Original Article

Psychological Distress and Pain Reporting in Australian Coal Miners

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ABSTRACT

Background: Coal mining is of significant economic importance to the Australian economy. Despite this fact, the related workforce is subjected to a number of psychosocial risks and musculoskeletal injury, and various psychological disorders are common among this population group. Because only limited research has been conducted in this population group, we sought to examine the relationship between physical (pain) and psychological (distress) factors, as well as the effects of various demographic, lifestyle, and fatigue indicators on this relationship.

Methods: Coal miners ($N = 231$) participated in a survey of musculoskeletal pain and distress on-site during their work shifts. Participants also provided demographic information (job type, age, experience in the industry, and body mass index) and responded to questions about exercise and sleep quality (on- and off-shift) as well as physical and mental tiredness after work.

Results: A total of 177 workers (80.5%) reported experiencing pain in at least one region of their body. The majority of the sample population (61.9%) was classified as having low-level distress, 28.4% had scores indicating mild to moderate distress, and 9.6% had scores indicating high levels of distress. Both number of pain regions and job type (being an operator) significantly predicted distress. Higher distress score was also associated with greater absenteeism in workers who reported lower back pain. In addition, perceived sleep quality during work periods partially mediated the relationship between pain and distress.

Conclusion: The study findings support the existence of widespread musculoskeletal pain among the coal-mining workforce, and this pain is associated with increased psychological distress. Operators (truck drivers) and workers reporting poor sleep quality during work periods are most likely to report increased distress, which highlights the importance of supporting the mining workforce for sustained productivity.

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1. Introduction

Increasingly companies are striving to support not only the physical safety of their employees, but also their psychological safety [1]. In part, this is driven by the high costs associated with psychological injuries, which tend to be higher due to increased periods of absence and higher medical, legal, and other claim payments [2,3]. Along with absenteeism, another key area of productivity cost is presenteeism [4]. Presenteeism, which also involves high cost, occurs when employees continue to attend work rather than be absent, as a result of which their productivity suffers [5]. One common contributor to presenteeism is working with

chronic musculoskeletal pain, which is also a risk factor for decreased work ability and performance [6]. Presenteeism is estimated to be more costly than absenteeism, and there is evidence [7] of increased prevalence of presenteeism among distressed workers. Therefore, understanding the relationship between physical factors (such as injury) and psychological factors (such as distress) in high-demand industries is important for developing injury prevention and management programs, building a sustainable workforce, and improving performance and productivity.

Previous studies have illustrated the importance of balancing job demands with adequate job control for better working health [8—13]. It has been demonstrated that employees working in high-

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strain jobs (i.e., jobs characterized by high demands, low job control, and low social support) will experience a greater number of health problems over time than workers in other jobs [14]. In Australia, it has been reported that blue-collar workers, machine operators, drivers, and laborers are less likely to rate their health positively compared with other occupational groups [15]. This may, in part, reflect the limited autonomy and control these workers have in relation to the planning and pacing of their work activities. It may also reflect the tendency in these male-dominated workforces to adopt a culture of stoicism, resulting in decreased help seeking and early intervention [16]. These health perceptions are particularly pertinent in production-driven industries such as mining. However, despite the political and media interest in this industry, only limited studies are published with regard to this population. Moreover, although safety and musculoskeletal injury have long been a focus of health and safety initiatives at mine sites, the potential impact of psychological health has only recently been acknowledged.

One psychological issue associated with pain and other health outcomes is psychological distress. The concept of distress is a broad label given to a variety of states and responses, most commonly those related to depression and anxiety [17,18]. As a construct, distress is positively related to both poor mental health and clinical psychological disorders, thereby making it an excellent general measure. A survey of large Australian companies found that 4.5% of full-time employees experience high levels of psychological distress in any given month [19]. This finding is significant as distress is associated with decreased work ability [20], and it appears that the majority of distressed employees are not receiving treatment (i.e., psychological counseling) [19]. Understanding the interaction between physical pain, injury, and psychological distress is therefore critical in organizational settings. A large survey of patient-care workers demonstrated significantly higher distress among workers who reported pain in the past 3 months than those who did not report pain [21]. In addition, pain intensity, number of bodily areas in which pain was experienced, psychological distress, and higher age were each independently associated with pain interference in work, suggesting that the combination of pain and distress may have particular significance for presenteeism.

