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Low back pain in car drivers: A review of studies published 1975 to 2005

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Abstract

This review investigates whether there is evidence of an association between car driving and low back pain, and evidence that whole-body vibration contributes to low back pain in car drivers. The evidence of an association between various physical, psychosocial and individual factors and low back pain in car drivers was also investigated. From 23 epidemiological studies of low back problems in groups that reported car driving, nine studies fulfilled simple criteria for detailed review: four cross-sectional studies, three case-control studies and two longitudinal studies. The definition of low back pain was often unclear and, mostly, the physiological mechanisms causing low back pain were not considered. Eight of the nine studies concluded that there was an increase in low back pain among car drivers but there was little consideration of the influence of the many physical factors, individual factors and psychosocial factors that might be associated with an increase in low back pain. Consequently, there is insufficient evidence to form a conclusion on whether whole-body vibration, postural stressors or other factors, specific or not specific to driving, are common causes of low back problems in car drivers.

1. Introduction

The possibility that exposure to whole-body vibration may cause disorders of the body has been the subject of many epidemiological studies. Reviews of epidemiological studies of persons occupationally exposed to whole-body vibration conclude that long-term exposure to whole-body vibration is associated with increased risk of low back pain, sciatic pain and degenerative changes in the spinal system [1–4]. Some reviews have suggested that other health problems, such as digestive and reproductive system disorders, peripheral nervous system disorders and vestibular and visual problems may also be increased among professional drivers [1,2].

The cause of increased prevalence of low back pain in populations is often uncertain. However, studies have found associations between low back pain and physical factors such as heavy manual work [5–10] and awkward postures held while working or driving [5,7,8,10]. Many studies have also found psychosocial factors, such as job satisfaction or stress [11,12] and individual factors (age, gender, anthropometrics, tobacco consumption, etc.) to be associated with back pain [13–20].

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Previous critical reviews of epidemiological studies of groups exposed to whole-body vibration have mostly considered tractor drivers, truck drivers, bus drivers, helicopter pilots, and drivers of heavy off-road machines (e.g. earth moving machines, cranes, excavators) [1–4,21]. Car drivers are sometimes considered as a control group in epidemiological studies. Although car drivers are usually exposed to a lower level of whole-body vibration than drivers of some other vehicles, long durations of exposure of vibration, prolonged sitting, and other factors common to car driving might be associated with low back pain.

This critical review was performed to investigate the quality of epidemiological studies of back pain among car drivers. The review considers studies published during the last 30 years and looks for evidence of an association between car driving and low back pain, evidence that low back pain in car drivers is caused by vehicular vibration, and evidence of an association between other physical, psychosocial and individual factors and low back pain in car drivers.

2. Methods

2.1. Source and selection of reviewed studies

Most of the reviewed epidemiological studies were found in the Human Response to Vibration Literature Collection at the Institute of the Sound and Vibration Research at the University of Southampton, United Kingdom. A search for related papers was also carried out on the Internet and in the Medline database (National Library of Medicine, United States of America). Electronic searches used various combinations of the following terms: whole-body vibration, driving, car, low back pain, herniated lumbar disc, sciatica, and epidemiology.

All epidemiological studies relevant to selected search terms were examined but only studies that fulfilled the following simple criteria were chosen for review: (i) epidemiological study, (ii) investigation of occurrence of low back pain or sciatica, (iii) investigation of car driving as a factor leading to low back problems. Because of the very small number of relevant studies, the selection criteria were based on the nature of the studies and not the quality of the studies. The text below provides information from which the quality of the studies can be judged.

2.2. Analysis of reviewed studies

Each study was analysed and summarised in tabular form under nine headings: (i) author and year of publication; (ii) study design; (iii) subject group; (iv) control group; (v) data source; (vi) confounders controlled for; (vii) driving exposure description; (viii) health outcome; and (ix) author's conclusion.

3. Results and discussion

3.1. Characteristics of study populations

Twenty-three studies were found [11,22–44]. Each of the studies is summarised in Table 1.

The influence of car driving was considered in all 23 studies. However it is mainly from nine studies that information specific to car drivers is available (e.g. factors associated with back problems in car drivers as opposed to factors associated with back problems in a wider group) [23,28,30,38–42,44].

