level and body mass index predict recovery from persistent neck pain in men and women of working age? A population-based cohort study. *Eur Spine J*. 2013;22:2077-2083. <https://doi.org/10.1007/s00586-013-2801-x>
63. Rice D, Nijs J, Kosek E, et al. Exercise-induced hypoalgesia in pain-free and chronic pain populations: state of the art and future directions. *J Pain*. 2019;20:1249-1266. <https://doi.org/10.1016/j.jpain.2019.03.005>
64. Ross R, Neeland IJ, Yamashita S, et al. Waist circumference as a vital sign in clinical practice: a consensus statement from the IAS and ICCR working group on visceral obesity. *Nat Rev Endocrinol*. 2020;16:177-189. <https://doi.org/10.1038/s41574-019-0310-7>
65. Safiri S, Kolahi AA, Hoy D, et al. Global, regional, and national burden of neck pain in the general population, 1990-2017: systematic analysis of the Global Burden of Disease Study 2017. *BMJ*. 2020;368:m791. <https://doi.org/10.1136/bmj.m791>
66. Schellingerhout JM, Heymans MW, Verhagen AP, Lewis M, de Vet HC, Koes BW. Prognosis of patients with nonspecific neck pain: development and external validation of a prediction rule for persistence of complaints. *Spine (Phila Pa 1976)*. 2010;35:E827-E835. <https://doi.org/10.1097/BRS.0b013e3181d85ad5>
67. Schünemann H, Brożek J, Guyatt G, Oxman A. GRADE handbook for grading quality of evidence and strength of recommendations. The GRADE Working Group; 2013. Available from www.guidelinedevelopment.org/handbook.
68. Schünemann HJ, Higgins JPT, Vist GE, et al. Completing 'Summary of findings' tables and grading the certainty of the evidence. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, eds. *Cochrane Handbook for Systematic Reviews of Interventions*. version 6.2 (updated February 2021). London, UK: Cochrane; 2021.
69. Schünemann HJ, Vist GE, Higgins JPT, et al. Interpreting results and drawing conclusions. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, eds. *Cochrane Handbook for Systematic Reviews of Interventions*. version 6.2 (updated February 2021). London, UK: Cochrane; 2021.
70. Shahidi B, Curran-Everett D, Maluf KS. Psychosocial, physical, and neurophysiological risk factors for chronic neck pain: a prospective inception cohort study. *J Pain*. 2015;16:1288-1299. <https://doi.org/10.1016/j.jpain.2015.09.002>
71. Sihawong R, Sitthipornvorakul E, Paksaichol A, Janwantanakul P. Predictors for chronic neck and low back pain in office workers: a 1-year prospective cohort study. *J Occup Health*. 2016;58:16-24. <https://doi.org/10.1539/joh.15-0168-OA>
72. Sitthipornvorakul E, Janwantanakul P, Lohsoonthorn V. The effect of daily walking steps on preventing neck and low back pain in sedentary workers: a 1-year prospective cohort study. *Eur Spine J*. 2015;24:417-424. <https://doi.org/10.1007/s00586-014-3577-3>
73. Sitthipornvorakul E, Janwantanakul P, Purepong N, Pensri P, van der Beek AJ. The association between physical activity and neck and low back pain: a systematic review. *Eur Spine J*. 2011;20:677-689. <https://doi.org/10.1007/s00586-010-1630-4>
74. Skillgate E, Pico-Espinosa OJ, Hallqvist J, Bohman T, Holm LW. Healthy lifestyle behavior and risk of long duration troublesome neck pain or low back pain among men and women: results from the Stockholm Public Health Cohort. *Clin Epidemiol*. 2017;9:491-500. <https://doi.org/10.2147/CLEP.S145264>
75. Sluka KA, Frey-Law L, Hoeger Bement M. Exercise-induced pain and analgesia? Underlying mechanisms and clinical translation. *Pain*. 2018;159(Suppl 1):S91-S97. <https://doi.org/10.1097/j.pain.0000000000001235>
76. Song JW, Chung KC. Observational studies: cohort and case-control studies. *Plast Reconstr Surg*. 2010;126:2234-2242. <https://doi.org/10.1097/PRS.0b013e3181f44abc>
77. Sterne JAC, Hernán MA, McAleenan A, Reeves BC, Higgins JPT. Assessing risk of bias in a non-randomized study. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, et al. *Cochrane Handbook for Systematic Reviews of Interventions*. version 6.2 (updated February 2021). London, UK: Cochrane; 2021.
78. van der Molen HF, Foresti C, Daams JG, Frings-Dresen MHW, Kuijter PPFM. Work-related risk factors for specific shoulder disorders: a systematic review and meta-analysis. *Occup Environ Med*. 2017;74:745-755. <https://doi.org/10.1136/oemed-2017-104339>
79. van Hecke O, Torrance N, Smith BH. Chronic pain epidemiology - where do lifestyle factors fit in? *Br J Pain*. 2013;7:209-217. <https://doi.org/10.1177/2049463713493264>
80. Van Looveren E, Bilterys T, Munneke W, et al. The association between sleep and chronic spinal pain: a systematic review from the last decade. *J Clin Med*. 2021;10:3836. <https://doi.org/10.3390/jcm10173836>
81. van Rijn RM, Huisstede BM, Koes BW, Burdorf A. Associations between work-related factors and specific disorders of the shoulder – a systematic review of the literature. *Scand J Work Environ Health*. 2010;36:189-201. <https://doi.org/10.5271/sjweh.2895>
82. Verwoerd M, Wittink H, Maissan F, de Raaij E, Smeets RJEM. Prognostic factors for persistent pain after a first episode of nonspecific idiopathic, non-traumatic neck pain: a systematic review. *Musculoskelet Sci Pract*. 2019;42:13-37. <https://doi.org/10.1016/j.msksp.2019.03.009>
83. Vos CJ, Verhagen AP, Passchier J, Koes BW. Clinical course and prognostic factors in acute neck pain: an inception cohort study in general practice. *Pain Med*. 2008;9:572-580. <https://doi.org/10.1111/j.1526-4637.2008.00456.x>
84. Walsh TP, Arnold JB, Evans AM, Yaxley A, Damarell RA, Shanahan EM. The association between body fat and musculoskeletal pain: a systematic review and meta-analysis. *BMC Musculoskelet Disord*. 2018;19:233. <https://doi.org/10.1186/s12891-018-2137-0>
85. Wells G, Shea B, O'Connell DL, et al. The Newcastle-Ottawa Scale (NOS) for Assessing the Quality of Nonrandomised Studies in Meta-Analyses. 2014
86. World Health Organization. Obesity: preventing and managing the global epidemic. Technical Report Series. No. 894. World Health Organization: Geneva; 2000.
87. Zhang TT, Liu Z, Liu YL, Zhao JJ, Liu DW, Tian QB. Obesity as a risk factor for low back pain: a meta-analysis. *Clin Spine Surg*. 2018;31:22-27. <https://doi.org/10.1097/BSD.0000000000000468>



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