J Occup Health 2009; 51: 177–192

Journal of Occupational Health

Review

Prevalence and Associated Factors for Thoracic Spine Pain in the Adult Working Population: A Literature Review

Andrew M. Briggs[1], Peter Bragge[2], Anne J. Smith[1], Dhruv Govil[1] and Leon M. Straker[1]

[1]School of Physiotherapy, Curtin University of Technology and [2]Global Evidence Mapping (GEM) Initiative, Department of Surgery (Royal Melbourne Hospital), University of Melbourne, Australia

Abstract: Prevalence and Associated Factors for Thoracic Spine Pain in the Adult Working Population: A Literature Review: Andrew M. Briggs, *et al*. School of Physiotherapy, Curtin University of Technology, Australia—Objectives: Spinal pain is a significant occupational health issue. Whilst neck pain and low back pain have received considerable attention, thoracic spinal pain (TSP) has not. The objective of this study was to systematically identify and report the evidence describing the prevalence and correlates of TSP within occupational groups. **Methods:** This literature review systematically searched for reports of TSP prevalence and associated factors for TSP in working adult cohorts using nine electronic databases. Studies were evaluated for level of evidence and epidemiologic data were narratively synthesised. **Results:** 52 studies were identified describing 65 cohorts covering manual labourers, office workers, health professionals, manufacturing and industrial workers, drivers, military personnel and performing artists. Prevalence varied with occupational group and time period. One year prevalence of TSP ranged from 3.0–55.0%, with most occupational groups having medians around 30%. Significant odds ratios for individual (concurrent musculoskeletal disorders, exercising, pre-menstrual tension and female gender), general work-related (high work load, high work intensity, perceiving ergonomic problems in the workplace, working in some specialised areas, performing boring/tedious work tasks, certain year levels of study, employment duration, driving specialised vehicles, and a high number of flying hours), physical work-related (manual physiotherapy tasks, climbing stairs and high physical stress) and psychosocial work-related (perceived risk of injury and high mental pressure) factors were reported. **Conclusions:** The high median prevalence rates suggest TSP may be a significant occupational health problem. The multiple domains of associated factors point to the need for prospective research encompassing these domains to inform targeted occupational interventions.
(J Occup Health 2009; 51: 177–192)

Key words: Adult, Correlate, Occupation, Pain, Prevalence, Thoracic spine, Working

Spinal pain and injury represent a significant impact on an individual's quality of life as well as a financial burden for employers[1)]. In the interest of human capital, careful monitoring and scrutiny of spinal pain characteristics among working populations are important as the societal cost of these conditions are significant, representing about 1% of gross national product per annum[2)] and a major contributor to reduced work productivity[3)]. Moreover, recent evidence highlights that medical expenditures for spinal pain continue to rise without a commensurate change in clinical outcomes[4)].

Although epidemiological characteristics of neck and low back pain are relatively well established among working populations[5–8)], little is known about the epidemiology of thoracic spine pain (TSP)[9)], which is considered to be pain experienced in the area of the upper back or middle back between vertebrae T1–T12 across the posterior aspect of the trunk. A major limitation of previous research is the use of a combined outcome measure for spinal pain. That is, specific results for the thoracic spine are rarely reported. Rather, only 'back' pain is reported which may encompass more than one spinal area. A similar limitation has also been identified in an earlier systematic review of neck pain[5)]. Interpretation of these data may therefore be limited as risk factors for the development of pain and dysfunction are likely to vary according to spinal level considering the diversity in functional demands for different spinal levels.

Received Nov 17, 2008; Accepted Feb 19, 2009
Published online in J-STAGE Apr 1, 2009
Correspondence to: L.M. Straker, School of Physiotherapy, Curtin University of Technology, GPO Box U1987, Perth 6845, Australia (e-mail: L.Straker@curtin.edu.au)

Compared to the lumbar and cervical spine, the thoracic spine has received less attention in terms of clinical and occupational research. Pain experienced in the thoracic spine can be equally disabling, potentially imposing similar burdens on the individual, community and the workforce. Notably, a recent two-year prospective cohort study identified TSP to be an independent predictor of failure of returning to work[10]. Working populations contribute most significantly to national wealth and productivity. Considering the personal and industrial burdens of spinal pain, identifying risk factors through prospective studies or multiple domain associated factors through cross-sectional studies for the condition is important for this population. Indeed, a focus on modifiable risk factors for back pain which address occupational factors was recently identified as a priority research area[11]. As a starting point is it important to know the prevalence and factors associated with a condition in order to inform occupationally-specific preventative and management programmes, rather than generic interventions. Generally, observational studies provide these data.

Developing an understanding of these issues for TSP is difficult when relying on single studies and interpreting the results in isolation. Arguably, there is a need to systematically identify and report on literature concerning TSP in working populations in order to comprehensively identify prevalence and associated factors. The aim of this paper was to provide a comprehensive report of prevalence and factors associated with TSP in adult working populations.

Methods

Searching and study selection

This literature review employed a systematic approach to search and study selection, in which explicit search and selection methods were used to address a focused clinical question[12]. This reduces the bias associated with non-systematic search and study selection methods[13].

Nine databases were searched from inception to January 2008 (Medline, CINAHL, Pub Med, ISI Web of Science, BioMed Central, PEDro, EMBASE, Cochrane, AMED). Automatic search alerts were set up in each database to alert the authors to any new papers published which met the search criteria after January 2008. One additional paper was identified from the search alerts[14]. Search strings pertaining to prevalence and risk factors were based on a previously conducted systematic review of prevalence and risk factors for musculoskeletal disorders in elite musicians[15]. Full search strings are available from the authors upon request. In addition, keywords were mapped to subject headings (MeSH headings) in MEDLINE to identify synonyms for epidemiological, thoracic spine and musculoskeletal disorder terms. Shorter search terms were used for databases that did not use subject headings or that had a limited number of allowable search terms. Reference lists of included papers were also reviewed to identify any other potentially suitable studies to include and minimise any bias associated with electronic literature searching methods.

For studies to be included in this review, the following criteria had to be met:

1. The population had to be a cohort of healthy adults (≥18 yr) working in a specific, defined occupation. No inclusion criteria were imposed on the nature of the occupation, job tenure or hours worked. Studies which did not define a specific occupational group were excluded (e.g. population-based or community studies). Studies involving professional sportspeople, performing artists and tertiary students were included so long as these activities were their predominant occupational activities.
2. The study had to report either prevalence of TSP or factors associated with TSP (cervico-thoracic and thoraco-lumbar were also accepted). TSP could be self-reported or clinically diagnosed. Owing to the lack of a standardised operational definition of TSP, any self-report of pain experienced in the thoracic spine, dorsal spine, upper back or mid-back was accepted and no inclusion criteria were imposed on pain severity, frequency, duration or pain-related disability.
3. The study design had to be case-control, cross-sectional or prospective-cohort or retrospective-cohort, as these are the appropriate study designs for investigating prevalence and associated factors[16].
4. The study had to be published in a peer-reviewed journal in English.

Titles and abstracts of citations were reviewed by two independent reviewers (AB, AS) with reference to the four inclusion criteria listed above to determine eligibility of each study for inclusion in this review. In circumstances where the abstract was not available, or based on the content of the abstract it was not clear whether the article met the inclusion criteria for the review, the full text article was assessed. Disagreement regarding eligibility for inclusion was resolved by a consensus meeting between the authors.

Quality appraisal

To obtain a broad indication of methodological quality, each included study was independently ranked by two assessors (AB and DG) according to its study design using the Australian National Health and Medical Research Council (NHMRC) Hierarchy of Evidence[17]. This approach has been adopted previously[18]. We considered this hierarchy to be appropriate as it comprises levels of evidence for each type of research question (intervention, diagnostic accuracy, prognosis, aetiology, screening intervention). For this review, the hierarchy of evidence

for 'aetiology' studies was employed. Studies are ranked on a nominal scale from I–IV with higher rankings indicating a broadly higher level of methodological strength and therefore a more robust source of evidence. Level I refers to systematic reviews of level II studies, level II refers to prospective cohort studies, level III-1 refers to a case-series where all or none of the people with the risk factor(s) experience the outcome to provide an unbiased representation of a prognostic effect, level III-2 refers to a retrospective cohort study, level III-3 refers to a case-control study, and level IV refers to a cross-sectional study or case-series.