These nine study populations were considered populations of 'car drivers', as indicated by the profession of the participants (taxi drivers [42,44], commercial travellers [30], professional drivers (taxi drivers, instructor drivers) [28], rally drivers [38,39]) or because their reported hours of driving exceeded 20 h per working week [23,40,41]. The remaining 14 studies were not considered to be populations of 'car drivers' because either there was no information on driving hours, or there were insufficient hours driven per week, or there was no information on the number of participants (or a low number of participants) driving for long durations. The following critical review therefore focuses on only nine epidemiological studies of low back pain among car drivers.

Table 1
Summary of reviewed epidemiological studies. The nine selected studies of car drivers are highlighted in *italic*

Author	Study design	Subject group	Control group	Data source	Confounders controlled for	Driving exposure description	Health outcome	Author's conclusion
Kelsey [22]	Case-control study ($n = 934$)	Subjects with acute HLID[a]	Subjects without problems (matched and unmatched control group)	X-ray, interview, diagnostic tests	Sitting, age, driving, lifting, pushing, pulling, carrying	Duration: job involving sitting half of the working time in a motor vehicle	Driving a motor vehicle and herniated disc: RR = 2.75	People in occupations requiring prolonged driving of motor vehicles appear to be at particularly higher risk of HLID. Another associated factor was prolonged sitting
Kelsey and Hardy [23]	*Case-control study ($n = 934$)*	*Subjects with acute HLID (group of drivers)*	*Subjects without problems (matched and unmatched control group)*	*X-ray, interview, diagnostic tests*	*Driving*	*Duration: job involving sitting half of the working time in a motor vehicle*	*Occupational driving and herniated disc: RR = 2.75 Other driving and herniated disc: RR = 2.16*	*Driving of motor vehicles was associated with an increased risk of HLID. Those spending half or more of the working time driving are about 3 times more likely to develop HLID*
Buckle et al. [24]	Cross-sectional study (pilot study)	General population ($n = 68$)	None	Interview	Driving, bending, lifting, twisting	Mileage: $\leqslant$19,000 miles/year >19,000 miles/year average annual miles: 16,754	69% of studied population reported more than one episode of LBP	Driving high mileages (over 19,000 miles/year) was a significant factor affecting occurrence and location of pain
Frymoyer et al. [11]	Cross-sectional study	General population $n = 3920$ ($\leqslant$55 years)	None	Questionnaire	Age, sport, psychosocial factors, smoking, lifting, carrying, pulling, pushing, bending, twisting, driving	No information about duration or distance of driving	LBP during past 3 years: males—11% females—9.5%	No relation was found between driving and LBP. Smoking, anxiety, depression, pregnancy, lifting, carrying, pushing, pulling, bending, twisting, and vibration (nondriving) were all identified to have a relation to LBP
Frymoyer et al. [25]	Cross-sectional study ($n = 1221$)	General population (no pain, moderate pain, severe pain) (18–55 years)	None	Questionnaire	Age, smoking, lifting, carrying, hand-transmitted vibration, driving, sport	No information about duration or distance of driving	Lifetime prevalence of LBP: 69.9%. 88.1% of patients with moderate pain and 89.5% of patients with severe LBP reported driving	Driving of automobiles was more frequent in those with LBP. Other risk factors associated with severe LBP were repetitive lifting, using vibratory hand-tools, smoking and tobacco consumption
Kelsey et al. [26]	Case-control study ($n = 566$)	Subjects with acute HLID	Subjects without problems (matched and unmatched control group)	X-ray, interview, diagnostic tests	Age, height, weight, smoking, lifting, driving, sport	Vehicle type: Ford Motor Company (FMC), American Motors (AM), General Motors (GM), Chrysler Corporation (CC), Japanese and Swedish cars	The risk for prolapsed lumbar disc was associated with each additional amount of 5 h/week spent driving the following vehicles: OR = 1.4 (FMC/AM),OR = 1.2 (GM/CC), OR = 0.7 (Swedish/Japanese cars)	Increased risk associated with each 5 hours per week spent driving in a motor vehicle over the past 5 years (except Swedish and Japanese cars). Another factor affecting HLID was smoking

Table 1 (*continued*)

