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Does Daily Exposure to Whole-Body Vibration and Mechanical Shock Relate to the Prevalence of Low Back and Neck Pain in a Rural Workforce?

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Objectives: To determine whether whole-body vibration (WBV) and mechanical shock exposure from quad bike use are associated with the prevalence of neck and low back pain (LBP) in New Zealand farmers and rural workers.

Methods: Full-day WBV and mechanical shock exposures were gathered from 130 farmers and rural workers. Participants were surveyed for a history of neck or LBP in the past 7 days and in the past 12 months. Anthropometric, personal, and workplace data were also gathered.

Results: Physical exposures (mechanical shocks), employee status, and low levels of workplace satisfaction are all significantly associated with the 12-month prevalence of LBP in this rural workforce that regularly use quad bikes. Both vibration and mechanical shock exposure were strongly associated with 12-month prevalence of neck pain. The 7-day prevalence of neck pain showed a non-significant association with mechanical shock and vibration.

Conclusions: Knowledge of these findings will be valuable information for those who teach and advise on safe driving techniques for such vehicles in the rural workplace where reduction of physical exposures and injury rates is of high importance.

Keywords: agriculture; exposure assessment; mechanical shock; musculo-skeletal injury; occupational groups; risk assessment; vibration

INTRODUCTION

Spinal musculoskeletal disorders in the rural workplace are a recognized occupational health concern (Firth *et al.*, 2002; Lovelock *et al.*, 2009; Fathallah, 2010). Vehicle driving is a common farm-based occupational task with drivers of tractors and all-terrain vehicles exposed to considerable whole-body vibration (WBV) and at risk of spinal pain [Matthews, 1966; Bovenzi and Betta, 1994; Lines *et al.*, 1995; Walker-Bone and Palmer, 2002; Scarlett *et al.*, 2007; Milosavljevic *et al.*, 2010; R. M. Stayner and A. G. M. Bean (unpublished data)].

The routine use of quad bikes on New Zealand farms (Fig. 1) exposes rural workers to high levels of occupational WBV and mechanical shock (Milosavljevic *et al.* 2010; Milosavljevic *et al.*, 2011). Such exposure, particularly around the resonant frequencies of 4–6 Hz, has been linked to structural spinal disorders such as a herniated lumbar disc, damage to the vertebral end plates, and accelerated degeneration of the spine (Bovenzi and Hulshof, 1998; Pope *et al.*, 2002; Bovenzi *et al.*, 2006; European Union, 2006; Hadjipavlou *et al.*, 2008). Recent research has found the daily WBV and mechanical shock exposure of rural workers using quad

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Fig. 1. Quad bike in use.

bikes is considerable and putatively associated with the high risk of low back pain (LBP) in farming (Milosavljevic *et al.*, 2010, 2011).

Many individuals also report neck problems from driving and previous surveys have identified a high prevalence of neck pain in farmers, with vibration exposure from farm vehicles considered a plausible source of symptoms (Viikari-Juntara *et al.*, 1996; Scutter *et al.*, 1997; Rehn *et al.*, 2002; Sjaastad and Bakketeig, 2002). Although Milosavljevic *et al.* (2010, 2011) have published vibration and mechanical shock data from rural quad bike use, the associations between these exposures and the prevalence of neck and LBP have yet to be explored.

The primary aim of this study is therefore to determine whether the prevalence of neck and LBP in New Zealand farmers and rural workers is associated with daily WBV and mechanical shock exposure from quad bike use. The secondary aim is to determine whether personal, physical, and workplace characteristics are also associated with neck and LBP.

MATERIALS AND METHODS

Design

A publicly available, community-based farm location directory was accessed to identify farms distributed within a 2-h drive about the regional township of Balclutha in South Otago, New Zealand. Farmers (self-employed) and rural workers (employees) were contacted to describe the study, seek consent to visit the farm, and provide further detail regarding potential participation (Milosavljevic *et al.*, 2011). In this way, 131 farmers and rural workers were contacted, recruiting a pragmatic sample of 130 (111 males and 19 females) farmers and rural workers who regularly used quad bikes (Fig. 1). The study was approved by the University of Otago Human Ethics Committee.

