Working nights and lower leisure-time physical activity associate with chronic pain in Southern African truck drivers: a cross-sectional study

Antonia L Wadley¹ PhD, Stella Iacovides¹ PhD, Johanna Roche¹ PhD, Karine Scheuermaier¹ MD, MMSc, WD Francois Venter² MBBCh, Alinda G Vos^{2,3} PhD; Samanta T Lalla-Edward² PhD

¹ Brain Function Research Group, School of Physiology, Faculty of Health Sciences, University of the Witwatersrand, South Africa

² Ezintsha, a sub-division of Wits Reproductive Health and HIV Institute, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

³ Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht, The Netherlands

Corresponding author: Antonia Wadley
School of Physiology, Faculty of Health Sciences,
University of the Witwatersrand, 7 York Rd, Parktown,
Johannesburg 2193
Email: antonia.wadley@wits.ac.za
Tel: +27 (0)11 717 2163

Short running title (45 characters): Night shifts and activity associate with pain

Keywords: chronic pain, night shifts, activity, depression, truck drivers, drivers

Funding sources: This work was funded by North Star Alliance through a research and implementation grant received from the Ministry of Foreign Affairs of The Netherlands managed by the Royal Dutch Embassy of Mozambique. The Amsterdam Institute for Global Health and Development and Wits RHI held separate contracts with North Star Alliance (AIGHD's grant reference: 0068 North Star – NSCDP; RHI's grant number: D1404070). The views of this study are those of the authors and do not necessarily reflect the views of any of the funders or the South African and Dutch governments.

Conflicts of interest: the authors declare no conflicts of interest

Abstract

Background

Globally the trucking industry employs millions of people. Recently the prevalence of chronic pain in Southern African truck drivers was reported at 10%. We investigated factors associated with chronic pain in truck drivers including mental health, physical activity, and sleep, as no study has done so.

Methods

Southern African truck drivers were recruited at truck stops in Gauteng and Free State Provinces, South Africa (n=614). Chronic pain was defined as pain present for at least the last three months. Depressive symptoms were assessed with the Patient Health Questionnaire-9, post-traumatic stress disorder with the Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5), exposure to traumatic events with the Life Events Checklist-5 (LEC-5) and daytime sleepiness with the Epworth Sleepiness Scale. Sleep quality was measured on a four-point Likert scale. Leisure-time physical activity was measured using the Godin-Shephard leisure-time physical activity questionnaire. Associations between these factors, demographic factors and chronic pain were investigated.

Results

Six hundred and fourteen male truck drivers were recruited. Multivariate analysis showed that working ≥ 2 nights/week (OR=2.68, 95% CI=1.55-4.68) was associated with chronic pain and physical activity was protective (OR=0.97, 95% CI 0.95-0.98). In an exploratory analysis, greater depressive symptoms ($p=0.004$), daytime sleepiness ($p=0.01$) and worse sleep quality ($p=0.001$) was associated with working ≥ 2 nights/week. Lower leisure-time physical activity was associated with worse sleep quality ($p=0.006$), but not daytime sleepiness or depressive symptoms ($p>0.05$).

Conclusions

There is a clear relationship between working nights and activity levels, and chronic pain, sleep quality, and depression in truck drivers.

Introduction

Trucking is a major industry and employer worldwide. In the US alone the trucking industry generated almost \$800 billion in revenue in 2018 and employed 3.5 million drivers (American Trucker Association). Studies to date of truck drivers' health have tended to focus on cardiovascular health and factors that associate with risk of accidents (1,2). Far fewer studies have investigated the prevalence of, and factors associating with pain in truck drivers. Studies that have been conducted have taken a primarily ergonomic approach to factors associating with pain including whole-body vibration, twisting and lifting (3,4).

In our recent study on the general health of 614 Southern African truck drivers, the prevalence of pain in the last three months was 10% (5). In other studies of truck drivers, the prevalence has ranged from 27-81% (3,4,6–8). There are several possible reasons for the wide range of pain prevalence reports including: the older age of other cohorts (3,4,7), the inclusion of both acute and chronic pain, and the varying definitions of pain, such as “any ache pain or discomfort in the last year” to “pain often or all the time in the 12 months prior” (3,4). Even taking the conservative end of the prevalence data reported, the sheer number of individuals working in the trucking industry worldwide indicate that investigating pain in truck drivers is warranted.

Factors associating with pain in truck drivers remain unclear because so few studies have been conducted and these studies have reported conflicting results. In particular, the associations between pain and whole-body vibration, lifting heavy weights, number of working hours, and number of hours sleep per night are equivocal (3,4,6,9). Psychosocial factors have a known association with pain (10) but few studies have explored the influence of psychosocial factors on truck drivers' pain. Of those studies that have, the factors have tended to be work-related e.g. job satisfaction, perceived work stress, effort-reward balance (4,8). Even when social support has been included it has been in terms of social support from employers and colleagues rather than from individuals' personal lives (4). In essence, studies investigating pain in truck drivers have not explored associations between pain and

depression, nor have they explored associations between pain and non-work-related stress or trauma.