Author	Study design	Subject group	Control group	Data source	Confounders controlled for	Driving exposure description	Health outcome	Author's conclusion
Heliövaara [27]	Longitudinal study ($n = 2732$)	Subjects with HLID or sciatica	General population	Questionnaire	Gender, occupational activity, work capacity, driving, chronic cough, stress	Occupation: motor vehicle drivers	Risk of HLID in vehicle drivers: RR = 2.9 Risk of HD or sciatica in vehicle drivers RR = 4.6	Motor vehicle drivers showed the highest relative risk of herniated lumbar disc. The risk of herniated lumbar disc was about three times and sciatica over four times higher than in other professional workers
Hedberg [28]	*Case-control study ($n = 570$)*	*Professional drivers*	*Professional drivers*	*Questionnaire*	*Age*	*Occupation: professional drivers (taxi drivers, driving instructors, lorry drivers, truck drivers, etc.)*	*Prevalence of LBP complaints was higher that in other body regions for all drivers group Risk of LBP in: taxi drivers RR = 0.91 instructor drivers RR = 1.17 (when all drivers used as comparison group)*	*The period prevalence of musculoskeletal complaints was highest for LBP and tended to increase with age*
Walsh et al. [29]	Cross-sectional study ($n = 545$)	General population (20–70 years)	None	Questionnaire	Age, lifting, driving, sitting, walking, using vibrating machinery	Duration: Driving car >4 h/day	Lifetime prevalence of LBP: males—64.5%, females—61.4%, Total—63% Sciatica: males—9.5%, females—2.03%	Car driving increased the risk of LBP among men but not among women. Lifting and carrying weights over 25 kg, and sitting >2 h/day were associated with LBP
Pietri et al. [30]	*Longitudinal study ($n = 1719$) (Baseline: cross-sectional)*	*Commercial travellers*	*None*	*Interview*	*Age, gender, smoking, BMI,* [b] *carrying, standing, psychosocial problems*	*Information about the vehicle driven Distance: km/year Duration: h/week*	*Prevalence of LBP (%): males = 25.1, females = 34.9 Incidence of LBP: males = 12.6, females = 16.8 OR for incidence of LBP and driving: 10–14 h/week: 4.0, 15–19 h/week: 4.8 20–24 h/week: 3.3, ⩾25 h/week: 3.7*	*Baseline study: the strongest relationship with LBP was observed for driving (⩾20 h/week), psychosomatic factors, smoking, standing, and carrying loads. Follow-up: the relationship with LBP was observed for driving and psychosocial factors*
Masset and Malchaire [31]	Cross-sectional study ($n = 618$)	Blue collar workers (⩽40 years)	None	Questionnaire	Age, driving, strained posture, lifting, psychosocial characteristics	Frequency of exposure	Lifetime prevalence of LBP: 66% 12-month prevalence of LBP: 50% 7-day prevalence of LBP: 25%	Daily duration of driving vehicles and heavy effort with shoulders were significantly associated with LBP
Liira et al. [33]	Cross-sectional study ($n = 38,540$)	Nine occupational groups (blue and white collar workers)	None	Questionnaire	Gender, age, smoking, education, sitting, driving, lifting, bending, BMI	Duration: driving for more than $\frac{1}{2}$ working day	OR of LBP and driving: white-collar workers OR = 1.15, blue-collar workers OR = 1.28	Age, smoking, blue-collar occupation, bending, lifting, working with vibrating machines, awkward position were all related to increased risk of LBP