Data extraction

Data extraction was performed by one author (DG) while a second author (AB) performed an accuracy audit of 20% of the extracted data. Data extracted included: occupation, ethnicity of the cohort, definition of TSP, sample size by gender (where reported), TSP prevalence as a percentage across 7 recall periods, and correlates of TSP expressed as a descriptor with an odds ratio and 95% confidence interval while noting any adjustment factors applied in the regression models. A meta-analysis was not possible owing to the heterogeneity of the included studies and therefore, data were synthesised narratively. Nonetheless, the structure and content of this review is consistent with recommendations outlined by the Meta-analysis of Observational Studies in Epidemiology (MOOSE) group for reporting meta-analyses of observational studies[19]. Where data were presented in a Figure, the corresponding author of the paper was contacted and asked to provide the dataset. In circumstances where the data set was not available, data were interpolated from the Figure.

Results

From the 9 databases searched, 1,725 citations were retrieved, of which 336 were duplicate citations. Of the remaining 1,389 citations, 1,219 were excluded after reviewing the titles and abstracts. Full-text papers of the remaining 170 citations were reviewed and 50 (3.6%) of 1,389 were selected for inclusion in this review on the basis of meeting the inclusion criteria[20–69]. One additional study was identified after reviewing the reference lists of the included papers[70], and one further study was identified from automatic searches established for the electronic databases[14], making a total of 52 papers included in the review. The characteristics, NHMRC hierarchy of evidence rank, TSP definition, and TSP prevalence of each study cohort included in this review (n=65 cohorts in 52 papers) are summarised in Table 1, grouped by occupational category.

There were 28 (43.1%) cohorts from Europe, 14 (21.6%) from USA/Canada, 11 (16.9%) from Asia, 4 (6.2%) from Australia, 3 (4.6%) from the Middle East, 3 (4.6%) from South America, and 2 from Africa (3.0%). Of the 52 studies ranked using the NHMRC hierarchy, 50 were cross-sectional surveys and 2 were prospective cohort studies[41, 49].

Prevalence data were expressed according to 7 occupational groups. Across all occupational groups TSP prevalence ranged from 3.7–77% (lifetime), 23.0–28.8% (2 yr), 3.0–55.0% (1 yr), 13.0–47.0% (3 mo), 20.0–38.0% (1 mo), 7.0–38.0% (1 wk), and 3.0–44.0% (point). The prevalence of TSP varied according to occupational group (Fig. 1). Health professionals reported the highest lifetime (77.0%) and 2 yr (28.0%) prevalence, performing artists and manual labourers reported the highest 1 yr (55.0% and 54.8% respectively) prevalence, manufacturers reported the highest 3 mo (47.0%) and 1 wk (38.0%) prevalence, manual labourers reported the highest 1 mo (38.0%) prevalence, and performing artists reported the highest point (44.0%) prevalence. As illustrated in Fig. 1, the 1 yr prevalence was the most commonly reported period in the literature. The median 1 yr prevalence of TSP was 29.1% in manual labourers, 30.0% in office workers, 35.4% in health professionals, 18.1% in manufacturers and industrial workers, 20.0% in drivers, 14.4% in military personnel, and 33.0% in performing artists.

Table 2 outlines the individual, general work-related, physical work-related, and psychosocial work-related factors reported in the literature to be associated with TSP. The individual factors significantly associated with TSP included having concurrent musculoskeletal symptoms, exercising, pre-menstrual tension and female gender. Significant general work-related factors included high work load, high work intensity, perceiving ergonomic problems in the workplace, working in some specialised areas (physiotherapy private practice, internal medicine, electronics, assembly line tasks), performing boring / tedious work tasks, certain year levels of study, employment duration, driving specialised vehicles, and a high number of flying hours. Significant physical work-related factors included manual physiotherapy tasks, climbing stairs, and high physical stress. Significant psychosocial work-related factors included perceived risk of injury and high mental pressure.

Discussion

To our knowledge, this paper is the first comprehensive review which describes the epidemiologic characteristics of TSP among working adults globally which has used a systematic search method. Although there are no data available to provide an interpretation of the impact of TSP on worker function, disability and absenteeism, the data do confirm the relatively high prevalence of TSP among working adults, and more importantly that TSP prevalence varies considerably between occupations. There also appear to be multiple domain correlates of

Table 1-1. National Health and Medical Research Council (NHMRC) hierarchy of evidence ranking, characteristics of each cohort, and period prevalence of thoracic spine pain (TSP) grouped by occupational category

Occupation	Citation number	NHMRC evidence rank	Country of origin	N	TSP definition	Thoracic spine pain prevalence (%)						
						Lifetime	2 yr	1 yr	3 mo	1 mo	1 wk	Point
Manual Labourers												
Farmers	(66)	IV	USA	M: 458, F: 301	Daily pain in mid-back			M: 8.5 F: 13.6				
Male sewage workers	(32)	IV	Austria	M: 255	Any pain, ache or discomfort in upper back	M: 65.1		M: 54.8			M: 29.8	M: 24.1
Male warehouse workers	(41)	II	France	M: 78	Any pain in upper back			M: 43.6				
Male foresters	(33)	IV	Greece	M: 78	Any pain, ache or discomfort in upper back			M: 29.4			M: 8.9	
Male farmers	(47)	IV	USA	M: 287	Any pain in upper and mid-back	M: 16.1						
Construction workers	(53)	IV	USA	M: 521, F: 5	Any pain, ache or discomfort in upper back			28.7				
Male manual handling warehouse workers	(67)	IV	Hong Kong	M: 217	Any pain , ache or discomfort in upper back			M: 32.9				
Hotel room cleaners	(39)	IV	USA	M: 10 F: 931	Any pain in upper back					20.0–38.0		
Male labourers (mixed):	(30)	IV	Holland		Regular pain or stiffness in mid-back							
20–29 yr				M:1,721								M: 10.0–11.0
30–39 yr				M:2,553								M: 14.0–16.0
40–49 yr				M:1,934								M: 16.0–20.0
50–59 yr				M:1,116								M: 14.0–16.0
Category range of TSP								*8.5–54.8*		*20.0–38.0*	*8.9–29.8*	*10.0–24.1*
Office Workers												
Air traffic controllers	(21)	IV	Sweden	M: 97, F: 90	Current pain in upper back			M: 25.0, F: 49.0			M: 7.0, F: 29.0	
Male office workers (mixed)	(30)	IV	Holland		Regular pain or stiffness in mid-back							
20–29 yr				M:772								M: 3.0–5.0
30–39 yr				M:1,814								M: 6.0–8.0
40–49 yr				M:1,365								M: 8.0–9.0
50–59 yr				M:735								M: 9.0–10.0
Aluminium plant office workers	(70)	IV	Norway	M: 796, F: 299	Any pain or discomfort in upper back			6.0*				
Office workers	(41)	II	France	M: 49, F: 68	Any pain in upper back			35.0				
Category range of TSP								*6.0*–49.0*			*7.0–29.0*	*3.0–10.0*

Table 1-2. (continued)