In addition to the association with pain, psychological distress appears to be an important factor in occupational injury, absence, and recovery. It has also been shown to be a predictor of accident rates [22], and psychological distress may therefore have important implications for both the antecedents to injury and the potential consequences of pain such as disability. Indeed, Hall and colleagues [23] found that a future disability level of individuals is influenced by the degree to which their psychological state has been affected by their initial pain experience. In addition, Coutu and colleagues [17] found that individuals who were unable to work as a result of disability experienced higher levels of distress than individuals who were working with pain. The authors argued that loss of working identity is a crucial phase in the development of distress. By contrast, other researchers [24] have argued that distress is primarily a cause, rather than a consequence of pain. Therefore, understanding the development of distress within a population that continues to work despite pain is of vital importance, especially given the potential economic burden of presenteeism. Moreover, understanding the diversity of physical and cognitive demands associated with different occupations and job types may help determine whether intervention is necessary, and if required when and how they can be targeted to the specific needs of the worker.

The relationship between pain and psychological distress is impacted by a number of job (e.g., experience and fatigue) and person-specific (e.g., age and gender) factors. Harkness and coworkers [25] examined this relationship in a cohort of newly employed workers followed up for 12 months and 24 months. They found a significant relationship between monotonous work and the increased risk of new-onset widespread pain. Similarly, work-related fatigue has been associated with decreased health and functioning, increased pain, depressive symptoms, and anxiety [26−28]. Miró and colleagues [27] demonstrated that poor sleep quality mediated the relationship of pain with both anxiety and depression, suggesting that pain effects sleep, which, in turn, has negative implications for mental health. In terms of age, a longitudinal analysis of the relationship between distress and musculoskeletal complaints among male oil and gas personnel showed that older individuals had a greater increase in musculoskeletal symptoms over a 5-year period [24]. In addition, nontraditional gender occupations (such as female laborers and male administrative staff) and long working hours have been associated with increased distress [19].

Lifestyle issues such as current tobacco use, sedentary behavior, and obesity have also been shown to have a linear relationship with distress, such that high distress is associated with increased risk of engaging in these unhealthy behaviors [29]. Numerous studies have demonstrated that obese individuals have an increased risk of musculoskeletal pain [24,30,31] and injury [32]. Parkes [33] examined the effects of shiftwork, job-role categories, and work perceptions on health-related outcomes based on data collected from 1,598 male personnel working on North Sea oil and gas installations. In this setting, social support was important for the prevention of mental health complaints, whereas musculoskeletal symptoms and injuries were strongly predicted by physical environment stressors (e.g., noise, vibration, poor air quality, and cramped work space). Moreover, the impact of shiftwork and job types on health was partially mediated by workers' perceptions of job control and demand. Therefore, it is suggested that how workers perceive the demands of their role and the control they have over their tasks are more important for health outcomes than objective job classification alone. Given the similarities between offshore oil and gas operations and coal mining, it is important to explore these relationships in other heavy industries and other countries as well.

Although psychological distress appears to be importantly associated with pain and injury, limited work has been done in high-risk, blue-collar industries such as mining. Such a population group is interesting as it operates 24/7 and is associated with significant psychosocial risk factors, including extended roster periods and shiftwork, high production demands, and "fly-in fly-out" arrangements causing longer periods of absence from family. In addition, how the distress−pain relationship differs by job type, age, and exposure to work requires further exploration.

The aim of this paper is to use data from a survey of Australian open-cut coal-mining personnel to examine the relationship between perceptions of musculoskeletal pain and psychological distress. It is hypothesized that (1) high psychological distress is associated with a greater number of identified pain-affected areas; (2) the aforementioned relationship will be more pronounced in monotonous workers (such as truck drivers), the overweight, less active workers, and those younger or less experienced in the industry; (3) in the presence of pain, psychological distress will be associated with greater absenteeism; and (4) fatigue indicators (i.e., sleep quality) will mediate the relationship between pain and distress.