Survey

A modified version of the Whole-Body Vibration Health Surveillance Questionnaire (WBVHSQ) collected personal and workplace data as well as 7-day and 12-month prevalence of neck and LBP, defined as having had at least one episode in the past 7 days or the past 12 months, respectively (Pope *et al.*, 2002). The self-reported causes of these episodes of LBP were recorded and presented descriptively. Work environment information including self-reported farm type and farm terrain, percentage of driving time on different farm surfaces, frequency of lifting and frequency of stooped and twisted working postures during a typical working day. Personal data included occupational status (employer or employee), anthropometric, and behavioural factors. A 15-item workplace satisfaction questionnaire was also embedded in the questionnaire (Pope *et al.*, 2002).

Vibration and mechanical shock measurements

Vibration and mechanical shock data were continuously collected and measured in accordance with international ISO standards (ISO 2631-1, 1997; ISO 2631-5, 2004) using a seat-pad containing a series 2 (10 g) tri-axial accelerometer (NEXGEN Ergonomics—with inbuilt eighth order, 1.2 elliptic low pass filter) taped to the seat directly under the ischial tuberosities of the driver. A stipulation of this research was that all drivers were asked to remain seated while driving their quad bikes. Accelerometer channels were aligned as: x anterior-posterior, y medio-lateral, and z superior-inferior. Participants were asked to undertake daily chores as normal, allowing collection of a full day's exposure to quad bike-induced vibrations and shocks. Data were sampled at 2000 Hz, low pass filtered at 500 Hz and digitally recorded in a Biometrics (DataLOG W4X8) 8 channel data logger (Biometrics™) mounted on the carrying rack of the quad bike. Biometrics PC Datalog software (V7.0) was used to summate vibration exposure epochs after extracting non-driving and idling data from the daily log. Vibration data were analysed with VATS™ software (version 3.4.4) supplied by NEXGEN Ergonomics.

Due to high amplitude peaks, crest factors >9.0, and the likelihood of mechanical shock, vibration exposures are expressed as the vibration dose value (VDV, in m $s^{-1.75}$). Bovenzi (2010) recently found VDVs to be better predictors for LBP compared to ordinary second power methods. Exposure to mechanical shock is expressed in Mega Pascals (MPa) as the daily equivalent static compression dose (S_{ed}) (ISO 2631-5, 2004). Vibration and shock results were also time normalized to 1 h to most clearly determine how non-temporal variables influenced vibration and mechanical shock exposure. Frequency weighted VDVs for X, Y, and Z were calculated [equation (1)] as the weighted fourth power of acceleration where a is acceleration and w_i the channel weighting ($w_x = 1.4$, $w_y = 1.4$, $w_z = 1.0$; ISO 2631-1, 1997).

$$\text{VDV}_i = \left[w_i \int_0^T a^4(t)\,\mathrm{d}t \right]^{1/4}. \tag{1}$$

S_{ed} was calculated [equation (2)] as the weighted sum of the three orthogonal daily acceleration dose values where m_x equals 0.015 MPa/(m s^{-2}), m_y equals 0.035 MPa/(m s^{-2}), and m_z equals 0.032 MPa/(m s^{-2}) (ISO 2631-5, 2004).

$$S_{\text{ed}} = \left[\sum_{k=x,y,z} (m_k D_{kd})^6 \right]^{1/6}. \tag{2}$$

Statistical analyses

Data were analysed using SPSS™ (version 16.0) and presented in both tabular and graphic format. The four dependent variables were 7-day and 12-month history of either neck or LBP categorically classified as (0 = no) or (1 = yes). As previous quad bike research has identified the greatest WBV exposure in the Z direction, often exceeding exposure action and limit values (Milosavljevic *et al.*, 2011), the four primary independent variables were daily and 1 h VDV$_Z$ (m s$^{-1.75}$), as well as daily and 1 h S_{ed} (MPa).

