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Review article

Physical and psychosocial work-related exposures and the occurrence of disorders of the elbow: A systematic review

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A R T I C L E I N F O

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A B S T R A C T

This systematic review updates a previous systematic review on work-related physical and psychosocial risk factors for elbow disorders. Medline, Embase, Web of Science, Cochrane Central and PsycINFO were searched for studies on associations between work-related physical or psychosocial risk factors and the occurrence of elbow disorders. Two independent reviewers selected eligible studies and assessed risk of bias (RoB). Results of studies were synthesized narratively. We identified 17 new studies and lateral epicondylitis was the most studied disorder (13 studies). Five studies had a prospective cohort design, eight were cross-sectional and four were case-control. Only one study had no items rated as high RoB. Combined physical exposure indicators (e.g. physical exertion combined with elbow movement) were associated with the occurrence of lateral epicondylitis. No other consistent associations were observed for other physical and psychosocial exposures. These results prevent strong conclusions regarding associations between work-related exposures, and the occurrence of elbow disorders.

1. Introduction

Elbow disorders such as lateral and medial epicondylitis are frequently reported in the working population, with a reported prevalence between 0.3 and 4.0% depending on the disorder and sex (An et al., 2017; Shiri and Viikari-Juntura, 2011; Shiri et al., 2006). Several prior reviews of the relationship between work-related factors and elbow disorders report that highly repetitive work and repeated or sustained elbow postures with >60° flexion or abduction is associated with the occurrence of diverse elbow disorders (Curti et al., 2021; Palmer et al., 2007; Shiri and Viikari-Juntura, 2011; van Rijn et al., 2009a). Accordingly, in numerous countries, work-related elbow disorders are reported as frequently occurring compensation claims or occupational diseases in various jobs and sectors of industry (Palmer et al., 2007). Besides physical work-related factors, research also suggests that psychosocial factors may contribute to the development and occurrence of elbow disorders (Shiri and Viikari-Juntura, 2011; van Rijn et al., 2009a).

We aimed to update a 2009 systematic review (van Rijn et al., 2009a) that contained 13 studies evaluating work-related risk factors for elbow disorders. The previous review indicated that several physical and psychosocial factors at work were associated with specific elbow disorders, but that longitudinal studies were required to corroborate these findings from cross-sectional studies. If the inclusion of new studies showed that these disorders were caused by work-related factors, this information would be relevant for the development of more targeted prevention and treatment strategies. In this way, these disorders can be better tackled in the work environment, and it will contribute to occupational health among the working population.

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2. Materials and methods

This review is part of a research project on work-related physical and psychosocial risk factors associated with the development of a set of predetermined musculoskeletal disorders of the upper and lower limbs. The protocol for this project was registered in PROSPERO (CRD42020170264) (Koes et al., 2020). Reporting of this systematic review adhered to the most recently published reporting recommendations of the Synthesis Without Meta-analysis (SWiM) guideline (Campbell et al., 2020). This systematic review is an update of a previous systematic review (van Rijn et al., 2009a), the results of which are briefly presented in this manuscript.

2.1. Study selection

Medline, Embase, Web of Science Core Collection, Cochrane Central and PsycINFO were searched from inception to January 2020 by combining keywords and controlled vocabulary representing (1) musculoskeletal disorders of the shoulder, elbow, hand/wrist, knee and foot, and (2) work-related physical and psychosocial risk factors. The search strategy for all databases is presented in the Appendix.

Duplicate records were removed. Articles were randomly assigned across the reviewers for screening (among HG, RvR, RE, KS, EM, JJ). Title and abstract screening against eligibility criteria was performed by two independent reviewers. Full-text screening of potentially eligible articles was then performed by two independent reviewers (among HG, RvR, RE, KS, EM, JJ). In case of disagreements (in both steps), a third reviewer (AC) made the final decision about inclusion. Screening was done with the Covidence software. Reasons for exclusion of downloaded full-texts are reported in Fig. 1.

2.2. Eligibility criteria

We included studies which reported sufficient data to calculate associations between work-related physical or psychosocial risk factors and the occurrence of musculoskeletal disorders of the elbow. Physical work-related exposures consisted of: 1) force (e.g., heavy physical work, lifting, pushing or pulling), 2) awkward postures (e.g., working with hands above shoulder level), 3) vibration, 4) repetition, and 5) combined exposure measures (i.e. combination of the aforementioned exposures). We included exposures assessed on different dimensions including duration, intensity level, or frequency, and which were either self-reported, observer-rated, or quantitatively measured. Psychosocial work-related exposures consisted of: social support, job demands, job control, decision latitude, job satisfaction, job security, time pressure, periodic interruptions, and job-related psychosocial distress. We included psychosocial exposures measured with validated and non-validated questionnaires, and self-constructed survey questions. We excluded studies which reported exposures only defined on the basis of job titles (Shiri and Viikari-Juntura, 2011). To be eligible for inclusion, a study needed to report data on the occurrence of at least one of the pre-specified elbow disorders in relation to a physical or psychosocial exposure factor that was measured with at least two levels of exposure (i.e. presence or absence of work-related physical or psychosocial factors). The set of specific elbow disorders were: lateral epicondylitis (also called extensor tendinopathy or tennis elbow), medial epicondylitis (also called flexor tendinopathy or golfer's elbow), cubital nerve syndrome (also called cubital tunnel syndrome), and radial nerve syndrome. We included studies that took place in an actual workplace or clinical settings. No laboratory experiments were included. Because we were interested in the identification of risk factors for the occurrence of elbow disorders, we focused our analyses and conclusions primarily on longitudinal cohort studies. However, as we expected to identify only a small number of cohort studies, we also included case-control and cross-sectional studies.

We included each dataset only once: in cases where multiple publications used the same dataset, we included the most recent or the most informative publication and consulted additional publications only in case of missing data. In the case of cross-sectional and longitudinal analyses published based on the same data set, we only included results