2. Materials and methods

2.1. Participants

Two hundred and thirty-one mine workers (89% response rate) completed questionnaires during the preshift period on-site. The

average age of workers was 37.11 years [standard deviation (SD) = 10.40 years] and they had been working in the mining industry (average) for 6.5 years (SD = 7.90 years). Table 1 shows the demographic characteristics of the study sample.

2.2. Measures

2.2.1. Demographics

Workers were asked to list their age, gender, number of years in the industry, and current position. They also reported their roster pattern, average shift length, and number of breaks. For analysis, age was categorized as <30 years, 30–39 years, 40–49 years, and ≥50 years and experience was categorized as <1 years, 1–4.9 years, 5–9.9 years, 10–19.9 years, 20–29.9 years, and ≥30 years.

2.2.2. Musculoskeletal pain

Pain was measured using a modified version of the Nordic Musculoskeletal Pain Questionnaire [34]. The questionnaire includes a pictorial representation of the human body (viewed from the back), divided into nine anatomical regions (neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles/feet). Participants were required to identify the body regions in which pain was experienced (binary yes/no) and to indicate whether the pain was experienced (yes/no) in the past week (acute pain) or over a 12-month period (chronic pain). Pain was then quantified as the total number of regions in which pain was experienced.

Participants were also asked to provide more detailed information about musculoskeletal problems relating to four main body areas, including the neck, shoulders, lower back, and wrist/hand. If participants reported ever having pain in these regions, they also provided the total length of time they had experienced symptoms during the past 12 months, whether pain reduced work or leisure activities, the total time that normal work activities were affected, and whether a medical practitioner or other health care professionals had been consulted for that pain.

2.2.3. Distress

Distress was measured using the Kessler K6 [35], a six-item measure that assesses nonspecific psychological distress experienced in the most recent 4-week period. Previous studies have supported the sensitivity and validity of the scale [36,37]. Participants respond to the stem "During the past 30 days, how much time did you feel …," and possible responses were none of the time, some of the time, a little of the time, most of the time, and all of the time. Based on the scoring system utilized by Australian population-based surveys, scores were summed up to a possible 30 points, with higher scores indicating greater distress [38]. In the current sample, the internal consistency of this scale was high ($\alpha = 0.90$).

2.2.4. Lifestyle behaviors and fatigue factors

Because of the challenges faced by this 24/7 workforce with respect to maintaining a healthy lifestyle, a range of questions was included to address issues such as shift schedules, exercise (frequency and duration of exercise on- and off-shift, and preferred exercise activities), body mass index (BMI; height and weight), and sleep patterns (quality and duration of sleep on- and off-shift).

2.3. Procedure

Ethical approval for the study was obtained from the Ethics Committee of the Queensland University of Technology, Brisbane, Australia. To optimize response rates, questionnaires were administered over a 1-month period to provide the opportunity for all workers to participate in this study during their work time. Completed questionnaires were collected and sent to the research team for analysis. The company received a full report and workers were provided with their aggregated results in presentations onsite.

2.4. Statistical analysis

The effects of demographic characteristics and lifestyle factors on perceived musculoskeletal pain symptoms and psychological distress were explored through a series of analysis of variance (ANOVA) and regression models conducted using SPSS (SPSS version 21; SPSS Inc., Chicago, IL, USA). All regression analyses controlled for age, gender, job category, and experience, with categorical variables were recoded to have two levels (i.e., job type was coded as 1 = operator and −1 = other occupations; gender was coded as 1 = men and −1 = women). The models were grouped as follows: (1) one-way ANOVAs that examined the effects of job category, age, experience, and gender on both psychological distress and pain regions; (2) a linear regression exploring the impact of job category and number of pain regions on psychological distress scores; (3) one-way ANOVAs that investigated the impact of interference with work and absenteeism due to either neck, shoulder, lower back, or wrist/hand bodily pain on psychological distress scores; (4) a linear regression exploring the possible moderating effects of exercise or BMI on the relationship between musculoskeletal pain symptoms and psychological distress; and (5) a linear regression examining whether perceived sleep quality mediated the relationship between musculoskeletal pain symptoms and psychological distress.