In this cross-sectional analysis of 614 male Southern African truck drivers, we investigated factors associated with chronic pain. We used chronic pain (defined as the experience of pain lasting at least 3 months), due to its greater personal, social and economic consequences than acute pain (11). We investigated factors not previously assessed including depression, post-traumatic stress and physical activity and explored associations with sleep.

Materials and methods

The study was designed to determine the general health of male truck drivers in South Africa and comprehensive descriptive analyses have been published elsewhere (5). In brief, the cross-sectional study was conducted during October 2016 and March 2017. Data were collected at several truck stops within the Gauteng and Free State provinces in South Africa. Inclusion criteria were males of 18 years or older and driving trucks as their current full-time occupation. The median age of the male truck drivers was 37 years (IQR 31-42), they had mostly completed secondary education (89%, 486/614) and two-thirds classified as overweight or obese (BMI $\geq$ 25, 65%, $n = 417/614$). The majority of the drivers were Zimbabwean (63%, 384/614), with the remainder being mostly South African (20%, 123/614) or Zambian (7%, 45/614).

Ethics clearance was obtained from the University of the Witwatersrand Human Research Ethics Committee (Medical), which adheres to the principles of the Declaration of Helsinki [clearance number M160760] and all participants gave written informed consent.

Trained nurses measured height, weight and tested for HIV using standard Department of Health procedures. Non-fasting blood was drawn to measure serum C-reactive protein.

Measures

Chronic pain

Chronic pain was classified as pain present for at least three months (12). Participants were asked to indicate any locations of pain from a list of body parts, where they had had pain or discomfort for more than three months.

Physical activity

Physical activity was measured using the Godin-Shephard leisure-time physical activity questionnaire (GSLTPAQ) (13). Number of 15-minute episodes of strenuous, moderate and light exercise per week were recorded. A leisure-time physical activity score was calculated by multiplying the strenuous episodes by nine, the moderate episodes by five and the light episodes by three. The questionnaire has been previously used in African contexts (14,15).

Sleep and daytime sleepiness

Subjective sleep parameters were assessed using the Pittsburgh Sleep Quality Index (PSQI)(16), which has been previously validated in the South African population (17). The PSQI is a self-administered questionnaire composed of 19 items, which measure multiple dimensions of sleep during the previous month. A PSQI global score is calculated from the questionnaire and ranges from 0 - 21, with higher scores indicating poorer sleep quality. The global score is comprised of seven component scores (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction) which can be analyzed separately (18). For the purpose of this study, we examined the overall sleep quality as assessed by the first component of the PSQI, which refers to question 9, where the participants are asked to rate their subjective sleep quality overall during the past month as “very good”, “fairly good”, “fairly bad” or “very bad” (18).

Excessive daytime sleepiness was measured using the Epworth Sleepiness Scale (ESS) (19). This is a self-administered and validated scale that aims to assess the presence and degree of daytime sleepiness, which has been previously validated in the South African population (17). The respondent is asked to answer how likely they are to doze off or fall asleep in eight different scenarios on a 4-point Likert scale of 0

(“would never dose”) to 3 (“high chance of dozing”). Possible scores range from 0 to 24 and in the general population, a score > 10 means excessive daytime sleepiness (19,20).

Mental health

Depressive symptoms were measured using the widely-used Patient Health Questionnaire (PHQ-9) (21). This is a 9-item questionnaire with answers ranging from 0 (Not at all) to 3 (Nearly every day). The answers are summed resulting in a score ranging from 0-27. Cut-off points for symptom severity are 5 for mild, 10 for moderate, 15 for moderately severe, and 20 for severe depression. The tool has been successfully validated in primary health care populations in South Africa (22,23).

Post-traumatic stress disorder (PTSD) was assessed using the Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5) (24). This is a 20-item scale where participants answer on a 5-point Likert scale from 0 (Not at all) to 4 (Extremely) to a range of DSM criteria for PTSD, including presence of intrusive symptoms, negative changes in cognitions and mood and alterations in arousal and reactivity (25). A total symptom severity score is calculated by summing the item scores resulting in a score ranging from 0-80. Cut-off scores for probable PTSD can range between 23-38 depending on the population the scale was validated in (26–29). The cut-off was 33 in an African population from Zimbabwe (30), the country from which the majority of the truck drivers came, so we used this cut-off score.