Potential confounders included: age (years); height (metres); mass (kilograms); body mass index (BMI; kilograms per square metre); farming experience (years); employment status (employer or employee); quad bike driving experience (years); farm type; farm terrains; driving surface; distance driven (kilometres); driving duration (hours); mean velocity (kilometres per hour); and how often they: lifted objects after dismounting from their quad bikes, lifted >20 kg on a typical work day (<3 = 0, 3–5 = 1, and >5 = 2), worked in a stooped posture, a twisted posture, and a stooped and twisted posture (seldom = 0, occasionally = 1, or often = 2). Farm type categories were: 0 = dairy; 1 = beef; 2 = sheep; 3 = mixed stock (sheep and beef ± venison); and 4 = other. Farm terrains were categorized as 0 = flat; 1 = rolling flat; 2 = hilly; and 3 = steep hilly. Self-reported percentages of driving time were recorded for sealed road, unsealed road, farm track, and paddock. Weekly alcohol consumption was categorically classified as 0 (none), 1 (one to three glasses), 2 (four to six glasses), and 3 (more than six glasses). Smoking was categorically classified as 0 (never smoked) or 1 (current or past history of smoking). Participating in regular physical exercise was categorized as 0 = no, 1 = yes. Bivariate logistic regression was used to test for associations between vibration (and shock) and 7-day and 12-month history of low back or neck pain. Covariates were included in multivariate models when initial tests of association demonstrated $P \leq 0.20$. All covariates were kept in the multivariate model when the effect of adding them strengthened the odds ratio (OR) for vibration or shock exposure, influencing the prevalence of neck or LBP, by >10.0% (Maldonado and Greenland, 1993). The final multivariate models were determined by a process of adding and removing covariates until the combination with the strongest OR was determined. Cronbach's Alpha determined the average inter-item correlation for the workplace satisfaction questionnaire (Pope *et al.*, 2002) giving an acceptable alpha of 0.78 allowing the use of the mean score as the composite indicator (Bland and Altman, 1997).

RESULTS

Participants had a mean age of 40.6 years, mean height of 1.77 m, mean mass of 87.0 kg, and a mean BMI of 27.6 (Table 1). They also had a mean 19.1 years of farm work experience; a mean 14.6 years of quad bike experience and the majority (85.4%) of the sample were male. Eighty-three (63.8%) described themselves as self-employed farmers, while 47 (36.2%) described themselves as farm employees (rural workers). Participants worked on several different types of farm: dairy (30.8%), beef (1.5%), sheep (10.8%), and mixed stock (53.8%). The farm terrains were self-described as either flat (15.4%), rolling flat (36.9%), hilly (30.0%), or steep hilly (17.7%).

Often lifting objects immediately after quad bike use was described by 48.5%; 51.5% often worked in stooped postures; 22.3% described often working in twisted postures; 19.2% in stooped and twisted postures; and 25.4% described lifting >20 kg on six or more occasions per average working day. Approximately 51.0% of participants did not take part in regular physical exercise; 40.0% had a history of smoking; 92.3% regularly drank alcoholic beverages (29.2% = one to three glasses, 40.8% = four to six glasses, and 22.3% = more than six glasses per week). On

Table 1. Personal, experience, and exposure information.

	Minimum	Maximum	Mean	SD
Age (years)	16.0	67.0	40.6	13.0
Height (m)	1.60	1.96	1.77	0.08
Mass (kg)	50.0	129.0	87.0	16.0
BMI (kg m^{-2})	17.7	41.6	27.6	4.3
Work experience (years)	0.5	51.0	19.1	13.2
Quad bike experience (years)	0.7	30.0	14.6	8.3
Duration (h)	0.2	5.8	2.1	1.0
Distance travelled (km)	5.0	60.0	22.2	10.8
Mean velocity (km h^{-1})	3.4	24.5	11.4	4.0
VDVZ (m $s^{-1.75}$)	7.3	33.5	17.2	4.8
VDVZ 1 h (m $s^{-1.75}$)	8.1	26.4	14.7	3.8
S_{ed} (Mpa)	0.1	0.8	0.4	0.2
S_{ed} 1 h (Mpa)	0.1	0.8	0.4	0.1
	Seldom (%)	Occasional (%)	Often (%)	
Lift after using quad bike	5.4	46.2	48.5	
Stooped postures	11.5	36.9	51.5	
Twisted postures	46.2	31.5	22.3	
Stooped and twisted postures	42.3	38.5	19.2	
	≤2 (%)	3–5 (%)	≥6 (%)	
Daily lifting > 20 kg	46.2	28.4	25.4	

the day of vibration and mechanical shock measurement, mean quad bike driving time was a mean 2.1 h from a mean 8.4 h daily data log; over a mean distance of 22.2 km at a mean velocity of 11.4 km h^{-1}.