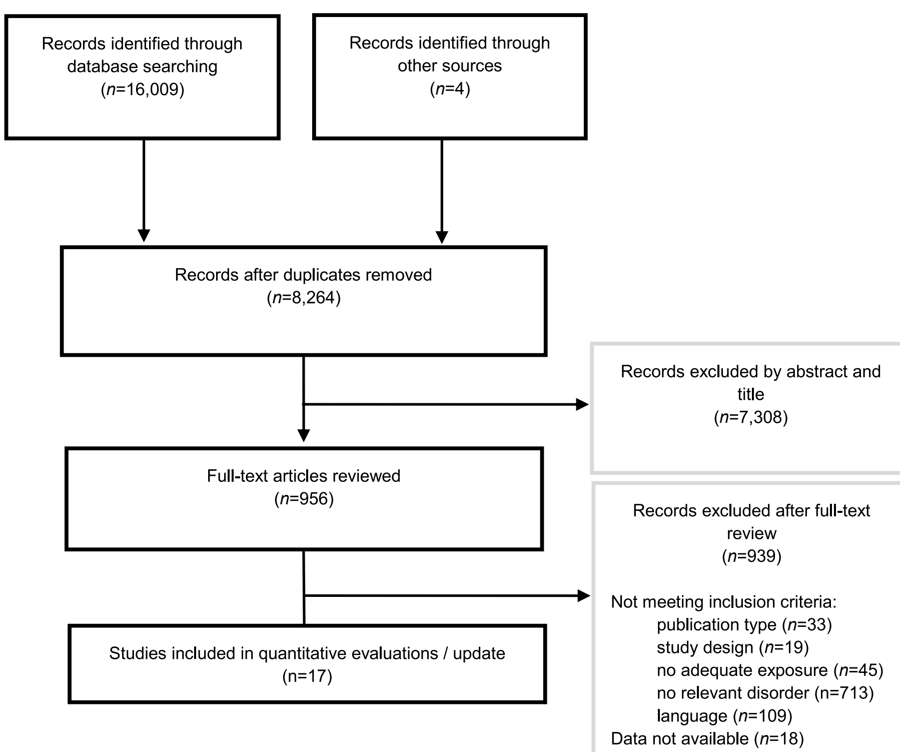

Fig. 1. Flow chart of study inclusion.

from the longitudinal analyses.

2.3. Outcomes

The occurrence of the specific disorders of the elbow, lateral epicondylitis, medial epicondylitis, cubital nerve syndrome, and radial nerve syndrome, were the primary outcomes, as reported by the study participants or based on clinical diagnosis.

2.4. Data extraction

We extracted participant characteristics (e.g. mean age of the study sample, sex, type of occupation), the outcome (definition of the musculoskeletal disorder), the type of exposure variables, and study details (e.g. study design, year of publication, adjustment for confounders). We extracted the number of cases and controls, and the number of study participants with and without the respective musculoskeletal disorder depending on the exposure to work-related physical or psychosocial exposure variables. In studies with more than two levels of exposure, we used the lowest level of exposure as reference.

Odds ratios (ORs) and other effect size measures (e.g. hazard ratios, risk ratios) were extracted from the included studies in addition to raw data. We extracted adjusted ORs from multiple or multivariable analyses if no backward selection of significant predictors was applied in the source studies. If only significant predictors were kept in the final multivariable model, we chose to extract data from univariable analyses.

Data extraction was done using an Excel spreadsheet, which included descriptive details for coding study information. Data were extracted by one researcher (HG) and verified by a second senior researcher (BK).

2.5. Risk of bias assessment

Risk of bias (RoB) was assessed according to criteria previously used in systematic reviews on the same topic in order to allow for comparability between previous work (van der Molen et al., 2017; van Rijn et al., 2009a; b, 2010). The content of the RoB tool corresponds to recently published tools for assessing RoB of observational studies (Bero et al., 2018). The criteria included 16 items covering five main domains: 1) study sample, 2) assessment of exposure, 3) assessment of outcome, 4) study design and analysis, 5) data analysis and presentation. Each item was rated as 'low', 'high' or 'unclear', and criteria on how to score each item were a-priori defined.

In line with most recent guidelines for systematic reviews (Higgins et al., 2019), no cut-off was used to differentiate studies of high or low RoB. Studies were randomly assigned to, and assessed for their RoB by two reviewers (HG, RvR, RE, KS, EM, JJ), and disagreements were resolved by a third reviewer (AC). RoB assessment was done with the Covidence software.

2.6. Strategy for data synthesis

We summarized results in tables including study descriptive information, and ORs for the association between work-related physical and psychosocial risk factors and the occurrence of the selected elbow disorders. Due to the small number of included studies for each combination of disorder and exposure, we did not perform meta-analyses.

3. Results

3.1. Study characteristics

Our entire literature search for upper and lower limb disorders yielded 8264 records after removal of duplicates (Fig. 1). After title and abstract screening, 956 full text articles were screened. A total of 17 studies were identified which fulfilled the inclusion criteria of this review (Aben et al., 2018; Andersen et al., 2012; Arcury et al., 2014; Bugajska et al., 2013; Descatha et al., 2013; Fan et al., 2014; Franzblau et al., 2005; Garg et al., 2014; Grzywacz et al., 2012; Herquelot et al., 2013; Holm et al., 2016; Nordander et al., 2013; Pullopdissakul et al., 2013; Svendsen et al., 2012; Thiese et al., 2016; Turhan et al., 2008; Walker-Bone et al., 2012). The 13 studies included in the previous 2009 review (van Rijn et al., 2009a) were also found in the search strategy. Since the previous review searched for evidence up to September 2007, only one study (Franzblau et al., 2005) published prior to that date was retrieved and included in this review. Thirteen of the included studies in this review reported the occurrence of lateral epicondylitis as the outcome, seven studies reported medial epicondylitis, two studies reported unspecified epicondylitis, and two studies cubital nerve syndrome (or ulnar neuropathy) (Table 1). Six studies had a cross-sectional design, four studies used a case control design, two studies were summaries of previously published cross-sectional studies, and five studies had a prospective cohort design. Four studies investigated incidence of elbow disorders while the remaining 13 studies reported prevalence. Fifteen included studies reported psychosocial exposures in addition to physical exposures. Table 1 summarizes relevant characteristics of the included studies; more detailed descriptions of the studies, including characteristics of physical and psychosocial exposure assessments, can be found in the Appendix.

3.2. Findings from previous review

The results and RoB assessment of the previous review are presented in the Appendix. Here a brief summary is presented. Of 13 studies: nine were cross-sectional, two case-control and two prospective cohort studies. The two cohort studies presented a lower RoB (Appendix) but they provided little information on association of physical and psychosocial exposures with lateral epicondylitis or cubital nerve syndrome. Significant associations were based on cross-sectional studies (Appendix). Force and repetitiveness exposures (handling tools > 1 kg, handling loads >20 kg at least 10 times/day, repetitive movements > 2 h/day) were found to be associated with the occurrence of lateral epicondylitis. Low job control (OR 2.2) and low social support (OR 1.8, psychosocial exposures) were also found to be associated with lateral epicondylitis. Exposures of force (handling loads >5 kg, handling loads >20 kg at least 10 times/day, high hand grip forces >1 h/day), repetitiveness (repetitive movements for >2 h/day) and vibration (working with vibrating tools > 2 h/day) were associated with medial epicondylitis. The occurrence of cubital nerve syndrome was associated with 'holding a tool in position' (OR 3.53), while force (handling loads >1 kg), and posture exposures (static work of the hand during the majority of the cycle time and full extension) were associated with radial nerve syndrome. Many associations, however, were not significant, and the pattern of findings was inconsistent among studies.