The life events checklist (LEC-5) (31) is a tool often used alongside the PCL-5, and determines exposure to traumatic life events. There are 16 stressful life events such as ‘Fire or explosion’, “Sexual assault” and “Sudden unexpected death of someone close to you” with an additional item for “Any other very stressful event or experience’. Respondents answer with ‘Happened to me’, ‘Witnessed it’, ‘Learned about it’, ‘Not sure’, ‘Doesn't apply’. For the purposes of this study, we determined that the total number of events with the response recorded as ‘happened to me’ as direct exposure, and we determined the number of events with the response recorded as ‘witnessed it’ as indirect exposure. We report both but used the former in our analyses.

Driving-related factors

Factors related to participants' driving were also recorded. These factors included number of years driving, average number of driving days per month, average number of hours driving per day. The number of working nights per week was determined by asking drivers how many times a week they drove for at least three hours between 10pm and 6am. Stressful events whilst working were determined by asking drivers if they had had an accident, and if so, the number of accidents (of any severity) they had had. Drivers were also asked if they carried dangerous cargo, such as explosives, flammable gases, combustible solids or radioactive material.

Data analysis

The analysis was run on GraphPad Prism (version 8.0.0, San Diego, California USA). Data were checked for normality and were non-parametric. As such, data are presented as median (interquartile range, IQR) and non-parametric statistical tests were run. The presence of chronic pain was the dependent variable. In univariate analysis, a Fisher's exact test was used to analyze 2x2 tables for its exact p value but Chi-square tests were used for categorical variables with more groupings. Variables routinely associated with pain, that is age, body mass index (BMI) and depressive symptoms (32), or variables achieving a p value <0.1 on univariate analysis were added to the multivariate logistic regression. In addition, as there is a known relationship between sleep, pain and depression (33), we ran exploratory analyses including sleep quality and depression levels with the significant main effects found in our model. P values <0.05 were considered to be significant.

Results

Six hundred and fourteen male Southern African drivers were recruited into the study. A description of the entire cohort has already been presented (5). Of the 614, 63 (10%) had chronic pain. Characteristics of those with and without chronic pain are shown in Table 1.

Table 1. Characteristics and comparison of the truck drivers with and without pain

241

	Chronic pain n=63	No chronic pain n=551	P value
Age (years) *	37.0 (31.0-41.5)	37.0 (31.0-42.0)	0.71 [†]
BMI* [§]	27.5 (24.5-31.7)	27.1 (24.1-30.5)	0.23 [†]
Level of education, n (%) [§]			0.80 [‡]
Primary or less	4 (6)	47 (9)	
Some secondary	55 (87)	431 (78)	
Tertiary	4 (6)	50 (9)	
Smoking, n (%) [§]	4 (6)	86 (16)	0.06 ^α
Activity score*	0 (0-27)	17 (0-27)	0.0001 [†]
HIV-positive, n (%) [§]	7 (11)	45 (8)	0.48 ^α
C-reactive protein (mg/l)* [§]	1.30 (0.50-3.10)	1.30 (0.50-2.75)	0.58 [†]
PHQ-9, n (%) [§]			0.11 [†]
Minimal	36 (57)	370 (68)	
Mild	20 (32)	135 (25)	
Moderate or greater	7 (11)	43 (8)	
PCL-5* [§]	6 (2-14)	0 (5-13)	0.49 [†]
LEC-5 * [§]	3 (1-4)	2 (0-3)	0.07 [†]
Sleep-related			
Sleep quality, n (%) [§]			0.94 [†]
Very good	29 (46)	217 (40)	
Fairly good	20 (32)	222 (40)	
Fairly bad	10 (16)	90 (16)	
Very bad	4 (6)	18 (3)	
ESS score*	6 (4-8)	5 (2-9)	0.30 [†]
Driving-related			
Number of years driving*	11 (4-15)	8 (5-14)	0.49 [†]
Driving days per month, n (%)	20 (20-24)	20 (15-24)	0.37 [†]
Hours driving per day* [§]	10 (9-12)	10 (8-12)	0.44 [†]
Working nights per week, n (%) [§]			0.0002 ^α
0-1	27 (44)	371 (68)	
2 or more	35 (56)	174 (32)	
Accident whilst driving, n (%) [§]	14 (22)	102 (19)	0.73 ^α
Number of accidents whilst driving* [§]	0 (0-0)	0 (0-0)	0.60 [†]
Carry dangerous cargo, n (%)	17 (27)	200 (36)	0.21 ^α

242

*Median (IQR); [†] Mann Whitney; [‡]Chi-square test for trend; ^α Fisher's exact

243

PHQ-9 = Patient Health Questionnaire-9; PCL-5 = Posttraumatic Stress Disorder Checklist for DSM-5;

244

LEC-5 = Life Events Checklist-5; ESS = Epworth Sleepiness Scale

245

PHQ-9 categories: minimal = score of 0-4, mild 5-9, moderate or more ≥ 10

246

Rounding resulted in some percentages not adding to 100%

247

248

[§]Missing data. BMI: chronic pain =1, no chronic pain =9; Education: no chronic pain=23; Smoking:

249

without chronic pain =3; HIV: no chronic pain =12; CRP: chronic pain =2, no chronic pain = 23; PHQ-9:

250

no chronic pain =3; PCL-5: no chronic pain =3; LEC-5: no chronic pain =2; Sleep quality: no chronic

pain =4; Hours driving per day: no chronic pain =7; Working nights per week: chronic pain =1, no chronic pain =6; Accidents whilst driving: chronic pain = 1; no chronic pain = 7; Number of accidents whilst driving: chronic pain =1, no chronic pain =9

Depressive symptoms (mild or greater, ≥ 5 on PHQ-9) occurred in 43% (27/63) of participants with chronic pain, and 32% (178/548) without chronic pain (Chi-squared test for trend, $p=0.11$). PTSD was present in 6% (4/63) of those with chronic pain and 4% (20/549) of those without. There was no difference between the groups (Fisher's exact, $p=0.3$). At least one traumatic life event had been directly experienced ("happened to me") by 75% (456/612) of the drivers. When witnessed traumatic life events were added to those directly experienced ("happened to me" and "witnessed it"), 95% (582/612) of the drivers reported previous exposure.

Factors associating with chronic pain

Table 1 also shows results of the univariate analysis to determine associations with chronic pain. Age, BMI, and HIV status were not associated with having pain ($p>0.05$). Lower leisure-time physical activity levels and working nights were associated with having chronic pain ($p<0.05$). Smoking, and traumatic life experiences as measured by the LEC-5 achieved p values <0.1 and so were included in the multivariate model.

Table 2 shows the results of the multivariate model. Leisure-time physical activity levels and working nights remained significant ($p<0.001$), whereby higher levels of activity were associated with lower likelihood of chronic pain (OR=0.97, 95% CI 0.95-0.98) and working ≥ 2 nights/week was associated with higher likelihood of chronic pain (OR=2.68, 95% CI=1.55-4.68).

Table 2. Results of multivariate logistic regression model for the presence of pain

	<i>Odds ratio</i>	<i>95% confidence intervals</i>	<i>p-value</i>
Age (years)	0.98	0.95-1.02	0.30
BMI	1.02	0.97-1.08	0.43
Smoking	0.44	0.13-1.20	0.13

Activity score	0.97	0.95-0.98	0.0008
PHQ-9	1.15	0.76-1.70	0.51
LEC-5	1.05	0.94-1.17	0.36
Working ≥ 2 nights per week	2.68	1.55-4.68	0.0004

BMI = Body mass index; PHQ-9 = Patient Health Questionnaire-9; LEC-5 = Life Events Checklist-5

Exploratory analysis

As pain, sleep and depression are tightly interrelated (33), we further hypothesized that the relationship between working nights and having chronic pain may be through worse sleep quality and higher depressive symptoms. Having found that working nights was associated with higher odds of having chronic pain, we verified whether sleep was worse in those working nights. Table 3 shows that sleep quality and daytime sleepiness were indeed worse in those working two or more nights a week (respectively, $p < 0.001$ and $p < 0.01$). We also found higher prevalence of mild/moderate depressive symptoms in those working ≥ 2 nights/week compared to those working < 2 (40% vs 30%, $p = 0.004$, see Table 3)).

Table 3. Comparison of depression and sleep-related measures between those working zero or one night a week to those working two or more nights per week

	Working 0 or 1 night/week n=398	Working ≥2 nights/week n=209	P value
Mental health-related			
PHQ-9 [§]			
Minimal	277 (70)	123 (60)	0.004 [†]
Mild	96 (24)	58 (28)	
Moderate	25 (6)	25 (12)	
Sleep-related			
Sleep quality [§]			
Very good	176 (44)	67 (32)	0.001 [†]
Fairly good	153 (39)	87 (42)	
Fairly bad	56 (14)	42 (20)	
Very bad	11 (3)	11 (5)	
ESS score	5 (2-9)	6 (3-10)	0.0096 [†]

Data presented as n (%) or median (IQR).

[†] Mann Whitney; [‡]Chi-square test for trend

[§] Number of missing data. PHQ-9 ≥2 nights n=3; Sleep quality: 0-1nights n=2, ≥2 nights =2

PHQ-9 = Patient Health Questionnaire-9; ESS = Epworth Sleepiness Scale

Secondly, as sleep, depression and physical activity are also interrelated and share common biochemical and neural pathways (34), we hypothesized that the relationship between lower activity and chronic pain may also be through worse sleep quality and higher depressive symptoms. Indeed, sleep quality was worse in those who had lower activity levels (Kruskal Wallis, KW statistic = 12.40, p=0.006), but there was no association with daytime sleepiness (Spearman's correlation, r=0.04, p=0.38) or depressive symptoms (Kruskal Wallis, KW statistic=0.82, p=0.66).