3. Results

3.1. Influence of demographics

A one-way ANOVA indicated significant differences in distress levels by job category [$F(3, 209) = 6.04$, $p = 0.001$]. *Post hoc* analysis suggested that operators ($M = 12.58$, SD = 5.85) were significantly more distressed than supervisors/professionals/administration staff ($M = 9.04$, SD = 3.19), and maintenance workers ($M = 10.10$, SD = 4.27, $p < 0.05$). However, there were no significant differences between other occupational groups ($p > 0.05$). Additional ANOVA revealed no significant differences in distress by age [$F(3, 210) = 0.91$, $p = 0.44$], experience in the mining industry [$F(5, 211) = 1.47$, $p = 0.20$], or gender [$t(212) = −1.76$, $p = 0.08$]. Similarly, the number of regions in which pain was experienced did not significantly differ by age [$F(3, 211) = 0.39$, $p = 0.76$], experience [$F(5, 212) = 0.56$, $p = 0.73$], job category [$F(3, 212) = 1.17$, $p = 0.32$], or gender [$t(213) = −0.41$, $p = 0.69$].

3.2. Distress and pain

Using the criteria outlined by Kessler and colleagues [35,37], the majority of the sample population (61.9%) was classified as having

Table 1
Participant characteristics

Variable	Sample %
Males	89
BMI < 25 kg/m^2 (normal)	21.2
BMI ≥ 30 kg/m^2 (obese)	40.2
Operator/truck driver	58.8
Maintenance/electrician/mechanic/fitter	22.1
Supervisor/professional/administration	12.4
Drilling and blasting	6.6

BMI, body mass index.

low-level distress, 28.4% were registered to have mild to moderate distress, and 9.6% had scores indicating high levels of distress. In terms of pain, 19.5% reported no pain, 28.2% reported pain in one or two areas, and 52.3% reported pain in three or more body areas.

Controlling for demographic variables, a regression analysis revealed that pain was significantly related to distress [F (6, 182) = 6.20, $p < 0.001$]. In addition to the number of pain regions ($\beta = 0.25$, $t = 3.59$, $p < 0.001$, partial $r^2 = 0.26$), both job type ($\beta = 0.30$, $t = 4.32$, $p < 0.001$, $pr^2 = 0.31$) and younger age ($\beta = -0.17$, $t = -2.26$, $p = 0.03$, $pr^2 = -0.17$) were significantly related to worker psychological distress.

Specific examination of the neck, shoulder, lower back, and wrist/hand body regions showed that lower back pain alone was associated with increased interference with work and absenteeism. Seventy-eight percentage of workers who reported lower back pain indicated that their back pain affected their work. ANOVA revealed that the number of days workers reported their normal work activity had been affected by their back pain was significantly associated with distress [F (3, 87) = 4.02, $p = 0.01$]. A Turkey *post hoc* analysis test indicated that those with the greatest interference (days affected > 30) were significantly more distressed ($M = 18.00$, $SD = 8.12$) than those whose work was affected between 1 day and 7 days ($M = 11.04$, $SD = 4.36$; $p = 0.02$), and those whose work was not affected by back pain ($M = 10.54$, $SD = 4.46$; $p = 0.005$). Among workers who reported lower back pain, distress was also related to absenteeism [F (2, 24) = 4.25, $p < 0.05$]. Specifically, over the past 12 months, those with low distress levels ($M = 2.17$ days; $SD = 4.20$) had fewer days away than those who reported high distress ($M = 23.75$ days; $SD = 37.85$). Neither interference with work nor absenteeism was related to pain in other body regions (shoulder, wrist/hand, neck), or in total number of pain regions ($p > 0.05$).

3.3. Influence of lifestyle factors

In general, participants reported greater exercise activity off-shift ($M_{time} = 2.70$, $SD_{time} = 1.03$; $M_{Freq} = 1.78$, $SD_{Freq} = 1.17$) than when they were rostered on ($M_{time} = 2.21$, $SD_{time} = 1.00$; $M_{Freq} = 1.14$, $SD_{Freq} = 1.29$). Inspection of workers whose scores signified high levels of psychological distress indicated that almost 85% were overweight or obese. As shown in Table 2, with the exception of time spent exercising when off-shift, none of the lifestyle variables significantly moderated the relationship between distress and pain. During time off, workers who spent more time exercising reported lower levels of distress, particularly in the context of the high number of pain-affected areas than did their counterparts who reported less time exercising when off-shift (Fig. 1).