3.3. Risk of bias

The RoB of the included studies varied (Table 2): one study had none of the 16 items rated as high RoB, and in the remaining studies most items were rated as unclear or high RoB. For the majority of studies (all but one study), outcomes were adequately defined and assessed, and data presentation was considered adequate in all studies; in the majority of the studies cross-sectional design (11 of 17 studies) and high RoB exposure assessment (including either self-reports only, or a lack of blinding in the exposure assessment) were the most relevant methodological issues leading to high RoB ratings.

3.4. Association between work-related physical exposure and the occurrence of elbow disorders

Of the 17 studies included in the review, several significant associations between force, repetition, posture, and combined exposure measures were reported (Table 3). Many associations, however, were

Table 1
Descriptive characteristics of included studies (n = 17).

First Author Publication year Study design Location	Study duration (months to follow-up)	Study population	Female/male mean age	Disorder	Type of data Outcome assessment/ diagnosis	Cases/ controls	Adjusted analyses
Grzywacz 2012 CS USA	0	poultry and nonpoultry manual workers (518)	319/423 NR	LE	prevalence self-report & physical examination	136/NR	All models were adjusted for the effects of age, sex, and indigenous language
Arcury 2014 CS USA	0	female manual workers (234)	234/0 34.4	epicondylitis (unspecified side)	prevalence self-report & physical examination	13/NR	-
Bugajska 2013 cohort (prospective) Poland	12	employees (725 at first measurement, and 542 at 2nd measurement) (office workers, toolmakers, welders, seamstresses, TV assembly workers, workers assembling electric elements, packers in the cosmetic industry, drivers, driving instructors, nurses)	77%/23% 43	ME	prevalence self-report & physical examination	t1: 12.2%/ NR t2: 7.6%/ NR	Individual variables (age and gender), organizational and physical factors (working hours, repetitive work, force), were controlled in all analyses.
				LE	prevalence self-report & physical examination	t1: 7.2%/ NR t2: 5.3%/ NR	*See above.*
Turhan 2008 CS Turkey	0	data entry operators (173)	159/14 30.5	LE (tennis elbow)	prevalence self-report & physical examination	19.6%/ NR	-
Holm 2016 CC Denmark	0	laboratory workers (291 clinical cases out of total 362 participants with symptoms)	291/0 40	LE	prevalence self-report & physical examination	9/NR	matching factors (age, worksite)
Aben 2018 CC Belgium	0	69 cases and 100 controls matched by age range and professions	91/78 46	LE (tennis elbow)	prevalence self-report & physical examination	69/100	results are reported separately for men and women as well
Andersen 2012 CC Denmark	0	546 patients with ulnar neuropathy and four referents per case matched on sex, age, and primary care centre	NR/NR NR	CNS (ulnar neuropathy)	prevalence technical procedure & physical examination	546/NR	force, repetition, non-neutral postures and exposure for hand arm vibrations, and individual factors
Herquelot 2013 cohort (prospective) France	60	workers (3231 workers without elbow pain at baseline; 1046 of these with complete follow up in 2007–2010 out of a total of 3710 initially assessed in 2002–2005; multiple imputation was used)	NR/NR NR	LE	incidence self-report & physical examination	171/NR	(iii) Model 3: adjusted for age, combined physical work exposure, and repetitiveness.
Descatha 2013 cohort (prospective) USA	36	workers (699 at follow up of originally 1107)	250/449 NR	LE	incidence self-report & physical examination	34/NR	adjusting for age, lack of social support and obesity
				ME	incidence self-report & physical examination	30/NR	*See above.*
Franzblau 2005 CS USA	0	workers (908) with mono-task jobs	%women/men across exposure categories: 56%–75%/25%–44% mean age range across exposure categories: 35 to 40.9	elbow/forearm tendonitis	prevalence self-report & physical examination	NR/NR	Given these features of the TLV, it was decided that for the present analyses it would be most realistic to assess outcomes with respect to the guidelines without any adjustments for individual or other workplace factors since such factors do not enter into the TLV in an explicit, quantifiable manner.
Nordander 2013 CS (Summary) Sweden	0	workers (2652)	1891/761 NR	LE	prevalence self-report & physical examination	NR/NR	Final models of exposure response relationships between the prevalence of disorders on the right side (complaints through questionnaire, and diagnoses by

(*continued on next page*)

Table 1 (*continued*)

First Author Publication year Study design Location	Study duration (months to follow-up)	Study population	Female/male mean age	Disorder	Type of data Outcome assessment/ diagnosis	Cases/ controls	Adjusted analyses
							physical examination) and group means of physical exposures, age and employment time, as well a proportion of subjects reporting high psychosocial exposure. Meta-regression was based on group data.
				ME	prevalence self-report & physical examination	NR/NR	*See above.*
Pullopdissakul 2013 CS Thailand	0	workers (591)	571/50 NR	LE	prevalence self-report & physical examination	20/571	Each ergonomic factor separated analysis and adjusted by gender, age, education and Body Mass Index.
				ME	prevalence self-report & physical examination	10/581	*See above.*
Svendsen 2012 CC Denmark	0	cases & referents (1996)	263/577 45.7	CNS (ulnar neuropathy)	prevalence technical proedure & physical examination	324/ 832	*Adjusted for body mass index (continuous), pack-years of smoking (continuous), alcohol consumption (continuous), side-specific fractures (never/ever), full anaesthesia within a 5-year period up to the index year (no/ yes), predisposing disorders (no/ yes), use of crutches within a 5-year period up to the index year (no/yes), hand–arm intensive sports (0, 1, 2) and weight loss ≥10 kg within half a year during a 5-year period up to the index year (no/yes). †Adjusted for the same variables as the partly adjusted ORs and all occupational biomechanical exposure variables seen in the table.
Thiese 2016 CS (Summary) USA	0	employees (1824)	59.65%/NR 41.12	LE	prevalence self-report & physical examination	121/NR	Multivariable modeling includes adjustment for confounding factors of age, gender, body mass index, and job physical exposures
				ME	prevalence self-report & physical examination	34/NR	Multivariable modeling includes adjustment for confounding factors of age, gender, body mass index, and job physical exposures
Walker-Bone 2012 CS UK	0	general population (6038)	3342/NR 45.6	LE	prevalence self-report & physical examination	45/NR	adjustment made for psychological distress, blue collar status, age and gender
				ME	prevalence self-report & physical examination	34/NR	adjustment made for psychological distress, blue collar status, age and gender
Fan 2014 cohort (prospective) USA	2–42	employees (594)	288/306 NR	LE	incidence self-report & physical examination	57/537	-
				ME	incidence self-report & physical examination	26/537	-
Garg 2014 cohort (prospective) USA	48	workers (495)	329/NR 41.9	LE	incidence self-report & physical examination	56/NR	* A single initial multivariable model was built using covariates (i.e., non-physical exposure factors) that were: (i) not collinear, (ii) biologically plausible, and (iii) had a univariate P-value 0.20.