Discussion

We investigated factors associated with chronic pain in a cohort of 614 male Southern African truck drivers. We took a holistic approach, and this is the first study to investigate general mental health, stress and sleep-related factors for associations with chronic pain in truck drivers. This was also the first study to investigate the association between working nights and pain. We found that working two or more nights a week and lower leisure-time physical activity was associated with having

chronic pain. Results of an exploratory analysis showed that those driving two or more nights a week had worse sleep quality, greater daytime sleepiness and greater depressive symptoms. Sleep quality was also worse in those doing less leisure-time physical activity.

Pain and sleep are believed to have a reciprocal relationship. Impaired sleep may be a more consistent predictor of pain, than pain is of impaired sleep (35,36). Furthermore, disrupted sleep and wake times may increase pain (37). Irregular bedtimes were associated with greater pain intensity in those with chronic pain (37). Long-distance truck drivers have reported irregular working hours (4,38) that resulted in irregular sleep-wake times (4). We only recorded average sleep-and wake-times over the past month, and hence are uncertain of the regularity/irregularity of our participants' day-to-day sleep-wake schedules. We inferred, however, that individuals working two or more nights a week would have irregular sleep- and wake-times. Thus, we hypothesize that the mechanism through which working nights may have influenced pain is via circadian misalignment.

The prevalence of depressive symptoms was higher in the truck drivers than males in the general South African population (40% vs 24%) (Mutiyambizi et al., 2019). We found a relationship between working two or more nights a week and greater depressive symptoms. Indeed, a meta-analysis found depression and night shift work were associated and that depression could be 40% more likely in those working night shifts (41). We hypothesize that working nights may also have been associated with depression via chronic circadian misalignment (42).

Clinical evidence elucidating a mechanism between low mood and irregular sleep-wake schedules include data from 23 participants subjected to the forced desynchrony protocol, which teases apart endogenous circadian rhythms from the sleep-wake cycle (43). A significant variation in the modulation of happiness was seen at different phases of the circadian rhythm: higher happiness coincided with core body temperature peak, and lowest happiness occurred at core body temperature trough, a time when normally-entrained individuals are asleep and therefore unlikely to report feeling less happy. Irregular sleep-wake schedules such as those seen in rotating shift workers may thus result in being awake at a time when

mood is more depressed. Further, irregular sleep-wake schedules lead to exposing the circadian pacemaker to light at exquisitely sensitive parts of the phase response curve, which may lead to large phase shifts even with little light exposure (44,45). This results in frequent phase shifts and loss of amplitude of endogenous rhythms in both rodents (46) and humans (47). Flattening of endogenous rhythms is associated with poorer sleep quality, which may spill over even on days off work. Indeed, we found an association between working more than two night shifts per week and lower sleep quality. Similarly, rhythms of mood regulation may be flattened, which may make depression/mood dysregulation more likely. The likelihood of being more depressed when working nights, therefore, may be either a direct effect of dysregulation of mood through lower circadian amplitude and/ or an indirect effect elicited by the lower quality of sleep in individuals experiencing chronic circadian misalignment.

Despite relationships between pain, sleep and mood (32), and between stress, sleep, and mood (48), and general comorbidity between chronic pain and stress (49), we did not find an association between markers of stress (PTSD, occurrence of traumatic life events, and potential driving-related stressors like carrying dangerous cargo) and chronic pain. Stress, therefore, may not be part of the mechanism linking pain, sleep and mood in this cohort. The one non-work-related psychosocial factor that has previously been investigated in studies on pain in truck drivers, however, is time away from family. Extended time away from family was associated with having pain in Japanese drivers (9). Anecdotally, Canadian drivers disliked spending large periods of time alone (4). These data suggest that loneliness, which has associated with pain (50–52), may be worthy of investigation in future studies on pain in long-distance drivers including its impact on mood and sleep.

We found that lower leisure-time activity was associated with having chronic pain. Individuals with chronic pain had a median leisure-time physical activity score of 0 compared to a score of 17 but both groups still classify as being insufficiently active (53). The truck drivers reported driving for a median of ten hours per day regardless of their chronic pain status. As our data are cross-sectional, we cannot report whether lower activity led to chronic pain or whether those with chronic pain were unable or unwilling to exercise. Physical activity may be associated with pain

mitigating effects either directly through exercise-induced hypoalgesia (54) and/ or through its known circadian phase shifting effects (55,56). Either way, physical activity is an integral component of pain management programs (57), so increasing physical activity, whether as a preventative or therapeutic strategy could be beneficial in populations of truck drivers for more than just their cardiovascular health (58). Truck drivers with pain may, however, require professional support to ensure that activity is at an appropriate level/pace.