LBP had a 7-day (35.4%, $n = 46$) and a 12-month prevalence (Table 2) of 57.7% ($n = 75$). Seven-day and 12-month prevalence for neck pain was 10.8% ($n = 14$) and 26.4% ($n = 34$), respectively. Causes of LBP (12 month) were categorized as unknown (38.7%), lifting (25.3%), wool harvesting (16.0%), upright posture activities (8.0%), and farm vehicle use (6.7%). For LBP (7 days), causes were unknown (43.5%), lifting (26.1%), wool harvesting (6.5%), and vehicle use (8.7%). For neck pain (12 months and 7 days), unknown causes were 35.3 and 57.1%, respectively, lifting (2.9 and 7.1%), wool harvesting (5.9 and 0.0%), upright posture activities (21.5 and 7.1%), and vehicle driving (35.3 and 28.6%). Mean RMS_Z of 0.9 m s^{-2} (SD = 0.2 m s^{-2}) had the highest unidirectional RMS score measured at the seat, while $RMS_{X \text{ and } Y}$ both demonstrated a lesser magnitude of 0.5 m s^{-2} (0.1 m s^{-2}). Mean daily and 1 h VDV_Z measured at the seat was 17.2 and 14.7 m $s^{-1.75}$, respectively (Table 1), while both mean daily and 1 h S_{ed} was 0.4 Mpa.

Associations between LBP and vibration and shock exposure

Twelve-month LBP. Bivariate logistic regression (LBP yes/no) for the four primary vibration and shock variables of VDV_z(daily), VDV_z(1 h), S_{ed}(daily), and S_{ed}(1 h) found only S_{ed}(1 h) had an acceptable association (OR = 1.24, $P = 0.092$) with 12-month prevalence of LBP (Table 3). A number of covariates were also below this threshold ($P \leq 0.20$) and included occupational status (farmer versus rural worker), description of both flat and hilly terrain, estimated percentage of time driving on a farm track, estimated number of days spent lambing and/or calving, mean workplace satisfaction score, estimated number of years of work experience, estimated number of years of quad bike exposure, and estimated percentage of time driving in a paddock (Table 3). All other potential confounders (see methodology above) did not meet the $P \leq 0.20$ inclusion threshold. The 12-month LBP prevalence rate of 57.7% ($n = 75$) allowed a sample size of 55 (accepting $n = 10$ per variable) to determine the additional four covariates for inclusion in a multivariate model for S_{ed} (1 h). The inclusion of occupational status and estimated percentage of time driving on a farm track (Table 3) in the model resulted in S_{ed} (1 h) being significantly associated with a 12-month history of LBP ($P = 0.011$; no LBP = 0.4 Mpa; OR = 1.45).

Seven-day LBP. Neither daily nor 1-h vibration (or mechanical shock) exposure demonstrated any association ($P \leq 0.20$) with 7-day prevalence of LBP. However, the covariates of mean workplace satisfaction, work experience, quad bike exposure,

Table 2. Descriptive causes of low back and neck pain (%).

	Unknown	Lifting	Wool harvesting	Upright activities	Vehicle use
12-month LBP	38.7	25.3	16.0	8.0	6.7
7-day LBP	43.5	26.1	6.5	0.0	8.7
12-month neck pain	35.3	2.9	5.9	21.5	35.3
7-day neck pain	57.1	7.1	0.0	7.1	28.6

Table 3. Univariate and multivariate associations for vibration and mechanical shock logistically regressed with 7-day and 12-month prevalence of low back and neck pain.

	LBP 7 days				LBP 12 months			
	95% CI				95% CI			
	OR	Lower	Upper	*P*	OR	Lower	Upper	*P*
Univariate								
VDV_Z (daily)	0.98	0.91	1.06	0.577	1.01	0.94	1.08	0.812
VDV_Z (1 h)	0.98	0.89	1.07	0.638	1.03	0.94	1.13	0.497
Shock (Mpa daily)	1.11	0.90	1.38	0.334	1.19	0.96	1.49	0.115
Shock (Mpa 1 h)	1.12	0.88	1.43	0.366	1.24	0.97	1.60	0.092
Farmer versus worker					2.65	1.27	5.53	0.009
Flat terrain					3.01	1.11	8.14	0.030
Steep hilly					0.42	0.15	1.14	0.089
Farm track (% time)					0.98	0.97	1.00	0.040
Lamb/calving (days)					0.97	0.96	0.99	0.006
Work satisfaction	0.33	0.14	0.79	0.013	0.29	0.12	0.74	0.010
Work experience (yrs)	1.02	1.00	1.05	0.091	1.02	1.00	1.05	0.095
Quad experience (years)	1.05	1.01	1.10	0.028	1.04	1.00	1.09	0.080
Paddock (% time)	1.02	1.00	1.03	0.045	1.02	1.00	1.03	0.043
Gravel road (% time)	0.96	0.93	1.00	0.038				
Sealed road (% time)	1.10	1.00	1.20	0.050				
Multivariate								
Shock (Mpa 1 h)		No significant models			1.45	1.09	1.93	0.011
Farmer versus worker					2.67	1.17	6.10	0.020
Farm track (% time)					0.98	0.97	1.00	0.077
Univariate	Neck 7 days				Neck 12 months			
VDV_Z (daily)	1.07	0.96	1.20	0.226	1.09	1.01	1.19	0.033
VDV_Z (1 h)	1.07	0.93	1.23	0.330	1.10	1.00	1.23	0.059
Shock (Mpa daily)	1.33	0.97	1.81	0.077	1.36	1.07	1.73	0.011
Shock (Mpa 1 h)	1.35	0.95	1.91	0.095	1.38	1.06	1.80	0.017
Exercise regularly					0.50	0.23	1.12	0.092
Work satisfaction	0.37	0.12	1.13	0.081				
Lamb/calving (days)	1.03	1.00	1.06	0.064				
Distance travelled	1.04	0.99	1.09	0.099				
Multivariate								
Shock (Mpa 1 h)	Sample size too small (neck pain $n = 14$)				No significant model			