Acronyms: CC = case control, CI = confidence interval; CNS = cubital nerve syndrome; CS = cross-sectional, HR = hazard ratio; LE = lateral epicondylitis; ME = median epicondylitis; NR = not reported; NS = not significant; RR = risk ratio.

a Studies used the datasets from several other studies with a similar design and reanalyzed them with respect to a new research question. None of the individual studies included in the pooled analysis is included in our systematic review independently.

Table 2
Risk of Bias assessment of the included studies.

Study	Herquelot 2013	Aben 2018	Andersen 2012	Thiese 2016	Garg 2014	Descatha 2013	Franzblau 2005	Nordander 2013	Walker-Bone 2012	Fan 2014	Svendsen 2012	Grzywacz 2012	Bugajska 2013	Holm 2016	Turhan 2008	Arcury 2014	Pullopdissakul 2013
Study population																	
1. Definition of study groups	low	low	high	low	low	high	low	high	low	low	low	low	low	low	low	Low	low
2. Participation ≥ 70%	unclear	unclear	unclear	unclear	low	high	low	unclear	high	low	high	low	unclear	low	unclear	Low	low
3. Number case ≥ 50	low	low	unclear	unclear	low	low	unclear	unclear	low	low	low	low	high	low	low	Unclear	low
Assessment of exposure																	
4. Exposure measurement																	
physical	low	NA	high	NA	low	low	low	low	unclear	low	low	low	unclear	low	unclear	Low	high
psychosocial	low	low	NA	unclear	high	unclear	NA	low	high	unclear	NA	low	low	NA	NA	Low	NA
5. Dose-response																	
physical	high	NA	high	NA	low	low	unclear	low	high	low	low	low	unclear	low	high	Low	high
psychosocial	high	low	NA	low	low	high	NA	unclear	unclear	high	NA	low	unclear	NA	NA	Low	NA
6. Blind for outcome status																	
physical	high	NA	unclear	NA	low	high	low	unclear	high	low	unclear	high	high	unclear	unclear	High	high
psychosocial	high	high	NA	high	high	high	NA	high	high	high	NA	high	high	NA	NA	High	NA
Assessment of outcome																	
7. Outcome definition	low	low	low	low	low	low	low	low	low	low	unclear	low	low	low	low	Low	low
8. Assessment method	low	low	low	unclear	low	low	low	low	low	low	low	low	low	low	low	Low	low
9. Blind for exposure status	unclear	low	unclear	unclear	low	unclear	low	high	unclear	low	unclear	high	unclear	low	low	Unclear	unclear
Study design																	
10. Longitudinal	high	high	high	high	low	low	high	high	high	low	low	high	low	low	high	High	high
11. Inclusion / exclusion criteria	low	low	low	high	low	low	unclear	high	low	unclear	low	low	low	low	high	Low	low
12. Follow-up period ≥1 year	high	high	high	high	low	low	high	high	high	low	unclear	high	low	low	high	High	high
13. Completers vs. withdrawals	unclear	unclear	unclear	unclear	unclear	unclear	unclear	high	unclear	unclear	unclear	unclear	low	unclear	unclear	Low	unclear
Data analysis																	
14. Data presentation	low	low	low	low	low	low	low	low	low	low	low	low	low	low	low	Low	low
15. Consideration of confounders	low	unclear	low	low	low	unclear	high	low	low	low	low	low	low	low	high	Low	unclear
16. Control for confounding	unclear	unclear	low	low	low	unclear	high	low	low	unclear	low	low	unclear	low	high	Low	unclear

Note. NA = not assessed

not significant, and the pattern of findings was inconsistent among studies. Higher levels of exposure and combined exposure measures appeared to show more consistent findings than individual exposure dimensions and lower levels of exposure. Three of the five prospective cohort studies (Fan et al., 2014; Garg et al., 2014; Herquelot et al., 2013) (all with different RoB, Table 2) consistently reported that higher levels of physical combined exposures (e.g. strain index through video analysis) were associated with the development of lateral epicondylitis. One cohort study (Descatha et al., 2013) reported that self-reported higher levels of posture (e.g. bending >4 h/day, rotating >4 h/day) were associated with incidence of lateral epicondylitis, whereas another cohort study (Herquelot et al., 2013) showed an association between self-reported repetitive tasks and the same disorder. The same findings were not replicated in the other cohort studies. Regarding the incidence of medial epicondylitis, the three cohort studies (Bugajska et al., 2013; Descatha et al., 2013; Fan et al., 2014) showed inconsistent associations. One cohort study (Descatha et al., 2013) demonstrated an association between posture (bending > 4 h/day and rotating > 4 h/day, with ORs ranging from 2.5 to 8.2) and the incidence of medial epicondylitis, however, the findings regarding posture were inconsistent in the other two studies with a similar longitudinal design (Fan et al., 2014; Garg et al., 2014) (Table 3).

3.5. Association between work-related psychosocial exposure and the occurrence of elbow disorders

Fifteen articles evaluated associations between psychosocial exposures and the occurrence of elbow disorders (Table 4). Overall the results were inconsistent, with none of the psychosocial exposures showing significant associations in all studies assessing that type of exposure. Of the five prospective studies (of varying risk of bias - Table 2), one reported significant associations between job demands and the incidence of both lateral epicondylitis and medial epicondylitis (OR = 1.10 for both), and one reported significant associations between a dichotomous measure of job satisfaction and the incidence of lateral epicondylitis and medial epicondylitis (hazard ratios of 1.68 and 1.74, respectively), while the other three prospective cohort studies found no significant association between psychosocial risk factors (including job demands, job satisfaction, and social support) and the incidence of lateral epicondylitis or medial epicondylitis.

4. Discussion

The results of our systematic review suggest several associations between work-related physical exposures and the occurrence of elbow disorders. Combined physical exposure indicators were associated with increased occurrence of lateral epicondylitis in three cohort studies. These combined exposures included strain index scores measured in two cohorts, and physical exertion ratings (Borg perceived exertion scale) combined with at least one elbow movement (dichotomized as < or >2 h a day) in the other cohort. Nevertheless, inconsistent findings were shown in both longitudinal and cross-sectional studies regarding other type of exposures (e.g. posture, force, repetitiveness) and the occurrence of lateral or medial epicondylitis. Some of the reported psychosocial exposures (e.g., job demands and job satisfaction) were significantly associated with the occurrence of lateral or medial epicondylitis in at

Table 3
Occurrence of elbow disorders depending on the presence of physical exposure.