In an exploratory analysis we investigated whether leisure-time activity levels associated with sleep or depressive symptoms. Whilst we did not find an association with leisure-time activity and depressive symptoms or sleepiness, we did find that those who were less active had worse sleep quality; a finding also reported in a meta-analysis of the effects of physical activity on sleep (59). We have already implicated the role of sleep irregularity on the presence of pain and depressive symptoms but there is also evidence that sleep irregularity associates with greater functional impairment in those living with chronic pain (37). The mechanisms influencing the relationships between physical activity, sleep, depression and pain certainly warrant further investigation.

There were several limitations to the work. The protocol for recruitment included handing out leaflets at truck stops and addressing several truck drivers at a time about the study. We cannot exclude the possibility, therefore, of selection bias in our sample. We only recorded average sleep and wake times and so we do not know how interrupted drivers' sleep-wake schedules actually were. We would recommend the use of week-long sleep diaries in future to ascertain sleep irregularity. Additionally, there is poor agreement between subjective and objective measures of both sleep (60) and activity (61–63). Objective measurement of both sleep and activity would strengthen future studies. Acceptability of objective measurement of sleep and has been demonstrated in British truck drivers and in clinical populations in South Africa (63,64). We classified individuals as not having chronic pain if they had not had pain for at least three months. There were individuals, however, who had experienced pain for less than three months and who may have gone on to develop chronic pain. This issue may have reduced the likelihood of determining

associations with pain. Nonetheless, working nights and activity were associated with chronic pain.

In this first study of factors associated with chronic pain in male truck drivers we found that working two or more nights a week and lower leisure-time physical activity were associated with having chronic pain. Working nights was associated with worse sleep and greater depressive symptoms, and lower leisure-time activity also associated with worse sleep quality. The relationship between chronic pain, sleep, depression and activity warrants further investigation in understanding the health consequences of shift work in truck drivers and other shift workers.

Acknowledgments

The authors would like to thank North Star Alliance for their assistance during participant recruitment and the truck drivers for their participation

References

1. Lemke MK, Apostolopoulos Y, Hege A, Wideman L, Sönmez S. Work organization, sleep and metabolic syndrome among long-haul truck drivers. *Occup Med.* 2017 Jun 1;67(4):274–81.
2. Thiese MS, Hanowski RJ, Kales SN, Porter RJ, Moffitt G, Hu N, et al. Multiple Conditions Increase Preventable Crash Risks among Truck Drivers in a Cohort Study. *J Occup Environ Med.* 2017 Feb;59(2):205–11.
3. Robb MJM, Mansfield NJ. Self-reported musculoskeletal problems amongst professional truck drivers. *Ergonomics.* 2007 Jun;50(6):814–27.
4. Sekkay F, Imbeau D, Chinniah Y, Dubé P-A, de Marcellis-Warin N, Beauregard N, et al. Risk factors associated with self-reported musculoskeletal pain among short and long distance industrial gas delivery truck drivers. *Appl Ergon.* 2018 Oct 1;72:69–87.
5. Lalla-Edward ST, Fischer AE, Venter WDF, Scheuermaier K, Meel R, Hankins C, et al. Cross-sectional study of the health of southern African truck drivers. *BMJ Open.* 2019 Oct 28;9(10):e032025.
6. Andrusaitis SF, Oliveira RP, Barros Filho TEP. Study of the prevalence and risk factors for low back pain in truck drivers in the state of São Paulo, Brazil. *Clin Sao Paulo Braz.* 2006 Dec;61(6):503–10.
7. Apostolopoulos Y, Sönmez S, Shattell MM, Gonzales C, Fehrenbacher C. Health survey of U.S. long-haul truck drivers: Work environment, physical health, and healthcare access. *Work.* 2013 Jan 1;46(1):113–23.
8. Yosef T, Belachew A, Tefera Y. Magnitude and Contributing Factors of Low Back Pain among Long Distance Truck Drivers at Modjo Dry Port, Ethiopia: A Cross-Sectional Study. *J Environ Public Health.* 2019 Sep 22;2019:6793090.
9. Miyamoto M, Shirai Y, Nakayama Y, Gembun Y, Kaneda K. An epidemiologic study of occupational low back pain in truck drivers. *J Nippon Med Sch.* 2000 Jun;67(3):186–90.
10. Edwards RR, Dworkin RH, Sullivan MD, Turk DC, Wasan AD. The Role of Psychosocial Processes in the Development and Maintenance of Chronic Pain. *J Pain.* 2016;17(9 Suppl):T70-92.
11. Raffaelli W, Arnaudo E. Pain as a disease: an overview. *J Pain Res.* 2017 Aug 21;10:2003–8.
12. Treede R-D, Rief W, Barke A, Aziz Q, Bennett MI, Benoliel R, et al. Chronic pain as a symptom or a disease: the IASP Classification of Chronic Pain for the International Classification of Diseases (ICD-11). *Pain.* 2019 Jan;160(1):19–27.
13. Godin G, Shephard RJ. A simple method to assess exercise behavior in the community. *Can J Appl Sport Sci.* 1985 Sep;10(3):141–6.