3.4. Fatigue indicators

Sleep quality was significantly related to both distress and pain, and participants reported improved sleep quality when rostered off work ($M = 3.71$, $SD = 0.95$) than when rostered on ($M = 3.02$, $SD = 0.95$). To test whether perceptions of sleep quality mediated the pain−distress relationship, it was established that pain accounted for significant variance in both sleep quality while on-shift [$R^2 = 0.03$, F (1, 212) = 6.31, $p = 0.01$] and sleep quality when rostered off [$R^2 = 0.04$, F (1, 213) = 9.65, $p = 0.002$]. Specifically, the coefficient for pain was significant both on-shift [$\beta = -0.08$, $p = 0.01$] and off-shift [$\beta = -0.09$, $p = 0.002$].

Focusing on sleep quality during on-shift periods, a hierarchical multiple regression was then conducted, with pain entered in Block 1 and sleep quality during work shifts added in Block 2. In the first step, pain accounted for a significant variance in distress [$R^2 = 0.06$, F (1, 206) = 12.64, $p < 0.001$], and the coefficient for pain was

Table 2
Results of regression models with lifestyle variables (exercise and BMI) entered in step 1 and the interaction with pain entered in step 2 [*]

		B	SE B	β	R^2 change	Model R^2	Model F
Model 1	Pain	0.51	0.17	0.21[‡]			
	EF-on	−0.05	0.29	−0.01			
	Job	1.37	0.37	0.26[§]			
	Experience	0.05	0.05	0.08			
	Age	−0.07	0.04	−0.15[‖]			
	Gender	−0.73	0.58	−0.09			
	EF-on X pain	0.17	0.13	0.09	0.01	0.14	4.57[†]
Model 2	Pain	0.74	0.23	0.31[‡]			
	ET-on	−0.29	0.53	−0.06			
	Job	1.34	0.57	0.24[‖]			
	Experience	−0.04	0.10	−0.04			
	Age	−0.05	0.05	−0.10			
	Gender	−0.67	0.76	−0.08			
	ET-on X pain	−0.47	0.26	−0.17	0.03	0.22	3.77[§]
Model 3	Pain	0.51	0.17	0.21[§]			
	EF-off	0.09	0.31	0.02			
	Job	1.39	0.37	0.26[§]			
	Experience	0.07	0.05	0.11			
	Age	−0.08	0.04	−0.16[‖]			
	Gender	−0.75	0.58	−0.09			
	EF-off X pain	0.15	0.14	0.07	0.01	0.15	4.70[§]
Model 4	Pain	0.56	0.20	0.22[‡]			
	ET-off	0.15	0.43	0.03			
	Job	1.50	0.36	0.29[§]			
	Experience	0.06	0.05	0.10			
	Age	−0.08	0.04	−0.16[‖]			
	Gender	−0.56	0.70	−0.06			
	ET-off X pain	−0.38	0.19	−0.15[‖]	0.02[‖]	0.16	3.95[§]
Model 5	Pain	0.59	0.17	0.24[§]			
	BMI	0.05	0.08	0.05			
	Job	1.50	0.36	0.29			
	Experience	0.06	0.05	0.10			
	Age	−0.08	0.04	−0.16[‖]			
	Gender	−0.81	0.68	−0.08			
	BMI X pain	0.04	0.04	0.07	0.00	0.17	5.41[§]

BMI, body mass index; EF-off, exercise frequency off-shift; EF-on, exercise frequency on-shift; ET-off, exercise time off-shift; ET-on, exercise time on-shift SE, standard error.

[*] For models without the interaction term included, please contact the first author.

[†] Various levels of significant.

[‡] $p < 0.05$.

[§] $p < 0.01$.