First Author Publication year Study design Location	Disorder	Exposure Domain	Exposure Description	Exposure assessment & data type (level of exposure)	OR (95% CI)	p	Results (descriptive)
Grzywacz 2012 CS USA	LE	force	heavy load	self-report continuous	0.83 (0.52–1.32)		NS in univariable analysis
		combined	awkward posture & repeated movements	self-report continuous	**1.51 (1.06–2.16)**	**<0.05**	Significant in univariable analysis
Arcury 2014 CS USA	epicondylitis	force	heavy load	self-report categorical (4)	1.01 (0.27–3.67)	0.98	multivariable: NR
		posture	awkward posture	self-report categorical (4)	1.74 (0.91–3.37)	0.09	multivariable: NR
Bugajska 2013 cohort (prospective) Poland	ME	combined	physical job demands	self-report NR	1.01 (0.67–1.52)	0.97	
	LE	combined	physical job demands	self-report NR	0.74 (0.44–1.26)	0.27	
Turhan 2008 CS Turkey	LE	posture	list of possible awkward postures such as excessive ulnar deviation, hyperextension of the thumb, hard keystrokes, leaning wrists on the keyboard, anterior tilt of the head, round back and asymmetric neck postures	observer report NR		NS	
Holm 2016 CC Denmark	LE	combined	amount of pipette work (h/week)	self- and observer report categorical (3)	*<2 h/week: 1.00 reference >2–5 h/week: 1.91 (0.34–10.70) >5 h/week: 1.14 (0.19–7.01)	0.95	
Aben 2018 CC Belgium	LE	repetitiveness	1 item about short-cycle work (from a questionnaire of 18 items developed by the Stichting Innovative & Arbeid in the context of the Synergy project)	self-report continuous		**0.031**	cases: N = 54; mean = 65.63; SD = 29.46 controls: N = 100; mean = 52.48; SD = 25.63;
Andersen 2012 CC Denmark	CNS	posture	Leaning on elbow (>=2 h); JEM Job Exposure Matrix (JEM) based on experts' ratings.	self-report dichotomous	**2.16 (1.06–4.44)**		unadjusted OR: 1.78 (1.02–3.12)
Herquelot 2013 cohort (prospective) France	LE	repetitiveness	doing repetitive tasks (>4 h/day)	self-report categorical (4)	IRR:men: never: 1.0 first: 1.2 (0.4–3.6) second: 1.1 (0.4–3.4) both: **2.6 (1.2–5.7)** women: never: 1.0 first: **2.5 (1.0–6.7)** second: 1.1 (0.3–4.0) both: 2.3 (0.8–6.5)	IRR:men: never: na first: 0.74 second: 0.80 both: **0.02** women: never: na first: **0.06** second: 0.88 both: 0.12	In multivariable analyses, the association with high physical exertion combined with at least one elbow movement at both questionnaires remained significant. Exposure to repetitive tasks at both questionnaires was not significantly associated with the incidence of epicondylitis in multivariable analyses adjusted for high physical exertion combined with elbow movements and age.
		combined	elbow-specific combined physical exposure	self-report categorical (4)	IRR:men: never: 1.0 first: na (no complete cases available) second: **2.5 (1.1–5.8)** both: **2.9 (1.4–5.9)** women: never: 1.0 first: 1.5 (0.5–4.7) second: na (no	IRR:men: never: na first: na second: **0.03** both: **<0.01** women: never: na first: 0.51 second: na	In multivariable analyses, the association with high physical exertion combined with at least one elbow movement at both questionnaires remained significant.

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Table 3 (*continued*)

First Author Publication year Study design Location	Disorder	Exposure Domain	Exposure Description	Exposure assessment & data type (level of exposure)	OR (95% CI)	p	Results (descriptive)
					complete cases available) both**: 3.2 (1.4–7.5)**	both: **<0.01**	
Descatha 2013 cohort (prospective) USA	LE	posture	Bending	self-report categorical (4)	no or <1 h/day: 1.0 1–2h/day: 0.8 (0.1–7.4) 2–4h/day: 2.8 (0.7–10.5) >=4 h/day: **4.4 (1.5–13.1)**		multivariable analyses: NR
		force	Gripping	self-report categorical (4)	no or <1 h/day: 1.0 1–2h/day: 1.3 (0.4–4.2) 2–4h/day: 1.5 (0.5–4.3) >=4 h/day: 1.7 (0.7–4.0)		multivariable analyses: NR
		posture	bending>=4 h/day & rotating>=2 h/day	self-report dichotomous	**3.0 (1.4–6.1)**		multivariable analysis: 2.5 (1.1–5.3)
	ME	posture	Bending	self-report categorical (4)	no or <1 h/day: 1.0 1–2h/day: 1.0 2–4h/day:**4.9 (1.1–20.7)** >=4 h/day: **8.2 (2.4–27.9)**		multivariable analyses: NR
		posture	Rotating	self-report categorical (4)	no or <1 h/day: 1.0 1–2h/day: 0.5 (0.1–3.9) 2–4h/day: 2.8 (1.0–7.7) >=4 h/day: **2.5 (1.0–5.8)**		multivariable analyses: NR
		force	Gripping	self-report categorical (4)	no or <1 h/day: 1.0 1–2h/day: 2.1 (0.6–7.2) 2–4h/day: 1.9 (0.5–6.5) >=4 h/day: **3.8 (1.5–9.6)**		multivariable analyses: NR
		posture	bending>=4 h/day & rotating>=2 h/day	self-report dichotomous	**3.6 (1.7–7.7)**		multivariable analysis: 3.1 (1.4–6.8)
Franzblau 2005 CS USA	elbow/ forearm tendonitis	combined	average hand activity level (HAL) and peak hand force	video-analysis categorical (3)		p (trend): **0.001**	Exposed cases: TLV 1: 11 TLV 2: 13 TLV 3: 34 Exposed controls: TLV 1: 194 TLV 2: 411 TLV 3: 245
Nordander 2013 CS (Summary) Sweden	LE	posture	wrist flexion p10	video-analysis continuous	beta (sex-adjusted): **0.31 (0.04–0.6)**		multivariable: beta: **0.3 (0.04–0.6)**
		posture	wrist flexion p90	video-analysis continuous	beta (sex-adjusted): 0.05 (-0.06 -0.2)		NR
		velocity	angular velocity p50	video-analysis continuous	beta (sex-adjusted): 0.0 (-0.08 - 0.08)		NR
		force	muscular activity p10	video-analysis continuous	beta (sex-adjusted): −0.34 (-1.1 - 0.05)		NR

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Table 3 (*continued*)