- 477 14. Aliyu ES, Adeniyi AF. Occupational Physical Activity of Health Care Providers in
478 a Nigerian Tertiary Hospital Setting. *Afr J Physiother Rehabil Sci*. 2017;9(1–
479 2):16–21.
- 480 15. Mukaruzima L. Leisure-time physical activity practices and the influencing
481 factors among government office employees in Kigali, Rwanda. *Occup Health*
482 *South Afr*. 2020;26:3–7.
- 483 16. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh
484 Sleep Quality Index: a new instrument for psychiatric practice and research.
485 *Psychiatry Res*. 1989 May;28(2):193–213.
- 486 17. Redman KN, Karstaedt AS, Scheuermaier K. Increased CD4 counts, pain and
487 depression are correlates of lower sleep quality in treated HIV positive patients
488 with low baseline CD4 counts. *Brain Behav Immun*. 2018;69:548–55.
- 489 18. Seay JS, McIntosh R, Fekete EM, Fletcher MA, Kumar M, Schneiderman N, et
490 al. Self-reported sleep disturbance is associated with lower CD4 count and 24-h
491 urinary dopamine levels in ethnic minority women living with HIV.
492 *Psychoneuroendocrinology*. 2013 Nov;38(11):2647–53.
- 493 19. Johns MW. A new method for measuring daytime sleepiness: the Epworth
494 sleepiness scale. *Sleep*. 1991 Dec;14(6):540–5.
- 495 20. Johns M. Rethinking the assessment of sleepiness. *Sleep Med Rev*. 1998
496 Feb;2(1):3–15.
- 497 21. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression
498 severity measure. *J Gen Intern Med*. 2001 Sep;16(9):606–13.
- 499 22. Bhana A, Rathod SD, Selohilwe O, Kathree T, Petersen I. The validity of the
500 Patient Health Questionnaire for screening depression in chronic care patients
501 in primary health care in South Africa. *BMC Psychiatry*. 2015 May 23;15:118.
- 502 23. Cholera R, Gaynes B, Pence B, Bassett J, Qangule N, Macphail C, et al.
503 Validity of the patient health questionnaire-9 to screen for depression in a high-
504 HIV burden primary healthcare clinic in Johannesburg, South Africa. *J Affect*
505 *Disord*. 2014 Oct;167:160–6.
- 506 24. Weathers F, Litz B, Huska J, Keane T. Boston: National Center for PTSD,
507 Behavioural Science Division; 1994.
- 508 25. American Psychiatric Association. Diagnostic and Statistical Manual of Mental
509 Disorders (DSM-5®). American Psychiatric Pub; 2013. 1520 p.
- 510 26. Ashbaugh AR, Houle-Johnson S, Herbert C, El-Hage W, Brunet A.
511 Psychometric Validation of the English and French Versions of the
512 Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5). *PLoS ONE*. 2016
513 Oct 10;11(10):e0161645.

27. Blevins CA, Weathers FW, Davis MT, Witte TK, Domino JL. The Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5): Development and Initial Psychometric Evaluation. *J Trauma Stress*. 2015;28(6):489–98.
28. Ibrahim H, Ertl V, Catani C, Ismail AA, Neuner F. The validity of Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5) as screening instrument with Kurdish and Arab displaced populations living in the Kurdistan region of Iraq. *BMC Psychiatry*. 2018 Aug 16;18:259.
29. Sveen J, Bondjers K, Willebrand M. Psychometric properties of the PTSD Checklist for DSM-5: a pilot study. *Eur J Psychotraumatology*. 2016 Apr 19;7(1):30165.
30. Verhey R, Chibanda D, Gibson L, Brakarsh J, Seedat S. Validation of the posttraumatic stress disorder checklist – 5 (PCL-5) in a primary care population with high HIV prevalence in Zimbabwe. *BMC Psychiatry*. 2018 Apr 23;18(1):109.
31. Weathers F, Blake D, Schnurr P, Kaloupek D, Marx B, Keane T. The Life Events Checklist for DSM-5 (LEC-5). [Internet]. 2013 [cited 2020 Jan 3]. Available from: https://www.ptsd.va.gov/professional/assessment/te-measures/life_events_checklist.asp
32. Mills SEE, Nicolson KP, Smith BH. Chronic pain: a review of its epidemiology and associated factors in population-based studies. *Br J Anaesth*. 2019 Aug 1;123(2):e273–83.
33. Boakye PA, Olechowski C, Rashid S, Verrier MJ, Kerr B, Witmans M, et al. A Critical Review of Neurobiological Factors Involved in the Interactions Between Chronic Pain, Depression, and Sleep Disruption. *Clin J Pain*. 2016 Apr;32(4):327–36.
34. Lopresti AL, Hood SD, Drummond PD. A review of lifestyle factors that contribute to important pathways associated with major depression: Diet, sleep and exercise. *J Affect Disord*. 2013 May 15;148(1):12–27.
35. Finan PH, Goodin BR, Smith MT. The association of sleep and pain: an update and a path forward. *J Pain*. 2013 Dec;14(12):1539–52.
36. Koffel E, Kroenke K, Bair MJ, Leverty D, Polusny MA, Krebs EE. The bidirectional relationship between sleep complaints and pain: Analysis of data from a randomized trial. *Health Psychol*. 2016 Jan;35(1):41–9.
37. McHugh RK, Edwards RR, Ross EL, Jamison RN. Does bedtime matter among patients with chronic pain? A longitudinal comparison study. *Pain Rep*. 2019 Jun;4(3):e747.
38. Maldonado CC, Mitchell D, Taylor SR, Driver HS. Sleep, work schedules and accident risk in South African long-haul truck drivers. *South Afr J Sci*. 2002;98:319–24.