Xu et al. [34]	Cross-sectional study ($n = 5185$)	Random sample of population (11 occupational groups)	None	Telephone interview	Gender, education, heavy lifting, concentration, walking, standing up, twisting or bending, driving	Duration: exposure to WBV <37 h/week exposure to WBV $\geqslant 37$ h/week	LBP prevalence: males—63% females—57%	Increased risk of LBP for vibration affecting the whole body, physical hard work, frequently twisting or bending, standing up, concentration demands
Barnekow-Berkvist et al. [35]	Longitudinal study (baseline: cross-sectional) ($n = 425$)	Students	None	Questionnaire, diagnostic tests	BMI, smoking, sport, fixed posture, lifting, driving	No information about duration or distance of driving	One year prevalence of LBP: males: 50% females: 40.5%	Low back problems were associated with monotonous work among men and women, and exposure to vibration among men
Levangie [36]	Longitudinal study (baseline: case-control study) ($n = 300$)	Subjects with low back pain ($n = 150$)	Subjects without low back pain ($n = 150$)	Questionnaire	Smoking, driving, sitting, lifting, standing, sport, BMI	Duration: <1 h/day, $\geqslant 1$ h/day	Association between LBP and spending $\geqslant 1$ h/day in car (compared with <1 h/day): OR $= 2.49$	LBP was positively associated with smoking, pregnancy, industrial vibration and time spent in a car
Ozguler et al. [37]	Cross-sectional study ($n = 725$)	Active workers (office, hospital, warehouse and airport sectors)	None	Questionnaire	Gender, age, BMI, psychological stress, pulling, pushing, carrying, driving for more than 2 h/day, bending	Duration: never or seldom, often or every day driving	Six-month prevalence of LBP: 43.03% (male and female), 40.85% (male), 45.4% (female)	Driving more than 2 h/day was a risk factor for chronic LBP
Videman et al. [38]	*Case-control study* ($n = 32$)	*Top rally drivers and co-drivers* ($n = 18$)	*General population* ($n = 14$)	*Interview, MRI* [c]	*Driving, age*	*Rally driving: mean speed* >100 *km/h up to 200 km/h, extreme vibration, shock impact from frequent jumps 2–5 m up to 20m*	*Twelve-month prevalence of LBP among rally drivers: 89% Twelve-months prevalence of LBP among control group: 79%*	*Results do not indicate driving and associated WBV exposure as significant causes of disc degeneration*
Mansfield and Marshall [39]	*Cross sectional study* ($n = 90$)	*Rally drivers and co-drivers*	*None*	*Questionnaire*	*Driving*	*Years of rallying, extreme driving condition*	*Problems: lumbar spine 70%, cervical spine 54%, shoulders 47%, thoracic spine 36%*	*Higher prevalence of LBP in drivers and co-drivers than generally reported by workers exposed to WBV. The prevalence of back problems is related to the extreme environment of the rally car*
Battié et al. [40]	*Longitudinal study (baseline: case-control)* ($n = 90$)	*Monozygotic twins*	*(identical twins)*	*Interview, MRI*	*Driving, smoking, lifting, twisting*	*Duration: h/week, type of vehicle, calculation of driving exposure for every job held*	*Frequency of LBP over past 12 months (1–7 scale): drivers: 4.7, twin siblings: 4.7*	*Driving was not associated with accelerated lumbar degeneration and structural abnormalities. Occupational drivers and their co-twins reported similar amounts of LBP*

Table 1 (*continued*)

Author	Study design	Subject group	Control group	Data source	Confounders controlled for	Driving exposure description	Health outcome	Author's conclusion
Porter and Gyi [32,41]	*Cross-sectional study ($n = 600$)*	*Randomly selected population*	*None*	*Interview*	*Age, gender, smoking, BMI, sport*	*Annual mileage (private), driving for work per week (hours, miles), journey to work per week (hours, miles)*	*Mean number of days ever absent from work with low back trouble: 22.4 (≥25,001miles/year), 3.3 (<5000miles/year), 51.4 (driving >20 h/week), 8.1 (<10 h/week)*	*Car driving, in terms of annual mileage, distance driven to work, and time taken to drive this distance, are associated with reported sickness absence due to low back troubles*
Chen et al. [42]	*Cross-sectional study ($n = 1242$)*	*Taxi drivers*	*None*	*X-ray, questionnaire*	*Lifting, twisting and bending, psychosocial factors, age, gender, BMI, sport, driving*	*Duration: ≤5 years of driving, 6–15 years of driving, >15 years of driving*	*One year prevalence of LBP = 51% Total prevalence of ASL[d] = 3.2% Prevalence of ASL: ≤5 years of driving = 1.1%, 6–15 years of driving = 2.4%*	*Driving taxi >5 years, age, BMI, strenuous exercise were significantly associated with higher prevalence of spondylolisthesis*
Tubach et al. [43]	Longitudinal study ($n = 3240$)	Subjects working in the national electricity and gas company	None	Questionnaire	BMI, hobby, carrying, driving, pulling, pushing, depression, job satisfaction	Duration: driving more than 2 h/day (combination of driving at work and commuting to and from work)	Persistence or occurrence of sciatica when driving >2 h/day: < once a week: OR = 2.37, > once a week: OR = 1.79, everyday: OR = 1.01	Factors that predict the persistence or recurrence of sciatica: a job involving carrying heavy loads or driving more than 2 h/day, a high psychosomatic score
Chen et al. [44]	*Cross-sectional study ($n = 1355$)*	*Taxi drivers*	*None*	*Questionnaire*	*Twisting and bending, lifting, driving, psychosocial factors*	*Duration: Years of driving, days/month driving, hrs/day driving*	*OR of LBP in different duration driving groups: ≤4hrs/day: OR = 1 4–8 h/day: OR = 1.41 8–10 h/day: OR = 1.76 >10 h/day: OR = 2.12*	*After adjustment of potential factors was found that driving time >4 h/day, frequent bending/twisting while driving, job stress, job dissatisfaction were significantly associated with higher LBP prevalence*

[a] HLID (herniated lumbar intervertebral disc).
[b] BMI (body mass index).
[c] MRI (magnetic resonance imaging).
[d] ASL (spondylolisthesis).