Occupation	Citation number	NHMRC evidence rank	Country of origin	N	TSP definition	Thoracic spine pain prevalence (%)						
						Lifetime	2 yr	1 yr	3 mo	1 mo	1 wk	Point
Health Professionals												
X–ray technologists	(40)	IV	Canada	M: 2, F: 18	Any pain in upper back							11.0
Sonographers	(54)	IV	Canada	M: 23, F: 188	Any pain in upper back	77.0						
Cytotechnologists	(64)	IV	USA	244	Any pain in upper back			52.7				
Physical therapists	(23)	IV	USA	M: 445, F: 483	Any musculoskeletal problem (pain, ache, or discomfort) in upper back			28.7				
Physical therapists	(28)	IV	Australia	M: 118, F: 418	Any pain or discomfort in upper back			41.0				
Physical therapists	(36)	IV	USA	M: 104, F: 266	Any injury in upper back		23.0					
Physical therapy assistants	(36)	IV	USA	M: 43, F: 210	Any injury in upper back		28.0					
Physical therapists	(55)	IV	Turkey	M: 28, F: 92	Any pain in upper back	9.0						
Female hospital nurses	(68)	IV	Hong Kong	F: 97	Any pain, ache or discomfort in upper back			F: 50.0				
Female hospital nurses	(63)	IV	China	F: 282	Any pain in upper back			F: 37.0				
Female hospital nurses	(60)	IV	Japan	F: 844	Any pain in upper back			F: 33.9				
Female hospital nurses	(61)	IV	China	F: 180	Any pain in upper back			F: 38.9				
Female community nurses	(38)	IV	Holland	F: 355	Any pain in upper back			F: 3.0				
Female hospital nurses	(37)	IV	Taiwan	F: 3950	Any pain in upper back			F: 8.3				
Female hospital nurses	(29)	IV	USA	F: 34	Any pain in upper back						F: 9.0	
Dental students	(44)	IV	Italy	M: 60, F: 54	Any pain or stiffness in upper back				21.1			
Dental students	(44)	IV	Lebanon	M: 117, F: 61	Any pain or stiffness in upper back				29.2			
Psychology students	(44)	IV	Italy	M: 60, F: 54	Any pain or stiffness in upper back				26.3			
Dental students	(52)	IV	USA		Any mid–back pain							
First year study				M:34, F:22					M: 32.4, F: 39.3			
Second year study				M:38, F:39					M: 32.4, F: 20.5			
Third year study				M:31, F:23					M: 38.7, F: 13.0			
Fourth year study				M:41, F:28					M: 22.0, F: 35.7			
Occupational therapy students	(58)	IV	Australia	M: 19, F: 128	Any pain in upper back			M: 42.1, F: 39.1				

Table 1-3. (continued)

Occupation	Citation number	NHMRC evidence rank	Country of origin	N	TSP definition	Thoracic spine pain prevalence (%)						
						Lifetime	2 yr	1 yr	3 mo	1 mo	1 wk	Point
Medical students	(59)	IV	Australia	M: 99, F: 155	Any pain in upper back			29.5				
Physicians	(62)	IV	China	M: 141, F: 145	Any pain in upper back			29.0				
Male dentists	(50)	IV	Israel	M: 60	Any pain in upper back			M: 20.0			M:13.3	
Primary care–givers (parents)	(56)	IV	USA	M: 10, F: 120	Any pain in upper back							16.0
Podiatry students	(57)	IV	Britain	132	Any pain, ache or discomfort in upper back			9.0				
Hospital workers (mixed)	(41)	II	France	M: 11, F: 69	Any pain in upper back			41.2				
Category range of TSP						*9.0–77.0*	*23.0–28.0*	*3.0–52.7*	*13.0–39.3*		*9.0–13.3*	*11.0–16.0*
Manufacturers and industrial												
Female lock assemblers	(65)	IV	Britain	191	Any pain in upper back			F: 28.9				
Industrial workers	(42)	IV	Taiwan	M:1,030 F: 7,368	Any pain or soreness in upper back			11.6				
Female maquila (assembly-line) workers	(35)	IV	Mexico	F: 466	Any pain, ache or discomfort in upper back			F: 38.4				
Ironworkers	(31)	IV	USA	M: 960, F: 21	Chronic or recurring pain, aching, discomfort or numbness in upper back			18.1				
Male rubber factory workers	(27)	IV	Iran	M: 454	Any pain in upper back			M: 38.1				
Female assembly-line workers	(24)	IV	Malaysia	F: 529	Any pain in mid-back			F: 34.8				
Female semiconductor workers	(25)	IV	Malaysia	F: 906	Any pain in upper back			F: 40.2				
Female semiconductor workers	(26)	IV	Malaysia	F: 906	Any pain in upper back			F: 40.2				
Female unskilled workers (metal-working/ food-processing)	(22)	IV	Sweden	F: 171	Thoracalgia (decreased mobility, pain and tenderness in the joints, ligaments and muscles of thoracic spine)				F: 47.0		F: 38.0	
Male cold storage workers	(48)	IV	Colombia	M: 50	Any pain, ache or discomfort in upper back			M: 26.0				
Male non-cold storage workers	(48)	IV	Colombia	M: 112	Any pain, ache or discomfort in upper back			M: 12.0				

Table 1-4. (continued)

Occupation	Citation number	NHMRC evidence rank	Country of origin	N	TSP definition	Thoracic spine pain prevalence (%)						
						Lifetime	2 yr	1 yr	3 mo	1 mo	1 wk	Point
Male petrochemical plant workers	(46)	IV	Italy		Pain in the thoracic spine (lifetime). Thoracic symptoms of any degree							
26–35 yr				M: 136	(1 yr)	M: 3.7		M: 2.9				
36–45 yr				M: 585		M: 7.2		M: 6.2				
46–55 yr				M: 484		M: 6.6		M: 5.4				
Aluminium plant operators	(70)	IV	Norway	M: 3,205, F: 412	Any pain, ache or discomfort in upper back			M: 7.0*, F: 12.0*				
Category range of TSP						*3.7–7.2*		*2.9–40.2*				
Drivers												
Male forest machine drivers	(51)	IV	Sweden	M: 215	Any pain, ache or discomfort in upper back			M: 20.0				
Male snowmobile drivers	(51)	IV	Sweden	M: 137	Any pain, ache or discomfort in upper back			M: 23.0				
Male snow-groomer drivers	(51)	IV	Sweden	M: 79	Any pain, ache or discomfort in upper back			M: 23.0				
Rally drivers (>10 rally days/yr)	(43)	IV	Britain	90	Any pain, ache or discomfort in upper back							37.0–38.0
Commercial motor vehicle drivers	(14)	IV	Nigeria	M: 299	Any upper or middle back pain in previous 12 months			M: 5.0				
Commercial motorcyclists	(14)	IV	Nigeria	M: 300	Any upper or middle back pain in previous 12 months			M: 17.0				
Category range of TSP								*5.0–23.0*				*37.0–38.0*
Military personnel												
Fighter pilots	(34)	IV	Finland	320	Any pain in upper back			32.0				
Warrant officers	(34)	IV	Finland	283	Any pain in upper back			19.0				
Naval officers (military)	(45)	IV	Norway	M: 1,550, F: 97	Any pain, ache or discomfort in upper back			4.3				
Naval officers (civilian)	(45)	IV	Norway	M: 483, F: 152	Any pain, ache or discomfort in upper back			9.7				
Category range of TSP								*4.3–32.0*				
Performing Artists												
Professional violinists	(20)	IV	Australia	M: 9, F: 23	Any pain in upper back	41.0						44.0
Music students	(69)	IV	Sweden	M: 112, F: 115	Any pain in thoracic spine			11.0				
Ballet dancers (professional)	(49)	II	Sweden	M: 17, F: 34	Any pain in upper back			55.0			24.0	
Category range of TSP								*11.0–55.0*				

M: Male; F: Female. Where the source paper did not report TSP by gender, a pooled gender estimate is reported without the M or F key. * data interpolated from Figure in source paper.