[‖] $p < 0.001$.

significant [$\beta = 0.59$, $p < 0.001$]. In Block 2, sleep quality added significantly to the variance accounted for distress, [R^2 change = 0.12, F (1, 205) = 29.05, $p < 0.001$], and the coefficient for the mediator was significant [$\beta = -1.96$, $p < 0.001$]. When sleep quality was entered in Block 2, the coefficient for pain decreased to $\beta = 0.44$, $p = 0.006$. A Sobel test of the indirect effect was significant, $z = 2.33$, $p = 0.02$, indicating that sleep quality partially mediated the relationship between pain and distress. Further
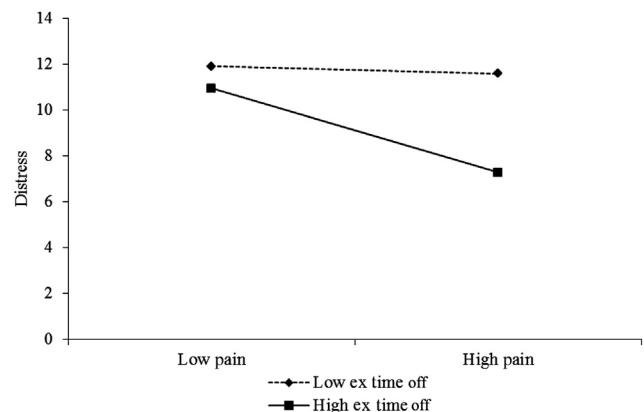

Fig. 1. Relationship between distress and pain for workers who reported high and low exercise times when rostered off shift.

evidence for the significance of this effect was obtained by applying more robust bootstrapping analysis. Following the advice provided by Preacher and Hayes [39], results based on 5000 bootstrapped samples indicated that both the Total Effect (TE = 0.59, SE = 0.17, $p < 0.001$)] and Direct Effect (DE = 0.44, SE = 0.16, $p = 0.006$) were significant. Thus, partial mediation of the pain–distress relationship by perceived sleep quality was supported during rostered on periods (lower 95% CI = 0.04, upper 95% CI = 0.29).

To test the effect of sleep quality when rostered off, pain was again entered in Block 1, and sleep quality was added in Block 2 of a hierarchical multiple regression model. In the first step, pain accounted for significant variance in distress [$R^2 = 0.05$, $F(1, 205) = 11.56$, $p = 0.001$], and the coefficient for pain was significant [$\beta = 0.56$, $p = 0.001$]. In Block 2, sleep quality added significantly to the variance accounted for distress [R^2 change = 0.02, $F(1, 205) = 4.72$, $p = 0.03$], and the coefficient for the mediator was significant [$\beta = -0.87$, $p = 0.03$]. When sleep quality while rostered off was entered in Block 2, the coefficient for pain again decreased slightly to $\beta = 0.50$, $p = 0.003$. However, a Sobel test of the indirect effect was not significant, z = 1.57, $p = 0.12$, indicating that sleep quality while rostered off did not significantly mediate the relationship between pain and distress.

4. Discussion

The physiological and psychological well-being of the workforce is an important indicator of healthy organizations [40]. The aim of this paper was to examine the relationship between musculoskeletal pain and psychological distress among an Australian mining population. As predicted, there was a significant relationship between pain and distress among coal miners, with more widespread pain associated with greater distress. Distress was also more pronounced among the operators/truck drivers, younger workers, and those who were less active during their time off work. It was also associated with absenteeism for workers who reported lower back pain. Pain and distress were also associated with fatigue, which was evidenced by the mediating effect of perceived sleep quality during working periods.

Consistent with mining industry compensation data [41], musculoskeletal pain was common within this study population. Eighty percent of the workers reported experiencing pain in at least one region of the body over the past 12 months, with >50% of the sample reporting multiple pain sites. Compared with data specific to the Australian working population, which indicate a 4.5% incidence of high distress [19], the studied sample of mining industry workers reported a high distress rate (9.6%) that was more than double the aforementioned value. This discrepancy may be attributable to the risks associated with specific job tasks or other possibilities such as workers continuing to work with musculoskeletal pain or other psychological disorders in heavy-industry populations. Although the connection between distress and pain is not new, evidence of this relationship in industries such as mining is limited. Such information is becoming increasingly important in an industry that has a high prevalence of workers with musculoskeletal disorders and a broad range of psychosocial problems associated with production demands and organizational issues such as long working hours. The significance of this relationship is increasingly reflected in costs associated with absenteeism and workers' compensation statistics. Greater understanding of this link is critical in implementing strategies to reduce risk factors and improve injury prevention and return-to-work outcomes.