Four of the nine papers reported low back pain in professional drivers (taxi drivers, insurance, real estate, technical salesmen and service advisors) [28,30,42,44]. Two studies investigated rally drivers and their co-drivers [38,39]. In four studies, the subject groups were not selected on the basis of whether their occupation or leisure time involved driving: two studies of the general public [23,41], and one study of monozygotic twins [40].

The research methods, how the study and control populations were chosen, and how some cases were excluded from each study, were described in all nine studies [23,28,30,38–42,44], but the response rate was reported in only six studies [23,28,39,40,42,44].

Four studies used a cross-sectional design with a single examination of the relationship between disease and the variables of interest in the selected population [39,41,42,44]. Three studies used a case-control design, where individual cases of disease were matched with individuals from a control group (the matching was based mainly on age and gender) [23,28,38]. The remaining two studies used a longitudinal design, where subjects were followed over a period of time with continuous or repeated monitoring of risk factors and health outcomes [30,40]. In one longitudinal study, the baseline was cross-sectional [30] and in another the baseline was case-control [40].

The comparison of epidemiological studies in this area is complex: there are differences in study design, study populations, measures of driving exposure, influencing risk factors and methods of analysis. Bovenzi and Hulshof [4] in their literature review used a quality rating that allowed them to select studies. The rating system was based on objective criteria such as the assessment of whole-body vibration exposure, assessment of health effects and methodology, etc. The adoption of the selection criteria used by Bovenzi and Hulshof would exclude all of the published studies of back problems in car drivers. Lings and Leboeuf-Yde [21] defined a quality criteria rating for their literature review based on the presence of a relevant control group, description of sampling methods, response rate, description of vibration dose, definition of the prevalence of low back pain in relation of exposure, etc. A rating system could be based on criteria for adequately considering and reporting relevant factors, such as those summarised in Tables 2 and 3. It would be essential to meet some of the criteria, but the most powerful studies would tend to be those that met the greatest number of criteria. With only nine studies to consider, it was decided that a rating system for selecting studies was inappropriate for the purposes of this review.

The study designs employed in some of the nine reviewed investigations are sufficient to doubt any conclusions. For example, some cross-sectional studies had no suitable control and all such studies are vulnerable to the 'healthy worker' effect in which those with symptoms leave the study population.

3.2. *Methods of collecting information*

The primary methods of collecting data were questionnaires and personal interviews. In four studies, the source of information was a self-administered health questionnaire [28,39,42,44], which was mostly based on the Nordic Musculoskeletal Questionnaire developed by Kuorinka et al. [45]. Only three papers reported how the questionnaire was modified to suit the selected population [28,38,42]. Five studies used an oral interview [23,30,38,40,41]. X-rays were obtained in two studies [23,42], and magnetic resonance images (MRI) in two other studies [38,40]. One study used diagnostic tests [23] (functional tests of muscular endurance, strength, flexibility and standing balance, straight leg raising test).

Almost all studies described the methods used to determine whether diseases were associated with population characteristics. Mostly, either the odds ratio or the relative risk was used as the quantitative measures of risk associated with a specific factor. Three studies used logistic regression to calculate odds ratios [30,42,44] and two studies calculated the relative risk [23,28] for individual factors that might contribute to the occurrence of back problems.

A clear definition of the back problems investigated was missing or unclear in five studies. The most frequently reported type of investigated low back problem was a herniation of an intervertebral disc (a rupture of the outer casing of an intervertebral disc allowing the soft nucleus of the disc to prolapse and rupture adjacent ligaments or press on a sciatic nerve and cause pain radiating down to legs) [23,38,40]. In five studies the type of back problem was not specified and often merely characterised as 'low back pain' or 'musculoskeletal problems'.