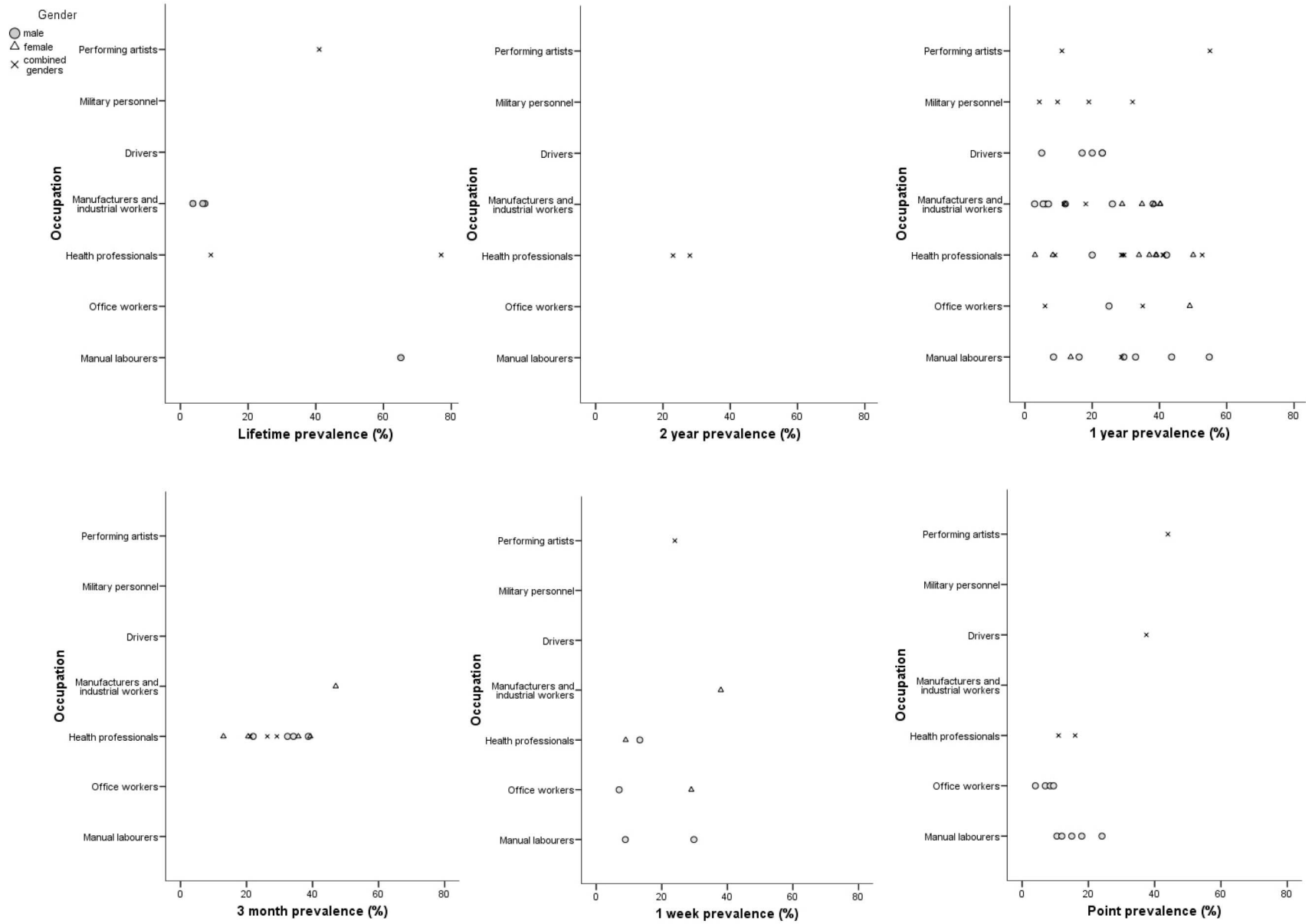

Fig. 1. Scatter plots illustrating TSP prevalence data for each cohort reported in the 52 studies. Data are expressed individually for each occupational group in six prevalence periods and where possible, by gender. A scatter plot was not created for 1 month prevalence as this was only reported in one cohort[39].

Table 2-1. Individual, general work-related, physical and psychosocial factors associated with thoracic spine pain across occupational groups

Associated factor by category	Citation number	Estimate of association: odds ratio (95% CI)	Adjustment factors
Individual factors			
Concurrent musculoskeletal symptoms vs. none	(68)	**8.4 (2.8–25.5)**	None
Increasing age (1 yr increments)	(60)	0.6 (0.2–2.1)	None
Alcohol consumption vs. none		1.4 (0.9–2.0)	
Tobacco consumption vs. none		1.2 (0.7–2.0)	
Currently married vs. unmarried		0.8 (0.5–1.5)	
Has children vs. no children		1.4 (0.7–2.8)	
Pre-menstrual tension vs. none		**1.9 (1.3–2.9)**	
Gender: female vs. male	(58)	2.6 (0.7–8.9)	Alcohol consumption, smoking, parenthood,
Age (>21 vs. ≤21 yr)		2.3 (0.9–6.1)	weekly exercise and family history of injuries
Gender: female vs. male	(59)	**2.5 (1.4–4.8)**	Age, gender, year of study, alcohol consumption, smoking & weekly exercise
Alcohol consumption vs. none		0.6 (0.3–1.1)	
Tobacco consumption vs. none		1.3 (0.3–6.2)	
Exercise vs. no regular exercise		**3.5 (1.1–15.5)**	
Age (1 yr increments)		0.6 (0.0–11.9)	
Gender: female vs. male	(62)	1.9 (0.8–4.7)	None
Alcohol consumption vs. none		1.2 (0.6–2.9)	
Tobacco consumption vs. non smoker		2.0 (0.8–5.1)	
Age (1 yr increments)		1.5 (0.1–40.3)	
Career length (1 yr increments)		0.6 (0.0–11.0)	
Gender: female vs. male	(45)	**3.1 (1.8–5.4)**	Employment category, age, gender, BMI, smoking, education and physical stressors index
General work-related factors			
≥15 hotel rooms cleaned per day vs. ≤14	(39)	1.2 (0.8–1.8)	Age, height, weight, smoking, alcohol use,
≥19 hotel beds made per day vs. ≤18		1.3 (0.9–1.8)	years of employment, hours worked per week,
Workload[#]: second quartile vs. first quartile		1.0 (0.6–1.7)	family member with special needs,
Workload[#]: third quartile vs. first quartile		1.6 (0.9–2.7)	psychological demands, decision latitude,
Workload[#]: highest quartile vs. first quartile		**3.5 (1.9–6.5)**	supervisor and co-worker support
Work intensification[##]: second quartile vs. first quartile		1.1 (0.7–1.9)	
Work intensification[##]: third quartile vs. first quartile		**1.8 (1.0–3.1)**	
Work intensification[##]: highest quartile vs. first quartile		1.7 (1.0–3.1)	
Ergonomic problems[###]: second quartile vs. first quartile		**2.6 (1.5–4.4)**	
Ergonomic problems[###]: third quartile vs. first quartile		**2.0 (1.2–3.5)**	
Ergonomic problems[###]: fourth quartile vs. first quartile		**4.2 (2.3–7.7)**	
Physical therapy private practice employment vs. never worked in private practice	(28)	**1.7 (1.2–2.5)**	None
Boring/tedious work vs. not	(63)	**2.0 (1.2–3.4)**	Age, total career length &
Inadequate staff numbers vs. adequate		1.6 (0.9–2.8)	department of employment
Weekly work hours (increments of 1 h/wk)	(60)	0.8 (0.1–4.2)	
Career length (1 yr increments)		1.7 (0.5–5.3)	
Inadequate staff numbers vs. adequate		0.7 (0.5–1.1)	
Inadequate work support vs. adequate		1.2 (0.8–1.7)	
Year of study: 4th vs. 1st or 2nd (occupational therapy students)	(58)	**3.3 (1.2–9.6)**	Alcohol consumption, smoking, parenthood, weekly exercise and family history of injuries