4.1. Work-related factors

When examined individually there was a clear discrepancy in distress levels between various job categories. Specifically, workers in more sedentary roles such as operators (i.e., truck driver, digger, or dozer operator) were significantly more distressed than workers in other job categories. Drivers are exposed to long periods of sitting (up to 12 hours) and truck drivers, in particular, experience monotonous driving conditions. In addition, ergonomic limitations associated with seating and poor matching of worker anthropometry with cabin and access/egress limitations and uneven road surfaces increase their exposure to vibration and trunk accelerations, which are well-known risk factors for musculoskeletal disorders of the vertebral column and back pain [42,43]. Although there is only limited evidence on the relationship between prolonged sitting while driving and mental health outcomes, it has been shown [44] that greater hours of occupational sitting among government employees was associated with higher prevalence of moderate or high psychological distress for men and women, respectively. In addition, job demands may have a curvilinear relationship with distress, such that extremes of physical demands may relate to increased distress levels among workers. Such a pattern has been demonstrated in relation to working hours, with periods >60 hours a week and <16 hours a week associated with increased psychological distress [19]. Therefore, how distress relates to job monotony, ergonomic designs, and exposure hazards for pain such as prolonged static postures and vibration need further examination in heavy industry such as mining.

Melamed and colleagues [45] studied a large sample of blue-collar workers and found a correlation between perceived job monotony and psychological distress. They also found that those exposed to objectively categorized monotonous tasks, specifically those involving periods of short-cycle repetitive work, were more likely to report distress. Similarly, more recent research [25,46] has shown that perceived monotony was connected to both shoulder and widespread pain among newly employed workers from diverse occupations. Although the current study did not measure monotony, the repetitive short cycles of load pickup and drop-off over long periods characteristic of truck drivers' work in this study may have contributed to the high distress levels observed in drivers. In the mining context, truck drivers are instrumental in the day-to-day production work on-site, and understanding the reasons for their distress may have considerable implications for the company's performance. Although the total number of body regions affected by pain appeared to be a useful indicator of distress levels, lower back pain was a strong determinant of pain and distress-related outcomes. Workers who reported lower back pain showed elevated levels of distress, especially if they were absent due to the pain, whereas 80% of workers indicated that pain impacted their ability to work normally. Both interference with work performance, an indication of presenteeism, and increased absenteeism have considerable cost impact on the employers. Because of the retrospective nature of the data, however, it cannot be determined whether pain was most likely to result in absenteeism and presenteeism as people became more distressed, or vice versa.

With the exception of those who reported lower back pain, most participants were not taking time off work to deal with their pain. This may indicate the potential for higher levels of presenteeism within the coal-mining population. Workers in high-demand low-resourced jobs have previously been reported to be more likely to attend work while sick [47]. However, if sickness or injury affects the workers' perceptions about their ability to perform work tasks competently or safely, this can lead to increased incidence of stress, anxiety, and depression [48]. Demerouti and co-workers [49] caution that presenteeism may ultimately lead to further deterioration in employee's mental and physical condition and should be discouraged. Further examination of job types, daily exposure to tasks, and the development of musculoskeletal pain and distress over time in the mining industry is important to understand these findings.

4.2. Individual and lifestyle factors

In contrast to general perceptions, BMI, age, and experience were not associated with increased pain or distress in the present sample when examined independently. However, when included in the larger model, age had a significant negative effect on distress reporting, suggesting that older workers may experience less distress. This variation may be indicative of the complex interplay among variables involved in the pain—distress relationship. Whereas the findings for age and experience may be explained by a survivor effect, the results for BMI are unclear. As reported, BMI in participants from sedentary job categories was so high, which may simply be due to a ceiling effect that prevented relationships from emerging. Alternatively, previous research involving law enforcement officers suggested that although BMI increased with psychological distress among females, there was no association among males [50]. This may reflect the limitations of BMI as a measure of body composition as it fails to distinguish between fat and lean body mass, which may have an impact on the ability to perform a particular task.