Table 2
Characteristics described in the nine selected studies of car drivers

First author and reference no.	Clear description of methods and selection of studied population	Occup. of driver	Clearly reported response rate	Data source		Statistical analyses clearly described	Type of back problems clearly described	Risk factors controlled for		
				Questionnaire/ Interview	Medical examination			Individual factors	Physical factors	Psychosocial factors
Kelsey [23]	Yes	No	Yes	Yes	Yes	Yes	Yes	Not reported		
Hedberg [28]	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes
Pietri [30]	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No
Videman [38]	Yes	Yes	No	Yes	Yes	No	No	Yes	No	No
Mansfield [39]	Yes	Yes	Yes	Yes	No	No	Yes	Not reported		
Battié [40]	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Porter [32,41]	Yes	No	No	Yes	Yes	Yes	No	Yes	No	Yes
Chen [42]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chen [44]	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes

Table 3
Risk factors for low back pain investigated in the nine selected studies of car drivers

First author and reference no.	Individual factors					Physical factors						Psychosocial factors
	Gender	Age	BMI	Sport	Smoking	Driving	Lifting	Twisting & Bending	Carrying	Sitting	Standing/ Walking	
Kelsey [23]	No	No	No	No	No	Yes (+)	No	No	No	No	No	No
Hedberg [28]	No	Yes (+)	No	No	No	Yes (+)	No	No	No	No	No	No
Pietri [30]	Yes (+)	Yes (−)	Yes (−)	Yes (+)	Yes (+)	Yes (+)	No	No	Yes (+)	No	Yes (+)	Yes (+)
Videman [38]	No	Yes (−)	No	No	No	Yes (−)	No	No	No	No	No	No
Mansfield [39]	No	No	No	No	No	Yes (+)	No	No	No	No	No	No
Battié [40]	No	No	No	No	Yes (−)	Yes (−)	Yes (−)	Yes (−)	No	No	No	No
Porter [32,41]	Yes (−)	Yes (−)	Yes (−)	Yes (−)	Yes (−)	Yes (+)	No	No	No	No	No	Yes (−)
Chen [42]	Yes (+)	Yes (+)	Yes (+)	Yes (+)	No	Yes (+)	Yes (−)	Yes (−)	No	No	No	Yes (−)
Chen [44]	No	No	No	No	No	Yes (+)	Yes (−)	Yes (+)	No	No	No	Yes (+)

Yes (+)—risk factor influenced the prevalence of low back pain in car drivers.
Yes (−)—no association between risk factor and low back pain was found.
No—factor not investigated.

3.3. Effects of car driving

The studies differ in the type and the quality of the information provided on exposure to driving.

3.3.1. Exposure to vibration

Information on the relationship between low back pain and whole-body vibration in the reviewed studies is unsatisfactory and consideration of a dose–response relationship minimal. Only one study reported the lifetime occupational driving hours and the frequency-weighted vibration driving hours (number of hours spent in driving jobs multiplied by an estimate of the frequency-weighted vibration magnitude for the corresponding vehicle type as measured according to an International Standard) [41]. This study found no tendency towards increased risk of low back pain in drivers compared with non-drivers, even though the drivers experienced greater levels of whole-body vibration.

3.3.2. Duration of driving

Six studies investigated back problems among participants divided into subgroups related to their duration of driving (e.g. driving for more than 2 h per day, driving for more than half of the working day, more than 5 years of driving, etc.) [23,30,40–42,44]. Two studies formed subgroups according to driving distance (e.g. annual mileage, weekly mileage, annual kilometres) [30,41]. In two studies, subjects were rally drivers and their co-drivers. Rally driving was characterised by driving at high speed (up to 200 km per hour) on poor quality roads with extreme vibration and shock impacts from frequent jumps (2–5 m up to 20 m) [38,39]. All except two of these studies concluded that drivers with increased duration of exposure to driving had increased risk of low back pain. In a study of taxi drivers it was found that a greater number of years of taxi driving was not associated with increased prevalence of low back pain, although driving for more than four hours per day was associated with low back pain [43]. Some studies of drivers occupationally exposed to levels of whole-body vibration greater than those in cars, have found increased occurrence of back pain with increasing duration of driving [13–15,46,47].

The authors of only one of the reviewed studies considered the effect of the model of car and car features as potentially influencing factors for low back problems [41].

3.4. Physical factors influencing back pain in car drivers

The physical risk factors investigated are summarised in Table 3.

All except five of the nine studies discussed the influence of factors other than driving tasks on the occurrence of back problems [30,40,42,44].

The most frequently considered influencing factors were lifting (3 studies), frequent twisting and bending (3 studies), carrying heavy loads (1 study), and standing (1 study).

3.4.1. Lifting

Repetitive heavy lifting has been found to be an important risk factor for low back pain in many previous studies [5–10]. In this review, lifting was investigated as a risk factor in only three of the nine studies [40,42,44] and in none of these was lifting found to be associated with low back pain. Whether lifting will have an effect on back pain will depend on the extent of lifting, but this was not usually reported. Possibly, the absence of an effect of lifting in some studies may arise from only a few of the population performing heavy or frequent lifting. Alternatively, the study designs were insufficiently sensitive to detect this well-established cause of low back pain.