Table 2-2. continued

Associated factor by category	Citation number	Estimate of association: odds ratio (95% CI)	Adjustment factors
Year of study: 1st vs. 2nd, 3rd, 4th (medical students)	(59)	1.1 (0.5–2.1)	Age, gender, year of study, alcohol consumption, smoking and weekly exercise
Year of study: 2nd vs. 1st, 3rd or 4th (medical students)		**0.4 (0.2–0.7)**	
Year of study: 3rd vs. 1st, 2nd or 4th (medical students)		1.4 (0.7–2.6)	
Year of study: 4th vs. 1st, 2nd or 3rd (medical students)		1.7 (0.8–3.6)	
Too much overtime vs. not	(62)	1.6 (0.8–3.2)	None
Inadequate work support vs. adequate		2.1 (0.9–5.1)	
Working in internal medicine vs. not (other depts)		**2.2 (1.2–4.2)**	
Working in surgery vs. not		2.7 (0.6–14.8)	
Working in orthopaedics vs. not		1.0 (0.2–5.6)	
Working in gynaecology vs. not		1.3 (0.2–8.2)	
Working in intensive care vs. not		0.4 (0.1–2.1)	
Maquila working in electronics vs. not working	(35)	**1.7 (1.1–2.3)**†	Sociodemographic characteristics, head of household
Maquila not working in electronics (other) vs. not working		**1.9 (1.3–2.5)**†	
Non-maquila vs. not working		**1.6 (1.1–2.5)**†	
Currently working vs. did not work		**1.8 (1.3–2.3)**†	
Previously worked as a maquila vs. did not work		1.5 (1.0–2.1)†	
Worked between 1 and 2 yr vs. never		**1.6 (1.1–2.2)**†	
Worked for >2 yr vs. never		**1.9 (1.3–2.5)**†	
Worked between 1 and 2 yr vs. >20 yr	(25)	1.4 (0.8–2.5)	Work task, temperature too cold and experienced stress in the past year
Worked between 2 and 5 yr vs. >20 yr		**1.8 (1.0–3.1)**	
Worked between 5 and 10 yr vs. >20 yr		1.7 (0.9–3.0)	
Worked between 10 and 20 yr vs. >20 yr		1.5 (0.8–2.6)	
Working in front of assembly line section vs. wafer fabrication		1.5 (0.8–2.7)	
Working in middle of assembly line section vs. wafer fabrication		**2.2 (1.2–4.0)**	
Working in end of assembly line section vs. wafer fabrication		**2.1 (1.2–3.5)**	
Working in parts assembly vs. wafer fabrication		1.2 (0.5–2.7)	
Working in wafer preparation vs. wafer polishing	(26)	3.8 (0.7–23.0)	Age
Working in wafer inspection/packing vs. wafer polishing		2.0 (0.4–10.0)	
Working in dye preparation vs. wafer polishing		2.4 (0.5–12.0)	
Working in dye attachment vs. wafer polishing		1.6 (0.3–8.10)	
Working in wire bonding vs. wafer polishing		2.9 (0.6–15.0)	
Working in molding vs. wafer polishing		4.0 (0.8–20.0)	
Working in forming/trimming vs. wafer polishing		3.6 (0.7–19.0)	
Working in plating/soldering vs. wafer polishing		2.8 (0.5–14.0)	
Working in dejunk/deflash vs. wafer polishing		4.4 (0.7–27.0)	
Working in dye marking and curing vs. wafer polishing		2.4 (0.5–12.0)	
Working in chip testing vs. wafer polishing		4.4 (0.9–21.0)	
Working in chip burn-in vs. wafer polishing		2.7 (0.5–13.0)	
Working in chip inspection vs. wafer polishing		4.5 (0.9–22.0)	
Working in chip packing vs. wafer polishing		3.5 (0.7–17.0)	
Working in assembly vs. wafer polishing		2.8 (0.5–16.0)	
Working in testing/marking/packing vs. wafer polishing		2.0 (0.3–12.0)	
Driving a forest machine vs. ordinary vehicle	(51)	**2.2 (1.2–3.9)**†	Age, smoking and job strain
Driving a snowmobile vs. ordinary vehicle		**2.9 (1.6–5.2)**†	
Driving a snowgroomer vs. ordinary vehicle		**2.7 (1.4–1.9)**†	
Total flight hours between 1–199 vs. 0 h	(34)	1.1 (0.3–4.3)	Age
Total flight hours between 200–499 vs. 0 h		3.5 (1.0–12.4)	
Total flight hours between 500–999 vs. 0 h		**3.6 (1.1–11.8)**	
Total flight hours over 1,000 vs. 0 h		**6.1 (1.6–23.1)**	

Table 2-3. continued

Associated factor by category	Citation number	Estimate of association: odds ratio (95% CI)	Adjustment factors
Physical work-related factors			
Mobilization/manipulation physical therapy tasks vs. none	(28)	**2.3 (1.6–3.3)**	None
Other 'hands on' physical therapy tasks vs. none		**1.9 (1.3–2.7)**	
High physical exertion vs. not	(63)	0.9 (0.5–1.5)	Age, total career length & department of employment
Manually handling patients vs. not		1.5 (0.8–2.6)	
Manually handling patients vs. not	(60)	1.3 (0.8–2.2)	None
Often bending/twisting vs. not		1.5 (1.0–2.2)	
Hard physical work vs. not		1.7 (0.9–3.6)	
Desk work: more than 5 h/wk vs. <5 h/wk	(58)	2.8 (0.6–14.3)	Alcohol consumption, smoking, parenthood, weekly exercise and family history of injuries
Computer usage: more than 5 h/wk vs. <5 h/wk		0.6 (0.2–2.1)	
Climbing steps for >4 h vs. <4 h	(25)	**3.5 (1.6–7.9)**	Work task, temperature too cold and experienced stress in the past year
Bending for >4 h vs. <4 h		1.2 (0.8–1.8)	
Twisting for >4 h vs. <4 h		1.3 (0.9–1.9)	
Hand-wrist movement for >4 h vs. <4 h		1.3 (0.9–1.8)	
Lifting for >4 h vs. <4 h		1.2 (0.9–1.5)	
Standing for >4 h vs. <4 h		1.0 (0.7–1.3)	
Sitting for >4 h vs. <4 h		1.2 (0.9–1.6)	
Pushing and pulling for >4 h vs. <4 h		1.1 (0.8–1.5)	
Physical activity in navy personnel vs. none	(45)	0.9 (0.9–1.0)	Employment category, age, gender, BMI, smoking, education and physical stressors index
High physical stress in navy personnel vs. very low		**2.1 (1.1–4.1)**	
Very high physical stress in navy personnel vs. very low		**2.9 (1.4–6.1)**	
Psychosocial work-related factors			
Perceived risk of injury from lifting (per unit increase on 7pt scale)	(67)	**1.4 (1.2–1.8)**	Age
High mental pressure vs. none (nurses)	(63)	1.2 (0.7–2.1)	Age, total career length & department of employment
Inadequate work support vs. adequate		1.9 (0.9–4.4)	
High mental pressure vs. none (nurses)	(60)	1.4 (0.9–2.2)	None
Boring/tedious work vs. not		0.8 (0.3–1.8)	
High mental pressure vs. not (physicians)	(62)	**2.3 (1.1–4.8)**	None
Inadequate work discussion vs. adequate		1.4 (0.6–3.2)	
Too much responsibility vs. not (physicians)		1.2 (0.6–2.2)	

[#]workload is a sum score of the frequency of 26 different job tasks/problems. [##]workload intensification is a sum score of the frequency of 26 job tasks/problems over 5 yr. [###]a sum score of 12 different specific ergonomic problems observed by room cleaners. [†]prevalence rate ratio rather than odds ratio.

TSP which supports a biopsychosocial framework for conceptualising its aetiology.