First Author Publication year Study design Location	Disorder	Exposure Domain	Exposure Description	Exposure assessment & data type (level of exposure)	OR (95% CI)	p	Results (descriptive)
		force	muscular activityp90	video-analysis continuous	beta (sex-adjusted): −0.02 (-0.2 - 0.1)		NR
	ME	posture	wrist flexion p10	video-analysis continuous	beta (sex-adjusted): 0.17 (-0.02 - 0.4)		NR
		posture	wrist flexion p90	video-analysis continuous	beta (sex-adjusted): 0.05 (-0.02 - 0.1)		NR
		velocity	angular velocity p50	video-analysis continuous	NR		multivariable: **0.1 (0.1–0.2)**
		force	muscular activity p10	video-analysis continuous	NR		NR
		force	muscular activityp90	video-analysis continuous	beta (sex-adjusted): 0.03 (-0.09 - 0.1)		NR
Pullopdissakul 2013 CS Thailand	LE	repetitiveness	repetitive work	self-rated dichotomous	0.85 (0.15–4.72)		Exposed cases: 18 Exposed controls: 442
		force	high force	self-rated dichotomous	1.91 (0.47–7.80)		Exposed cases: 7 Exposed controls: 167
		posture	awkward posure	self-rated dichotomous	1.01 (0.25–4.00)		Exposed cases: 15 Exposed controls: 292
		other	contact stress (e.g. using hand as hammer)	self-rated dichotomous	1.82 (0.44–7.59)		Exposed cases: 5 Exposed controls: 116
	ME	repetitiveness	repetitive work	self-rated dichotomous	3.21 (0.71–14.4)		Exposed cases: 8 Exposed controls: 452
		force	high force	self-rated dichotomous	1.51 (0.58–3.97)		Exposed cases: 4 Exposed controls: 170
		posture	awkward posure	self-rated dichotomous	**3.14 (1.10–8.95)**		Exposed cases: 5 Exposed controls: 279
		other	contact stress (e.g. using hand as hammer)	self-rated dichotomous	1.20 (0.40–3.58)		Exposed cases: 4 Exposed controls: 117
Svendsen 2012 CC Denmark	ulnar neuropathy	force		self- and observer rating categorical (3)	0 points: 1.00 **>0-<1 point: 2.73 (1.42 to 5.25)>=1 point: 3.85 (2.04 to 7.24) trend: 1.81 (1.35 to 2.43)**		
		repetitiveness	repetition time	self- and observer rating categorical (3)	0 h/day: 1.00 reference >0-<2.5 h/day: 0.47 (0.25–0.90)>= 2.5 h/day: 0.94 (0.43–2.06) trend: 0.91 (0.63–1.29)		
		posture	nonneutral posture time	self- and observer rating categorical (3)	<1 h/day: 1.00 reference >=1-<2 h/day: 0.94 (0.54–1.63)>=2 h/day: 1.06 (0.53–2.12) trend: 1.08 (0.78–1.49)		
		vibration	HAV time	self- and observer rating categorical (3)	0 h/day: 1.00 reference >0-<1 h/day: 1.05 (0.45–2.47)>=1 h/day: 1.07 (0.44–2.60) trend: 1.15 (0.76–1.74)		

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Table 3 (*continued*)

First Author Publication year Study design Location	Disorder	Exposure Domain	Exposure Description	Exposure assessment & data type (level of exposure)	OR (95% CI)	p	Results (descriptive)
Walker-Bone 2012 CS UK	LE	combined	use of a keyboard	self-rated dichotomous	NR	NR	NR
		repetitiveness	repetitive movements of the wrist or fingers	self-rated dichotomous	NR	NR	NR
		posture	bending/straightening elbow	self-rated dichotomous	**2.5 (1.2–5.3)**	0.02	univariable: 2.5 (1.2–5.5), p = 0.017
		vibration	use of hand/arm vibrating tools	self-rated dichotomous	NR	NR	NR
		posture	working with arms above shoulder height	self-rated dichotomous	NR	NR	NR
		force	carrying weights on one shoulder, lifting weights >5 kg in one hand; working with neck bent forwards	self-rated dichotomous	NR	NR	NR
		posture	working with neck twisted	self-rated dichotomous	NR	NR	NR
	ME	combined	use of a keyboard	self-rated dichotomous	NR	NR	NR
		repetitiveness	repetitive movements of the wrist or fingers	self-rated dichotomous	NR	NR	NR
		posture	bending/straightening elbow	self-rated dichotomous	**5.3 (1.9–14.9)**	0.002	univariable: 5.1 (1.8–14.3), p = 0.002
		vibration	use of hand/arm vibrating tools	self-rated dichotomous	NR	NR	NR
		posture	working with arms above shoulder height	self-rated dichotomous	NR	NR	NR
		force	carrying weights on one shoulder, lifting weights >5 kg in one hand; working with neck bent forwards	self-rated dichotomous	NR	NR	NR
		posture	working with neck twisted	self-rated dichotomous			
Fan 2014 cohort (prospective) USA	LE	force	intensity of exertion	video-analysis categorical (5)	*Light: 1.00 reference Somewhat hard: 0.78 (0.39–1.52) Hard: 1.66 (0.70–3.92) Very hard: 0.93 (0.21–4.07) Near max: 0		
		force	duration of exertion	video-analysis categorical (5)	*<10: 1.00 reference 10–29.9: 1.87 (0.22–16.07) 30–49.9: 1.42 (0.17–11.68) 50–79.9: 1.42 (0.18–11.02) >=80: 2.30 (0.29–18.32)		
		posture	hand/wrist posture	video-analysis categorical (5)	*Very good: 1.00 reference Good: infinity Fair: infinity Bad: infinity Very bad: not a number		
		combined	low vs high exposure (strain index<=5; >5)	Video-analysis dichotomous	HR: **2.00 (1.13–3.54)**		Multivariable analysis (adjusted): HR: **2.06 (1.16–3.65)**
	ME	force	intensity of exertion	video-analysis categorical (5)	*Light: 1.00 reference Somewhat hard: 1.09 (0.44–2.71) Hard: 1.72 (0.48–6.13) Very hard: 1.10 (0.14–8.65) Near max: 0.00		

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Table 3 (*continued*)

First Author Publication year Study design Location	Disorder	Exposure Domain	Exposure Description	Exposure assessment & data type (level of exposure)	OR (95% CI)	p	Results (descriptive)
		force	duration of exertion	video-analysis categorical (5)	*<10: 1.00 reference 10–29.9: infinity 30–49.9: infinity 50–79.9: infinity >=80: infinity		
		posture	hand/wrist posture	video-analysis categorical (5)	*Very good: 1.00 reference Good: infinity Fair: infinity Bad: infinity Very bad: infinity		
		combined	low vs high exposure (strain index<=5; >5)	Video-analysis dichotomous	HR: 1.42 (0.64–3.13)		Multivariable analysis (adjusted): HR: 1.41 (0.64–3.12)
Garg 2014 cohort (prospective) USA	LE	force	peak force	self-rating & video-analysis continuous	HR: 1.1 (0.89–1.35)	0.39	
		combined	HAL	self-rating & video-analysis continuous	HR: 1.2 (0.98–1.36)	0.08	
		posture	typical hand/wrist posture	video-analysis categorical (5)	HR: very good: good: 0.2 (0.03–1.60) fair: 1.0 (–) poor: 0.7 (0.31–1.40) very poor: 1.4 (0.19–9.85)	very good: good: 0.14 fair: poor: 0.28 very poor: 0.77	
		combined	strain index	video-analysis dichotomous	<=6.1: 1.0 >6.1: **2.6 (1.26–5.28)**	**<0.01**	significant in multivariable model Exposure (no/yes): <=6.1: 133 >6.1: 362 Cases (non-exposed/exposed): <=6.1: 9 >6.1: 47

Figures in bold represent statistically significant findings.