3.4.2. Twisting and bending

Three studies considered twisting and bending in car drivers [40,42,44], but only one found a relationship between bending and twisting and low back pain [44]. Many other studies have found that twisting and bending are associated with increased risk of low back pain [5,7,8,10].

3.4.3. Other physical factors

Among the nine populations of car drivers, one study found the carrying of heavy loads a risk factor for low back pain in the cross-sectional stage of the study but not in the longitudinal stage of the study [30]. The same study investigated the influence of standing on back problems and concluded that standing increased low back pain at the cross-sectional stage of the study, although there was no relation with low back pain over the longitudinal stage of the study [30].

3.5. Effects of individual factors and psychosocial factors on low back pain in car drivers

Of the nine studies of car drivers, the influences of individual risk factors (e.g. gender, age, body size) and psychosocial risk factors (e.g. stress) were investigated in seven studies [28,30,38,40–42,44]. The individual risk factors and the psychosocial risk factors investigated are summarised in Table 3.

3.5.1. Gender

Of three studies that compared the occurrence of low back pain between males and females, two found a higher probability of developing low back problems among female participants [30,42]. This is consistent with other studies [16,17], although it should be taken in account that women report a slightly higher level of many symptoms [12,35]. The remaining six studies of car drivers did not investigate the influence of gender on low back pain.

3.5.2. Age

Many studies have found that the risk of back pain increases with age [13,14]. In the studies reviewed here, only two found the prevalence of low back pain to be greater with increased age [28,42], while three studies found that age did not increase the risk of low back pain [30,38,41]. In the remaining studies, age was not investigated as a risk factor for low back pain. The influence of age is likely to be complex. For example, older drivers with back pain may be more likely to leave their job. Age may co-vary with the characteristics of the car, so older drivers may drive cars of a different size or with different features, such as automatic gearboxes.

3.5.3. Smoking

Smoking is a commonly reported risk factor for back problems [18–20]. The mechanisms associating low back pain with smoking are not proven. One explanation is that smoking increases chronic coughing which puts more pressure on the intervertebral disc and influences disc prolapse and sciatica. Another explanation is that smoking changes disc nutrition and reduces bone mineral content, making the disc more vulnerable to microfractures [11,25,26]. Three of the nine studies of car drivers considered the influence of smoking: one study found that smoking increased low back pain in the cross-sectional part of the study but not in the follow-up study [30], and two studies did not find an influence of smoking on low back pain in car drivers [40,41].

3.5.4. Psychosocial factors

Psychosocial factors (stress, depression, anxiety, etc.) have relationships with back pain [11,12] but the evidence is too limited to be certain of the mechanisms. Psychosocial stress was investigated in only four of the nine studies. Two studies found that psychosocial stress was not related to low back pain [41,42], whereas another two found an association between psychosocial factors and low back pain in commercial drivers and in taxi drivers [30,44].

3.5.5. Other individual factors

Three studies investigated the relationship between body mass index and low back problems. One study reported that a higher body mass index was a risk factor leading to low back pain [42], but the other two studies did not find a link between low back pain and body mass index [30,41].

Two studies reported an increased risk of low back pain when investigating the relationship between participation in sport and low back pain [30,42] whereas another study that considered the influence of sport did not discover an increased risk of low back pain [41].

3.6. Is the evidence presented in the reviewed studies sufficient to conclude that driving a car is a risk factor for low back pain?

Many of the studies may be considered unsatisfactory due to the lack of information about driving, and a critical review could cast doubt on the interpretation of most studies. Nevertheless, the body of evidence cannot be lightly dismissed—the risk of back pain among car drivers merits consideration.

Overall, seven of the nine studies reviewed here concluded that there is a relation between low back pain and car driving [23,28,30,39,41,42,44]. However, the strength of the evidence on which this conclusion is based varies greatly between the studies. A relation between low back pain and driving is consistent with, but not necessarily explained by, the conclusion of the literature review of Bovenzi and Hulshof [4] who were mainly concerned with driving environments having high levels of whole-body vibration (truck, tractor, bus drivers, crane operators, etc.).