CI, confidence interval.

and percentages of time spent driving in the paddock, gravel, or sealed road did demonstrate acceptable levels of association ($P \leq 0.20$) for inclusion in a multivariate model. All other potential confounders did not meet the inclusion threshold. The 7-day prevalence of LBP (35.4%) essentially allowed a maximum of three variables for inclusion in such a model. Although each of the vibration and shock variables was entered separately into a multivariate model (with each covariate), no significant combined model was identified ($P > 0.05$). Similarly post-hoc multivariate analyses of all accepted covariates did not offer any significant combined models of association with 7-day prevalence of LBP.

Associations between prevalence of neck pain and vibration and shock exposure

Twelve months. Mean daily $\mathrm{VDV_z}$, mean daily $\mathrm{S_{ed}}$, and 1 h equivalent $\mathrm{S_{ed}}$ demonstrated statistically significant ($P < 0.05$) associations with 12-month prevalence of neck pain, while 1 h equivalent $\mathrm{VDV_z}$ was also below the $P \leq 0.20$ multivariate inclusion threshold. Other than a categorical description of regular exercise (yes/no), no other covariate met the $P \leq 0.20$ multivariate inclusion criteria. Reports of undertaking regular exercise did not statistically demonstrate ($P > 0.05$) any combined association with any of the vibration and shock models.

Seven days. Only mechanical shock exposure (daily and 1 h equivalent $\mathrm{S_{ed}}$) demonstrated primary univariate associations ($P \leq 0.20$) with 7-day prevalence of neck pain. Mean workplace satisfaction, the estimated number of days spent lambing and calving, and distance travelled on the recorded day of exposure were the three covariates also meeting the $P \leq 0.20$ multivariate inclusion threshold. However, a prevalence rate of 10.8% ($n = 14$) was too small to allow meaningful construction and interpretation of a multivariate model and so this analysis was not completed.

DISCUSSION

A combined model of $\mathrm{S_{ed}}$ 1 h, occupational status and percentage time on a farm track link exposure to mechanical shock with 12-month LBP (OR = 1.45; $P = 0.011$). Thus, a 1 U (0.1 Mpa) shock increase >0.4 Mpa increases the OR of having had LBP by 1.45 and a 4 U increases this to 4.42. Rural workers compared to their employers (OR = 2.67) appear to generate greater levels of mechanical shock and will be those most likely to have had an episode of LBP in the past 12 months (Fig. 2).

Although workplace satisfaction, flat terrain, days lambing, and/or calving demonstrated significant associations with LBP (12 month), they did not strengthen the final model, and thus their effects appear to be independent of shock exposure. While neither vibration nor mechanical shock demonstrated associations ($P > 0.20$) with LBP (7 day), low levels of workplace satisfaction (OR 0.33; $P = 0.013$) carried up to three times the risk of being associated with LBP (7 days). Years of quad bike use and estimated percentages of time spent driving on a sealed road, gravel road, or in a paddock also demonstrated weak associations implying that experience and different surface conditions will also affect exposure. As none of these covariates demonstrate any combined associations, their effects appear to be independent of each other. Furthermore, no significant associations ($P > 0.20$) were found for self-reported frequency of lifting after using a quad bike; workplace postures; frequency of lifting in excess of 20 kg; and the 7-day or 12-month prevalence rates of LBP and thus they did not confound the combined model for mechanical shock, occupational status, and riding on a farm track. Descriptively, much of the prevalence of LBP and neck pain (~40%) was attributed to unknown causes, while interestingly ~ 30% of causes for 7-day and 12-month prevalence of neck pain were attributed to farm vehicle use suggesting that cumulative load exposures from vehicle vibrations, shocks, and other physical activities may be a strong factor in the development of spinal pain. However, further research is needed with head and/or helmet mounted accelerometers to determine the true extent of vibration transmission from the seat to head and to determine whether attenuation or amplification of signals occurs at different frequencies (e.g. dampening or resonance).