Acronyms: CC = case control, CI = confidence interval; CNS = cubital nerve syndrome; CS = cross-sectional, HR = hazard ratio; LE = lateral epicondylitis; ME = median epicondylitis; NR = not reported; NS = not significant; RR = risk ratio.

*Data calculated from raw data available in the individual studies.

a The datasets from several primary studies with a similar design were used and reanalyzed with respect to a new research question. None of the individual studies included in the pooled analysis is included in our systematic review independently.

least one study, but none of the associations were consistent across all studies for a given exposure. The RoB assessment indicated many studies had high RoB, including in the assessment of exposure which could contribute to the inconsistency of findings across studies. Due to the inconsistency of results, the rather low quality of evidence, and the scarcity of longitudinal studies, no strong conclusions can be drawn regarding potentially causal associations between work-related psychosocial exposures and the occurrence of elbow disorders.

In contrast to the previous review (van Rijn et al., 2009a), we found a higher number of studies (17 additional studies vs 13 studies in the previous review) and higher number of longitudinal studies (five vs two); in fact, the conclusions of the previous review were mainly based on cross-sectional studies. In this regard, the approach undertaken here to analyze only the studies included in this update seems appropriate, as the conclusions can be mainly based on longitudinal studies. Despite this fact, the conclusions of this updated review highlight large inconsistency in the association between physical and psychosocial exposures, and specific elbow disorders. This is in line with the findings of the previous review, for both no strong conclusions can be drawn with regards to causality on the available evidence.

In contrast to previous reviews (Palmer et al., 2007; van Rijn et al., 2009a), we restricted the included studies to those directly assessing physical activities on a person-based level as indicators of physical exposures, and we excluded studies using job titles as exposure indicators. In accordance with our review, previous reviews also found conflicting evidence regarding physical exposures (Curti et al., 2021; Palmer et al., 2007; Shiri and Viikari-Juntura, 2011; van Rijn et al., 2009a), and found evidence regarding psychosocial exposures was less consistent than for physical exposures (Shiri and Viikari-Juntura, 2011; van Rijn et al., 2009a). Due to the differences in worker samples, work characteristics, methodology, and assessment, a direct comparison of our findings with previous systematic reviews and meta-analyses is difficult and should be done with caution (Shiri and Viikari-Juntura, 2011; Spielholz et al., 2001). However, because the previous (van Rijn et al., 2009a) and the present review both included studies which demonstrated associations between work-related exposures and the occurrence of disorders of the

Table 4
Occurrence of elbow disorders depending on the presence of psychosocial exposure.

First Author Publication year Study design	Disorder	Exposure domain	Exposure description	Exposure assessment & data type (level of exposure)	OR (95% CI)	P	Results (descriptive)
Grzywacz 2012 CS USA	LE	job control	job control	self-report continuous	0.79 (0.59–1.05)	NR	significant in univariable analysis
		job demand	job demand	self-reportcontinuous	1.09 (0.82–1.43)	NR	NS in univariable analysis
Arcury 2014 CS USA	epicondilitis	job demand	psychological demand	self-report categorical (4)	1.76 (0.85–3.6)	0.12	multivariable: NR
		decision latitude	decision latitude	self-report categorical (4)	**0.36 (0.15–0.85)**	**0.01**	multivariable: NR
		other	supervisor control	self-report categorical (4)	0.84 (0.23–2.95)	0.78	multivariable: NR
		other	work safety climate	self-report continuous	0.94 (0.82–1.07)	0.37	multivariable: NR
		other	skill variety	self-report categorical (4)	0.83 (0.45–1.53)	0.56	multivariable: NR
Bugajska 2013 cohort (prospective) Poland	LE	job demand	mental job demands	self-report NR	**1.10 (1.02–1.19)**	**0.017**	
		decision latitude	decision latitude	self-report NR	1.02 (0.97–1.07)	0.417	
		job insecurity	job insecurity	self-report NR	0.92 (0.69–1.24)	0.595	
		social support	social support	self-report NR	1.05 (0.92–1.20)	0.441	
	ME	job demand	mental job demands	self-report NR	**1.10 (1.01–1.21)**	**0.038**	
		decision latitude	decision latitude	self-report NR	0.98 (0.93–1.03)	0.417	
		job insecurity	job insecurity	self-report NR	0.96 (0.69–1.35)	0.828	
		social support	social support	self-report NR	1.08 (0.93–1.27)	0.304	
Aben 2018 CC Belgium	LE (tennis elbow)	job satisfaction	work satisfaction	self-report continuous	NR	NR	cases: N = 54; mean = 7.56; SD = 1.56 controls: N = 100; mean = 7.82; SD = 1.13; p = 0.559
		job demand	workload	self-report continuous	NR	NR	cases: N = 55; mean = 48.06; SD = 15.31 controls: N = 99; mean = 43.26; SD = 10.56; p = 0.030
		decision latitude	autonomy	self-report continuous	NR	NR	cases: N = 56; mean = 50.94; SD = 19.84 controls: N = 98; mean = 56.38; SD = 14.80; p = 0.055
Herquelot 2013 cohort (prospective) France	LE	social support	low social support	self-report categorical (4)	IRR:men: never: 1.0 first: 1.2 (0.6–2.6) second: 0.9 (0.3–2.3) both: 1.5 (0.7–3.4) women: never: 1.0 first: 1.1	IRR:men: never: na first: 0.6 second: 0.77 both: 0.30 women: never: na first: 0.9	multivariable analyses: NS

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Table 4 (*continued*)