Even if car drivers have increased risk of back pain relative to non-drivers, the means of reducing the problem are not obvious without more information on the cause of any increase. In some studies, back problems may have arisen because those driving cars had been at increased risk from some other activity or influencing factor. Indeed, in the extreme, while some people may have back problems as a result of driving cars, others may be driving cars because they have back problems! The cause–effect relationships might be better understood if more studies had explored systematically the chronology of the back pain, such as the extent to which it occurs in association with car driving (e.g. while driving, after driving, at other times, and the onset of pain in relation to variations in driving patterns) and its seriousness (e.g. the extent of the disability).

Back pain in car drivers might be associated with driving, sitting, or some environmental influence while driving. From the published studies it is not clear the extent to which factors related to car design (e.g., back posture during sitting, forces at the feet when operating foot pedals, load from the arms, head posture, back movement, twisting to look rearward while reversing, forces during entry and exit from a car) influence the risk of low back pain. Some of these factors (e.g. sitting posture) are likely to be important for both car drivers and car passengers. The more constrained posture of drivers than passengers might influence the risks of back pain. The influence of sitting for long periods without breaks or physical activity has been considered in only a few studies. Only one of the nine studies focusing on car drivers tried to investigate the importance of some of the above factors [44].

One of the many potential risk factors for back pain in car drivers is exposure to whole-body vibration. However, the reviewed studies do not allow any conclusions on whether different exposures to vibration among car drivers are associated with different risks of low back pain.

Overall, the risks of back pain from car driving appear to be less than those associated with some other occupations and activities. From 12,907 people who responded to a population survey, Palmer et al. [48] examined associations between low back pain and exposure to whole-body vibration from cars, vans, buses, coaches, trains and motor cycles after excluding those exposed to whole-body vibration in industrial vehicles. In both men and women, there were significant trends for increased low back pain in those most exposed compared with those least exposed, but the risks from work with the hands above shoulder height and occupational lifting were all relatively more important than the risks from exposure to whole-body vibration from cars, vans, buses, coaches, trains and motor cycles.

In each population of car drivers, and in each individual car driver, there are different risk factors, so some may be at high risk and others at no measurable risk. Studies that have considered physical risks to the back (such as frequent lifting, carrying heavy loads, twisting and bending) have clearly demonstrated increased risk of low back pain. It can be anticipated that reducing these risks among car drivers will be likely to reduce the risks of low back pain.

Although for the population as a whole the risk to the back from car driving may be low relative to some other activities, there will be some at greater than average risk (e.g. some driving with exceptionally poor postures). Large numbers of persons drive cars and so even a small excess risk will result in large numbers with back pain. It therefore seems appropriate to seek a better understanding of the risk factors among car drivers and identify how to reduce them. Further research is required to clarify the role of driving in the development of low back pain, the factors associated with the development of back pain in car drivers, and the means of reducing the risks.

3.7. Limitation of the review

As in all reviews, there may be various sources of bias in the presented results. For example, studies with negative results are less likely to be submitted and accepted for publication (a reporting bias and a publication bias) and they may be less likely to be referenced by others and become known to subsequent reviewers. There may be a selection bias arising from the omission of some studies because they were not identified using key words, because they have not been published in the English language, or because they were excluded after misunderstanding the nature of the study.

The conclusions from this review are based on the findings of only nine studies that fulfilled weak criteria for inclusion (an epidemiological study of low back pain in car drivers). The populations can be considered to be 'car drivers' on the basis of their profession or their reported hours of driving. There are many other studies of the influence of some of the reviewed risk factors on low back pain, but they do not include sufficient car drivers to meet the criteria for inclusion in this review of low back pain among car drivers.

4. Conclusion

Epidemiological studies of the relation between car driving and back problems require care in their preparation and caution in their interpretation. There are many limitations that arise from factors such as the study design, the choice of study population, sample size, type of question, response rate, and the large number of factors that can influence back pain.

The reviewed studies mostly conclude that car driving is associated with increased risk of low back problems. The incomplete consideration of important risk factors in many studies suggests caution in accepting the presented conclusions, but it seems possible that some car drivers are at increased risk of back problems. Some studies have reported increased risk of low back pain with increased driving, but no study has shown that the risk of low back pain is greater with increased exposure to whole-body vibration from car driving. From the published studies reviewed here it cannot be concluded that the whole-body vibration experienced by car drivers has been found to be a cause of low back problems.

Further studies are needed to clarify the relationship between risk factors and low back pain in car drivers. Epidemiological studies should take into account the potential risk factors (including posture, driving duration, sitting while not driving, exposure to whole-body vibration, individual risk factors, physical risk factors, and psychosocial risk factors) that may be associated with low back pain in car drivers.

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