Study design and quality assessment

A systematic approach to search and study selection was followed in order to facilitate replication of the search strategy for future updating of this review. We ranked the study design of each paper with an appropriate hierarchy of evidence tool for studies of aetiology[17]. The majority of studies included in this review were cross-sectional in design, limiting inferences about causality and prognosis for TSP. Thus, the evidence base (relating primarily to

study design) may be classified as poor according to NHMRC criteria. However, the aim of this review was to report the prevalence and correlates of TSP, for which studies with a cross-sectional design is appropriate. Prospective studies are required in order to identify modifiable risk factors for the condition. Moreover, these studies would also provide important information to employers regarding the natural history of TSP and ultimately trajectories in certain occupational groups.

TSP prevalence

The range of TSP prevalence across the time periods was very broad. Indeed, this finding is consistent with studies on neck and low back pain[71–73]. The considerable variability in prevalence ranges likely reflects firstly research method issues and secondly the unique physical, environmental, and psychosocial stressors which act on workers in different occupational groups. Direct comparisons of prevalence between studies are limited due to inconsistencies in sampling methods, operational definitions of pain, and prevalence periods chosen. These method issues have been highlighted previously for limitations in comparing low back pain studies[74]. An international working party has published guidelines for operational definitions of low back pain and a recall period with the aim of introducing some standardisation[75] to the field. Arguably, these criteria should also be applied to TSP studies.

One year prevalence was the most common recall period reported in the literature. Although a Delphi study of international experts for low back pain recommended a standard recall period of 1 mo be used[75], the 1 yr period is arguably more relevant to occupational studies as it allows meaningful comparisons to industry-relevant outcome measures that are determined annually, such as absenteeism, days lost to injury, and compensation claims information. Moreover, the 1 yr recall period is standard in the widely used Nordic Musculoskeletal Pain Questionnaire[76]. Although recall bias becomes more problematic with a longer recall period[77], it is less likely to be threatened in the context of chronic pain, which is most relevant to employers, insurance providers, and policy makers. It is evident from this review that there is a lack of consensus regarding a standard recall period among researchers. For example, not all studies reported 1 yr prevalence while single studies reported 2 yr[36] and 1 mo[39] prevalence.

An extensive body of research has been dedicated to examining prevalence and risk factors for neck and low back pain among working populations. Consistent with the findings in this review, the prevalence of neck pain varies across occupational groups. For example, a recent systematic review reported the point prevalence to range from 4.8% in shoe-makers to 50.8% in drivers, the 1 wk prevalence ranged from 7.3% in office workers to 53.0% in plant workers, and the annual prevalence ranged from 17.0% in dentists to 74.0% in crane operators[8]. Occupational low back pain shares similar characteristics. Although the aggregate point prevalence for low back pain among European workers was 33.0% in 2000, it ranged from 22.0–57.0% depending on the occupation[78]. Collectively, these data highlight the importance of examining spinal pain characteristics across a range of occupational groups.

The results of TSP prevalence in this review are comparable with those of neck and low back pain. Although we cannot comment directly on the impact of TSP in working populations, based on the concordance in prevalence estimates, it may be that TSP imparts a similar personal and societal burden as neck and low back pain. An important avenue for future research in TSP will be to examine the severity, impact and sequelae of the condition among working populations. Examining spinal pain characteristics in discrete occupational groups may ultimately lead to the identification of occupationally-specific modifiable risk factors for TSP.

Given that many studies included more than one occupationally discrete cohort, we considered it more meaningful to report prevalence by cohort rather than by study. One year prevalence was the most commonly reported recall period (74% of cohorts, Fig. 1) and therefore the most valid dataset to compare TSP between occupational groups. In many occupational groups the maximum TSP prevalence was around 50% with the median around 30%. Within most groups there was marked variation in TSP prevalence. For example, within health professionals, cytotechnologists, physical therapists, nurses and occupational therapy students experienced more TSP than other health professionals. Whether these prevalence differences are due to different methods or actual disorder prevalence differences is unclear. When interpreting the TSP prevalence data across occupational groups, readers should be aware that the reported data are not age-adjusted.

In occupational cohorts where data for both genders were reported separately, females reported a higher prevalence of TSP in all occupational groups (farmers, air traffic controllers, aluminium plant operators) other than dental and occupational therapy students. The finding that generally females had a higher prevalence of TSP is consistent with trends in the general population and for neck and back pain[79]. The reason for male dental students reporting a higher prevalence of TSP is unknown, while the high prevalence of TSP among male occupational therapy students may be an aberration attributable to the very low number of males in that cohort (19 males vs. 128 females).

Factors associated with TSP

TSP seems to be associated with a broad range of

factors including individual worker, general work, physical work and psychosocial work factors. This is consistent with biopsychosocial models of the aetiology of work-related musculoskeletal disorders[80–82]. It is also consistent with reviews of the evidence for the work-relatedness of musculoskeletal disorders for the upper limb, neck and low back[83, 84]. The findings of this review confirm the need for future research to assess across multiple domains to adequately understand the role and interaction of different associated factors.

The factors identified are also consistent with prior research on work-related musculoskeletal disorders in other anatomical locations. For example, gender, high workload and high psychological load and have been reported as factors for upper extremity disorders[85, 86].

The associated factors identified in this review ranged from those which were relatively easy to operationalise (such as gender, concurrent musculoskeletal disorders and stair climbing) through to others which provide limited exposure information (such as 'perceived ergonomic problem' and 'high physical stress'). The difficulties in adequately capturing exposure to physical, and to a lesser extent psychosocial, factors is a recognised limitation of past research[87].

Strengths, limitations and future directions

Significant strengths of this review include the systematic search method utilised, ranking of study quality and assessment of an overall evidence base, and the selection of broad search terms which identified studies where reporting the prevalence and/or correlates of TSP was not a primary outcome. However, the review was limited to studies published only in English. It may be important to extend this work to compare TSP between different ethnic groups where occupational tasks remain constant. Notably, there is evidence to suggest that ethnicity influences low back and neck pain prevalence[8, 88, 89]. Although a broad indication of methodological strength can be obtained from ranking study design in a Hierarchy of Evidence, this literature review did not undertake a more detailed quality appraisal of the included studies, using a critical appraisal tool. Information from a more in-depth quality appraisal may have uncovered sufficient levels of bias in some studies to influence interpretation of their results, and hence the findings of this review should be interpreted in this context. However, the primary focus of this review was not in-depth quality appraisal, but a systematic gathering and reporting of current research evidence and this rationale has been used previously[18, 90]. A further limitation was that the majority of correlates for TSP were derived from bivariate analyses which are easily confounded as they fail to control for other potentially important associations. Studies using multiple regression models yield more robust risk and association estimates and should be used in future studies. Finally, risk factor estimates may be over estimates if there is a publication bias towards positive findings.

Acknowledgments: Dr Andrew Briggs, Dr Anne Smith and Professor Leon Straker are supported by fellowships awarded by the Australian National Health and Medical Research Council. The authors acknowledge Jay-Shian Tan and Jason Chua for providing administrative assistance.