When included in the larger model, exercising when time off work appeared to be protective, such that workers who were more active off-shift reported lower levels of distress regardless of pain. Moreover, compared with their sedentary counterparts, their distress was particularly lower at high levels of reported pain, supporting the efficacy of physical activity in reducing psychological distress.

4.3. Fatigue

Perceived sleep quality during work periods partially mediated the relationship between pain and distress. More widespread pain was associated with decreased sleep quality, and workers were more likely to report being distressed in this situation. Miró and coworkers [27] suggested that pain may disturb sleep and that poor sleep quality may contribute to emotional distress by compromising the sleep processes that regulate mood state. Interestingly, this mediation was only apparent when rostered on and sleep quality did not significantly mediate the relationship between pain and distress when rostered off. This discrepancy highlights the particular importance of adequate rest and perceived quality of rest during working periods. For example, insufficient quality and quantity of sleep have been associated with increased risk of injury [51,52] and poorer health status [26,28] such as diabetes [53]. The risk of diabetes is also increased by the high prevalence of overweight or obese workers in the driver/operator categories of the studied workforce. Exposure to 12-hour rotating shifts accommodating travel and meals leaves limited time for sleep and effective recovery, which thus continues to increase the risk of presenteeism and chronic health problems.

4.4. Limitations

Because of the cross-sectional nature of this study, the underlying cause of distress remains unclear, as indeed does the direction of the effect. Research over a 5-year period with oil and gas personnel suggested that psychological distress was a primary cause of musculoskeletal pain rather than an outcome [24]. However, they suggest that although anxiety may be a causal factor, depression may be a result of musculoskeletal disorders. Because a nonspecific measure of distress was used in this study, the differential associations between anxiety and depression could not be examined. A previous study [14] has demonstrated the relationship between work characteristics (i.e., job demands, job control, and supervisor support) and mental health to be reciprocal, and therefore the pattern of causation among work-related pain and mental distress and environmental context needs to be examined longitudinally.

There are a number of limitations in this study that need to be acknowledged. First, the distress measure used is general and not related explicitly to work. Therefore, stress outside of work could be the main cause of distress and context-dependent distress may relate differentially to work outcome variables. This poses a challenge to organizations as it is outside of managements' control, although many companies offer a counseling service to employees experiencing personal or psychological problems. In addition, it would have been beneficial to have information about whether participants were currently receiving psychological treatment, which may mask some potential relationships. Further, we do not have matched injury data for the individuals in the study, and therefore although we can infer a link between pain and injury risk, we cannot determine the association. Despite these limitations, the study is strengthened by the high response rate (89%), which ensures that, although cross sectional, a representative sample of miners at the test site was achieved.

In summary, this paper attempted to examine the relationship between musculoskeletal pain and distress in an Australian mining population. Specifically, it focused on the impact of individual, work, and lifestyle factors, and demonstrated that for truck drivers or machine operators exercise time and sleep quality had important implications for the pain—distress relationship. Moreover, it is suggested that the presentation of distress is complex, with the combined interplay among contributory variables being more important than the simple effect of pain. Given the array of individual, work, and lifestyle factors possible, it is likely that these findings underestimate the complexity of pain experiences, and therefore why and how this translates into psychological distress. As such, questions unanswered by this study open up several new avenues for further research. For instance, it remains to be determined whether psychological distress is a time-dependent risk factor for work-related injuries in mining. Although the study utilized a large company with a workforce representative of the industry, it would be valuable to know whether risk factors for pain and distress varied between underground and surface operations. Although the study results suggest that exercise time off-shift and sleep quality on-shift may be beneficial to reduce the impact of pain on distress, more information is also needed about the individual characteristics of people who are able to cope with, and work through, pain. Furthermore, determining whether other recovery activities besides sleep and exercise benefit workers in the mining industry would also be a valuable contribution to the field. In order for occupational health and safety researchers and practitioners to decrease occupational injury rates and the compensation costs that follow, a proactive approach to monitor the occurrence of both pain and distress among the workforce to identify individuals in need of early intervention is essential. This may be particularly critical for truck drivers and machine operators, workers who have difficulty sleeping, and workers with lower back pain, as these conditions were associated with poorer outcomes for pain, distress, and work interference.

Conflicts of interest

All contributing authors declare no conflicts of interest.

Acknowledgments

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