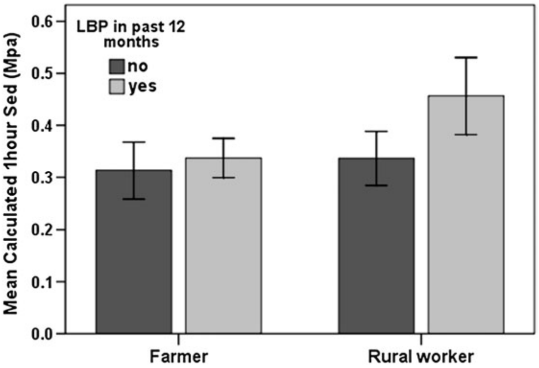

Fig. 2. Comparative S_{ed} (1 h) shock exposure farmers versus rural workers (error bars display 95% confidence intervals).

Daily exposure to mechanical shock indicate that a 4 U (0.4 Mpa) increase in daily mechanical shock exposure will be linked to an OR = 3.42 (95% confidence interval = 1.41–8.96) for 12-month neck pain. Daily exposure was a stronger model than 1-h exposure indicating that duration is also important. Despite numerical weakness daily mechanical shock exposure demonstrated the strongest (albeit non-significant) association with 7-day prevalence of neck pain (OR = 1.33; $P = 0.077$).

There is strong evidence for multifactorial contributions to LBP(12 months) covering a biopsychosocial spectrum of biomechanical factors (mechanical shock) linked with differences in occupational status (employer/employee) and workplace characteristics (flat terrain) to suggest a model of risk for LBP for a farm worker exposed to high levels of mechanical shock. Interestingly, workplace satisfaction was significantly but independently associated with LBP (both 12 months and 7 days) demonstrating the complexity of factors linked to LBP. It is likely that the association of neck pain with mechanical shock is relevant to terrain and driving behaviour including velocity, duration, and driving route. The quad bike is lightweight, with a short wheelbase and no back rest, driven in off-road and on-farm conditions, for a variety of work tasks. Shock attenuation will be minimal under these conditions and thus will likely be associated with excessive loading of the cervical spine and subsequent injury and pain.

This exploratory investigation has gathered data that are both cross-sectional and retrospective, and thus, any identified relationships will be limited by not knowing the exposures at the time the farmer/rural worker developed spinal pain. However, they suggest that the farmers/rural workers, who describe recent episodes of neck and LBP, demonstrate quad bike driving behaviours that generate greater levels of mechanical shock that can adversely influence the structures of the spine. Further prospective research with a larger national sample of randomly recruited rural quad bike drivers will be required to confirm these hypotheses. Recent laboratory-based biomechanical investigations, however, demonstrate that such vibration exposure is related to accelerated disc damage (Gregory and Callaghan, 2011) as well as further intra-discal damage to a structure already damaged by previous trauma (Yates and McGill, 2011). How such exposure relates to primary intra-discal damage over a working lifetime is still unknown.

As these farmers/rural workers use their quad bikes on a daily basis, it was accepted that these results were typical of such daily exposure. Although the recollection of neck and/or LBP is dependent on recall and subject to recall bias, only the response to the presence or absence of neck or LBP was chosen for statistical analysis. As these events are relatively common, it was accepted that they would be readily recalled by most farmers and rural workers.

CONCLUSION

In this sample of farmers/rural workers, the 12-month prevalence of LBP and neck pain is significantly associated with exposure to high levels of mechanical shock. A low level of workplace satisfaction is also significantly associated with these symptoms but independently of shock exposure. These results are consistent with a biopsychosocial model to represent why neck and LBP occur in this rural work force. From the perspective of physical exposure, a rural worker driving a quad bike over uneven and rough surfaced terrain will generate high levels of mechanical shock and likely be at increased risk of developing neck and LBP. These results provide valuable information for those who advise on safe driving techniques for such vehicles in the rural workplace.

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