References

1) Dagenais S, Caro J, Haldeman S. A systematic review of low back pain cost of illness studies in the United States and internationally. Spine Journal 2008; 8: 8–20.
2) Hansson EK, Hansson TH. The costs for persons sick-listed more than one month because of low back or neck problems. A two-year prospective study of Swedish patients. Eur Spine J 2005; 14: 337–45.
3) Collins JJ, Baase CM, Sharda CE, et al. The assessment of chronic health conditions on work performance, absence, and total economic impact for employers. J Occup Environ Med 2005; 47: 547–57.
4) Martin BI, Deyo RA, Mirza SK, et al. Expenditures and health status among adults with back and neck problems. J Amer Med Assoc 2008; 299: 656–64.
5) Ariens GAM, van Mechelen W, Bongers PM, Bouter LM, van der Wal G. Physical risk factors for neck pain. Scand J Work Environ Health 2000; 26: 7–19.
6) Hoogendoorn WE, van Poppel MNM, Bongers PM, Koes BW, Bouter LM. Physical load during work and leisure time as risk factors for back pain. Scand J Work Environ Health 1999; 25: 387–403.
7) Hoogendoorn WE, van Poppel MNM, Bongers PM, Koes BW, Bouter LM. Systematic review of psychosocial factors at work and private life as risk factors for back pain. Spine 2000; 25: 2114–25.
8) Cote 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 2008; 33: S60–74.
9) Briggs AM, Straker LM. Thoracic spine pain in youth: Should we be concerned? Spine Journal 2009; 9: 338–9.
10) Dionne CE, Bourbonnais R, Fremont P, et al. Determinants of "return to work in good health" among workers with back pain who consult in primary care settings: A 2-year prospective study. Eur Spine J 2007; 16: 641–55.
11) van der Windt D, Hay E, Jellema P, Main C. Psychosocial interventions for low back pain in primary care - Lessons learned from recent trials. Spine 2008; 33: 81–9.
12) Jones T, Evans D. Conducting a systematic review. Aust Crit Care 2000; 13: 66–71.
13) Guyatt GH, Sinclair J, Cook DJ, Glasziou P. User's guide to the medical literature: XVI. How to use a

treatment recommendation. Evidence-Based Medicine Working Group and the Cochrane Applicability Methods Working Group. J Amer Med Assoc 1999; 281: 1836–43.
14) Akinbo SRA, Odebiyi DO, Osassan AA. Characteristics of back pain among commercial drivers and motorcyclists in Lagos, Nigeria. West African J Med 2008; 27: 87–91.
15) Bragge P, Bialocerkowski A, McMeeken J. A systematic review of prevalence and risk factors associated with playing-related musculoskeletal disorders in pianists. Occup Med (Oxford) 2006; 56: 28–38.
16) Elwood MJ. Critical Appraisal of Epidemiological Studies and Clinical Trials, 2nd ed. Oxford: Oxford University Press; 1998.
17) National Health and Medical Research Council. NHMRC additional levels of evidence and grades for recommendations for developers of guidelines. Canberra: NHMRC. [Online]. 2008 [cited 2008 Mar 2] ; Available from: URL: http://www.nhmrc.gov.au/guidelines/consult/consultations/add_levels_grades_dev_guidelines2.htm
18) Weevers HJA, van der Beek AJ, Anema JR, van der Wal G, van Mechelen W. Work-related disease in general practice: a systematic review. Family Practice 2005; 22: 197–204.
19) Stroup DS, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology. A proposal for reporting. J Am Med Assoc 2000; 283: 2008–12.
20) Ackermann B, Adams R. Physical characteristics and pain patterns of skilled violinists. Med Prob Performing Artists 2003; 18: 65–71.
21) Arvidsson I, Arvidsson M, Axmon A, Hansson GA, Johansson CR, Skerfving S. Musculoskeletal disorders among female and male air traffic controllers performing identical and demanding computer work. Ergonomics 2006; 49: 1052–67.
22) Bjorksten MG, Talback M. A follow-up study of psychosocial factors and musculoskeletal problems among unskilled female workers with monotonous work. Eur J Pub Health 2001; 11:102–8.
23) Bork BE, Cook TM, Rosecrance JC, et al. Work-related musculoskeletal disorders among physical therapists. Phys Ther 1996; 76: 827–35.
24) Chandrasakaran A, Chee HL, Rampal KG, Tan GL. The prevalence of musculoskeletal problems and risk factors among women assembly workers in the semiconductor industry. Med J Malaysia 2003; 58: 657–66.
25) Chee HL, Rampal KG. Work-related musculoskeletal problems among women workers in the semiconductor industry in Peninsular Malaysia. Int J Occup Environ Health 2004; 10: 63–71.
26) Chee H-L, Rampal KG, Chandrasakaran A. Ergonomic risk factors of work processes in the semiconductor industry in Peninsular Malaysia. Ind Health 2004; 42: 373–81.
27) Choobineh A, Tabatabaei SH, Mokhtarzadeh A, Salehi M. Musculoskeletal problems among workers of an Iranian rubber factory. J Occup Health 2007; 49: 418–23.
28) Cromie JE, Robertson VJ, Best MO. Work-related musculoskeletal disorders in physical therapists: Prevalence, severity, risks, and responses. Phys Ther 2000; 80: 336–51.
29) Daraiseh N, Genaidy AM, Karwowski W, Davis LS, Stambough J, Huston RL. Musculoskeletal outcomes in multiple body regions and work effects among nurses: the effects of stressful and stimulating working conditions. Ergonomics 2003; 46: 1178–99.
30) de Zwart BCH, Broersen JPJ, Frings Dresen MHW, van Dijk FJH. Repeated survey on changes in musculoskeletal complaints relative to age and work demands. Occup Environ Med 1997; 54: 793–9.
31) Forde MS, Punnett L, Wegman DH. Prevalence of musculoskeletal disorders in union ironworkers. J Occup Environ Hyg 2005; 2: 203–12.
32) Friedrich M, Cermak T, Heiller I. Spinal troubles in sewage workers: epidemiological data and work disability due to low back pain. Int Arch Occup Environ Health 2000; 73: 245–54.
33) Gallis C. Work-related prevalence of musculoskeletal symptoms among Greek forest workers. Int J Ind Ergon 2006; 36: 731–6.
34) Hamalainen O. Thoracolumbar pain among fighter pilots. Military Med 1999; 164: 595–6.
35) Harlow SD, Becerril LAC, Scholten JN, Monroy DS, Sanchez RA. The prevalence of musculoskeletal complaints among women in Tijuana, Mexico: sociodemographic and occupational risk factors. Int J Occup Environ Health 1999; 5: 267–75.
36) Holder NL, Clark HA, DiBlasio JM, et al. Cause, prevalence, and response to occupational musculoskeletal injuries reported by physical therapists and physical therapist assistants. Phys Ther 1999; 79: 642–52.
37) Hou J, Shiao JS. Risk factors for musculoskeletal discomfort in nurses. J Nursing Res 2006; 14: 228–36.
38) Knibbe JJ, Friele RD. Prevalence of back pain and characteristics of the physical workload of community nurses. Ergonomics 1996; 39: 186–98.
39) Krause N, Scherzer T, Rugulies R. Physical workload, work intensification, and prevalence of pain in low wage workers: results from a participatory research project with hotel room cleaners in Las Vegas. Am J Ind Med 2005; 48: 326–37.
40) Kumar S, Moro L, Narayan Y. Morbidity among X-ray technologists. Int J Ind Ergon 2004; 33: 29–40.
41) LeClerc A, Landre M, Pietri F, Beaudoin M, David S. Evaluation of interventions for prevention of back, neck, and shoulder disorders in three occupational groups. Int J Occup Environ Health 1997; 3: 5–12.
42) Lee HY, Yeh WY, Chen CW, Wang JD. Prevalence and psychosocial risk factors of upper extremity musculoskeletal pain in industries of Taiwan: a nationwide study. J Occup Health 2005; 47: 311–8.
43) Mansfield NJ, Marshall JM. Symptoms of musculoskeletal disorders in stage rally drivers and co-drivers. Brit J Sports Med 2001; 35: 314–20.