First Author Publication year Study design	Disorder	Exposure domain	Exposure description	Exposure assessment & data type (level of exposure)	OR (95% CI)	P	Results (descriptive)
					(0.3–3.3) second: 1.0 (0.4–3.0) both: 1.3 (0.5–3.4)	second: 0.92 both: 0.56	
Descatha 2013 cohort (prospective) USA	LE	social support	lack of social support	self-report dichotomous	1.3 (0.5–3.1)	NR	multivariable analysis: 1.0 (0.4–2.6)
	ME	social support	lack of social support	self-report dichotomous	1.4 (0.6–3.2)	NR	multivariable analysis: 1.1 (0.4–2.8)
Nordander 2013 CS (Summary) Sweden	LE	job demand	high job demands	self-report continuous	beta (sex-adjusted): 0.03 (−0.03-0.08)	NR	multivariable analysis: NR
		job control	low job control	self-report continuous	beta (sex-adjusted): 0.02 (−0.02-0.05)	NR	multivariable analysis: NR
		job strain	job strain	self-report continuous	beta (sex-adjusted): 0.03 (−0.02 - 0.07)	NR	multivariable analysis: NR
	ME	job demand	high job demands	self-report continuous	beta (sex-adjusted): 0.01 (-0.02 - 0.05)	NR	multivariable analysis: NR
		job control	low job control	self-report continuous	beta (sex-adjusted): **0.03 (0.00–0.05)**	NR	multivariable analysis: NR
		job strain	job strain	self-report continuous	beta (sex-adjusted): **0.03 (0.00–0.06)**	NR	multivariable analysis: NR
Thiese 2016 CS USA	LE	job satisfaction	job satisfaction	self-report categorical (3)	satisfied: 1.0 undecided: **1.88 (1.15–3.08)** dissatisfied: **2.33 (1.31–4.14)**	trend: **<0.05**	
		social support	supervisor support (how well participants get along with their closest or immediate supervisor)	self-report categorical (3)	always: 1.00 occasionally: 0.94 (0.62–1.43) never: 1.21 (0.56–2.59)	trend: >0.05	
	ME	job satisfaction	job satisfaction	self-report categorical (3)	satisfied: 1.0undecided : 2.10 (0.85–5.23) dissatisfied: 1.53 (0.49–4.82)	trend: **<0.05**	
		social support	supervisor support (how well participants get along with their closest or immediate supervisor)	self-report categorical (3)	always: 1.0 occasionally: 0.58 (0.25–1.34) never: 0.42 (0.06–3.15)	trend: >0.05	
Walker-Bone 2012 CS UK	LE	social support	support from colleagues and seniors	self-report NR	NR	NR	NR
		decision latitude	latitude at work	See above.	NR	NR	NR
		job satisfaction	job satisfaction	See above.	NR	NR	NR
	ME	social support	support from colleagues and seniors	self-report NR	NR	NR	NR
		decision latitude	latitude at work	See above.	NR	NR	NR
		job satisfaction	job satisfaction	See above.	NR	NR	NR
Fan 2014 cohort (prospective) USA	LE	job demand	high job demands	self-report dichotomous	HR: 1.01	NR	reference is 'yes'
		decision latitude	high decision latitude	self-report dichotomous	HR: 1.22	NR	reference is 'yes'
		job satisfaction	high job satisfaction	self-report dichotomous	**HR: 1.68**	**sig**	reference is 'yes'
		social support	high social support	self-report dichotomous	HR: 1.1	NR	reference is 'yes'
		job insecurity	high job security	self-report dichotomous	HR: 1.27	NR	reference is 'yes'
	ME	job demand	high job demands	self-report dichotomous	HR: 1.15	NR	reference is 'yes'

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Table 4 (*continued*)

First Author Publication year Study design	Disorder	Exposure domain	Exposure description	Exposure assessment & data type (level of exposure)	OR (95% CI)	P	Results (descriptive)
		decision latitude	high decision latitude	self-report dichotomous	HR: 0.74	NR	reference is 'yes'
		job satisfaction	high job satisfaction	self-report dichotomous	**HR: 1.74**	**sig**	reference is 'yes'
		social support	high social support	self-report dichotomous	HR: 1.29	NR	reference is 'yes'
		job insecurity	high job security	self-report dichotomous	HR: 1.24	NR	reference is 'yes'
Garg 2014 cohort (prospective) USA	LE	job satisfaction	job satisfaction	self-report categorical (4)	HR:very satisfied: 1.0 satisfied: 0.8 (0.42–1.58) neither/nor: 1.0 (0.46–2.17) dissatisfied/v. dissatisfied: 2.2 (0.70–6.68)	very satisfied: satisfied: 0.54 neither/nor: 0.99 dissatisfied/v. dissatisfied: 0.18	
		social support	supervisor shows appreciation	self-report categorical (4)	HR:always: 1.0 often: 0.5 (0.25–1.18) seldom: 1.1 (0.55–2.20) never: 0.8 (0.29–2.37)	always: often: 0.13 seldom: 0.79 never: 0.74	

Figures in bold represent statistically significant findings.
Acronyms: CC = case control, CI = confidence interval; CNS = cubital nerve syndrome; CS = cross-sectional, HR = hazard ratio; LE = lateral epicondylitis; ME = median epicondylitis; NR = not reported; NS = not significant; RR = risk ratio.
a The datasets from several primary studies with a similar design were used and reanalyzed with respect to a new research question. None of the individual studies included in the pooled analysis is included in our systematic review independently.

elbows, further longitudinal cohort studies may attempt to replicate these associations. Additionally, future research may investigate the impact of modifying workplaces in preventive efforts to reduce physical and psychosocial risk factors on the occurrence of disorders of the elbow (Shiri and Viikari-Juntura, 2011), as well as the potentially preventive effects of exercise, which have been demonstrated in previous research (Kelly et al., 2018).

The heterogeneity of psychosocial work-related exposure findings hampers the ability to draw strong conclusions regarding the effect of these factors. However, evidence to date, as synthesized in this review, is incomplete and does not confirm that psychosocial factors are not relevant in the development of elbow disorders. Rather, further investigation in the form of cohort studies is required into the role of these factors in elbow disorders risk.

4.1. Limitations

First, data extraction was not performed by two independent reviewers. However, the correctness of the extracted data was verified by a second researcher. Second, we cannot rule out that we missed relevant studies. But, based on the broad and systematic literature search in medical and psychological databases and the large number of screened articles, we consider the risk for the occurrence of selection bias rather small. Third, we focused only on predefined exposures/risk factors. If not accounted for in source studies (i.e., using adequate statistical methods), we cannot rule out confounding or interactions with other risk factors (e.g., sex or age). Fourth, the included studies predominantly reported associations between exposures and one specific elbow disorder; associations may have been more consistent or stronger if multiple elbow disorders had been included together as a single outcome measure. Fifth, recording only the prevalence of a disorder prevents the possibility to detect the natural course of the disorder, i.e. the number of new cases that occurred during the time of observation cannot be determined, nor it is possible to detect how many cases remitted. This limits possibilities to draw conclusions regarding causal or temporal relationships between the observed exposures and disorders. Finally, differences across studies in worker demographics, work characteristics, methodologies, and analyses make direct comparisons difficult and interpretations based on such comparisons should be done with caution.

5. Conclusions

Our systematic review updates our previous review, adding 17 new studies to the body of evidence, including 5 longitudinal cohorts. In three cohort studies, combined exposure indicators and high exposure levels were associated with an increased occurrence of lateral epicondylitis. No other consistent pattern of associations were found between work-related physical exposures and the occurrence of elbow disorders. Two studies showed psychosocial exposures (e.g. job demands and job satisfaction) were significantly associated with the occurrence of elbow disorders, but none of the psychosocial exposures had consistent evidence for such an association across all studies.

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All authors have no conflict of interest to declare.

Data availability statement

Not applicable.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.apergo.2022.103952.

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