44) Melis M, Abou-Atme YS, Cottogno L, Pittau R. Upper body musculoskeletal symptoms in Sardinian dental students. J Can Dent Assoc 2004; 70: 306–10.
45) Morken T, Magerøy N, Moen BE. Physical activity is associated with a low prevalence of musculoskeletal disorders in the Royal Norwegian Navy: A cross sectional study. BMC Musculoskelet Disord 2007; 8: 56.
46) Occhipinti E, Colombini D, Grieco A. Study of distribution and characteristics of spinal disorders using a validated questionnaire in a group of male subjects not exposed to occupational spinal risk factors. Spine 1993; 18: 1150–9.
47) Park H, Sprince NL, Whitten PS, Burmeister LF, Zwerling C. Risk factors for back pain among male farmers: analysis of Iowa Farm Family Health and Hazard Surveillance Study. Am J Ind Med 2001; 40: 646–54.
48) Piedrahita H, Punnett L, Shahnavaz H. Musculoskeletal symptoms in cold exposed and non-cold exposed workers. Int J Indust Ergon 2004; 34: 271–8.
49) Ramel EM, Moritz U, Jarnlo G. Recurrent musculoskeletal pain in professional ballet dancers in Sweden: a six-year follow-up. J Dance Med Sci 1999; 3: 93–100.
50) Ratzon NZ, Yaros T, Mizlik A, Kanner T. Musculoskeletal symptoms among dentists in relation to work posture. Work 2000; 15: 153–8.
51) Rehn B, Bergdahl IA, Ahlgren C, et al. Musculoskeletal symptoms among drivers of all-terrain vehicles. J Sound Vibration 2002; 253: 21–9.
52) Rising DW, Bennett BC, Hursh K, Plesh O. Reports of body pain in a dental student population. J Am Dental Assoc 2005; 136: 81–6.
53) Rosecrance JC, Cook TM, Zimmermann CL. Work-related musculoskeletal symptoms among construction workers in the pipe trades. Work 1996; 7: 13–20.
54) Russo A, Murphy C, Lessoway V, Berkowitz J. The prevalence of musculoskeletal symptoms among British Columbia sonographers. Appl Ergon 2002; 33: 385–93.
55) Salik Y, Ozcan A. Work-related musculoskeletal disorders: A survey of physical therapists in Izmir-Turkey. BMC Musculoskeletal Disord 2004; 5.
56) Sanders MJ, Morse T. The ergonomics of caring for children: an exploratory study. Am J Occup Ther 2005; 59: 285–95.
57) Shaw CJ, Shaw TF, Bowden PD. Study to determine the incidence of musculoskeletal complaints amongst podiatry students at Salford University. Brit J Podiatry 2001; 4: 120–3.
58) Smith D, Leggatta P, Clark M. Upper Body Musculoskeletal Disorders among Australian Occupational Therapy Students. Brit J Occup Ther 2006; 69: 365–72.
59) Smith DR, Leggat PA. Prevalence and distribution of musculoskeletal pain among Australian medical students. J Musculoskeletal Pain 2007; 15: 39–46.
60) Smith DR, Mihashi M, Adachi Y, Koga H, Ishitake T. A detailed analysis of musculoskeletal disorder risk factors among Japanese nurses. J Safety Res 2006; 37: 195–200.
61) Smith DR, Wei N, Kang L, Wang RS. Musculoskeletal disorders among professional nurses in mainland China. J Prof Nurs 2004; 20: 390–5.
62) Smith DR, Wei N, Zhang YJ, Wang RS. Musculoskeletal complaints and psychosocial risk factors among physicians in mainland China. Int J Ind Ergon 2006; 36:599–603.
63) Smith DR, Wei N, Zhao L, Wang RS. Musculoskeletal complaints and psychosocial risk factors among Chinese hospital nurses. Occup Med (Oxford) 2004; 54: 579–82.
64) Thompson SK, Mason E, Dukes S. Ergonomics and cytotechnologists: Reported musculoskeletal discomfort. Diagnostic Cytopath 2003; 29: 364–7.
65) Williams NR, Dickinson CE. Musculoskeletal complaints in lock assemblers, testers and inspectors. Occup Med (Lond) 1997; 47: 479–84.
66) Xiang H, Stallones L, Hariri S, Darragh A, Chiu Y, Gibbs-Long J. Back pain among persons working on small or family farms—Eight Colorado counties, 1993–1996. Morbidity and Mortality Weekly Report 1999; 48: 301–4.
67) Yeung SS, Genaidy A, Deddens J, Alhemood A, Leung PC. Prevalence of musculoskeletal symptoms in single and multiple body regions and effects of perceived risk of injury among manual handling workers. Spine 2002; 27: 2166–72.
68) Yeung SS, Genaidy A, Levin L. Prevalence of musculoskeletal symptoms among Hong Kong nurses. Occup Ergon 2004; 4: 199–208.
69) Zetterberg C, Backlund H, Karlsson J, Werner H, Olsson L. Musculoskeletal problems among male and female music students. Med Prob Performing Artists 1998; 13: 160–6.
70) Morken T, Moen B, Riise T, et al. Prevalence of musculoskeletal symptoms among aluminium workers. Occup Med (Lond) 2000; 50: 414–21.
71) Cassidy JD, Carroll LJ, Cote P. The Saskatchewan Health and Back Pain Survey: The prevalence of low back pain and related disability in Saskatchewan adults. Spine 1998; 23: 1860–7.
72) Hogg-Johnson S, van der Velde G, Carroll LJ, et al. The burden and determinants of 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 2008; 33: S39–51.
73) Linton SJ, Hellsing A, Hallden K. A population-based study of spinal pain among 35–45-year-old individuals: prevalence, sick leave, and health care use. Spine 1998; 23: 1457–63.
74) Watson KD, Papageorgiou AC, Jones GT, et al. Low back pain in schoolchildren: Occurrence and characteristics. Pain 2002; 97: 87–92.
75) Dionne CE, Dunn KM, Croft PR, et al. A consensus approach toward the standardization of back pain definitions for use in prevalence studies. Spine 2008; 33: 95–103.
76) Kuorinka I, Jonsson B, Kilbom A, et al. Standardised

Nordic questionnaires for the analysis of musculoskeletal symptoms. Appl Ergon 1987; 18: 233–7.
77) Orhede E. Nordic cooperation in research on the work environment. Scand J Work Environ Health 1994; 20: 65–6.
78) Paoli P, Merllie D. Third European survey on working conditions 2000. Dublin: European Foundation for the Improvement of Living and Working Conditions; 2001.
79) Schneider S, Randoll D, Buchner M. Why do women have back pain more than men?—A representative prevalence study in the Federal Republic of Germany. Clin J Pain 2006; 22: 738–47.
80) Armstrong TJ, Buckle P, Fine LJ, et al. A conceptual model for work-related neck and upper-limb musculoskeletal disorders. Scand J Work Environ Health 1993; 19: 73–84.
81) Kumar S. Theories of musculoskeletal injury causation. Ergonomics 2001; 44: 17–47.
82) Moon S, Sauter S. Psychosocial aspects of musculoskeletal disorders on office work. London: Taylor and Francis; 1996.
83) Bernard BP. A critical review of epidemiological evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. Cincinnati: DHHS (NIOSH); 1997.
84) Buckle P, Devereux J. Work-related neck and upper limb musculoskeletal disorders. Surrey: Robens Centre for Health Ergonomics, European Institute of Health and Medical Sciences; 1999.
85) Punnett L, Gold J, Katz JN, Gore R, Wegman DH. Ergonomics stressors and upper extremity musculoskeletal disorders in automobile manufacturing: A one year follow up study. Occup Environ Med 2004; 61: 668–74.
86) Norman K, Floderus BHM, Toomingas A, Tornqvist EW. Musculoskeletal symptoms in relation to work exposures at call centre companies in Sweden. Work 2008; 30: 201–14.
87) Winkel J, Mathiassen SE. Assessment of physical work load in epidemiologic studies: Concepts, issues and operational considerations. Ergonomics 1994; 37: 979–88.
88) Hardt J, Jacobsen C, Goldberg J, Nickel R, Buchwald D. Prevalence of chronic pain in a representative sample in the United States. Pain Med 2008; 9: 803–12.
89) Alexopoulos EC, Burdorf A, Kalokerinou A. A comparative analysis on musculoskeletal disorders between Greek and Dutch nursing personnel. Int Arch Occup Environ Health 2006; 79: 82–8.
90) Jeffries LJ, Milanese SF, Grimmer-Somers KA. Epidemiology of adolescent spinal pain. A systematic overview of the research literature. Spine 2007; 32: 2630–7.