- 553 39. Mutyambizi C, Booyesen F, Stornes P, Eikemo TA. Subjective social status and
554 inequalities in depressive symptoms: a gender-specific decomposition analysis
555 for South Africa. *Int J Equity Health*. 2019 Jun 13;18:87.
- 556 40. Williams DR, Herman A, Stein DJ, Heeringa SG, Jackson PB, Moomal H, et al.
557 Twelve-month mental disorders in South Africa: prevalence, service use and
558 demographic correlates in the population-based South African Stress and
559 Health Study. *Psychol Med*. 2008 Feb;38(2):211–20.
- 560 41. Lee A, Myung SK, Cho JJ, Jung YJ, Yoon JL, Kim MY. Night Shift Work and
561 Risk of Depression: Meta-analysis of Observational Studies. *J Korean Med Sci*.
562 2017 Jul;32(7):1091–6.
- 563 42. Daut RA, Fonken LK. Circadian regulation of depression: A role for serotonin.
564 *Front Neuroendocrinol*. 2019;54:100746.
- 565 43. Boivin DB, Czeisler CA, Dijk DJ, Duffy JF, Folkard S, Minors DS, et al. Complex
566 interaction of the sleep-wake cycle and circadian phase modulates mood in
567 healthy subjects. *Arch Gen Psychiatry*. 1997 Feb;54(2):145–52.
- 568 44. Khalsa SBS, Jewett ME, Cajochen C, Czeisler CA. A phase response curve to
569 single bright light pulses in human subjects. *J Physiol*. 2003 Jun 15;549(Pt
570 3):945–52.
- 571 45. Kripke DF, Elliott JA, Youngstedt SD, Rex KM. Circadian phase response
572 curves to light in older and young women and men. *J Circadian Rhythms*. 2007
573 Jul 10;5:4.
- 574 46. Benstaali C, Bogdan A, Touitou Y. Effect of a short photoperiod on circadian
575 rhythms of body temperature and motor activity in old rats. *Pflugers Arch*. 2002
576 May;444(1–2):73–9.
- 577 47. Nesthus T, Cruz C, Boquet A, Detwiler C, Holcomb K, Della Rocco P. Circadian
578 temperature rhythms in clockwise and counter-clockwise rapidly rotating shift
579 schedules. *J Hum Ergol (Tokyo)*. 2001 Dec;30(1–2):245–9.
- 580 48. Hege A, Lemke MK, Apostolopoulos Y, Whitaker B, Sönmez S. Work-Life
581 Conflict among U.S. Long-Haul Truck Drivers: Influences of Work Organization,
582 Perceived Job Stress, Sleep, and Organizational Support. *Int J Environ Res*
583 *Public Health*. 2019 Jan;16(6):984.
- 584 49. Lunde CE, Sieberg CB. Walking the Tightrope: A Proposed Model of Chronic
585 Pain and Stress. *Front Neurosci*. 2020 Mar 26;14:270.
- 586 50. Jaremka LM, Andridge RR, Fagundes CP, Alfano CM, Povoski SP, Lipari AM,
587 et al. Pain, depression, and fatigue: Loneliness as a longitudinal risk factor.
588 *Health Psychol*. 2014;33(9):948–57.
- 589 51. Jaremka LM, Fagundes CP, Glaser R, Bennett JM, Malarkey WB, Kiecolt-
590 Glaser JK. Loneliness Predicts Pain, Depression, and Fatigue: Understanding
591 the Role of Immune Dysregulation. *Psychoneuroendocrinology*. 2013
592 Aug;38(8):1310–7.

52. Wolf LD, Davis MC. Loneliness, Daily Pain, and Perceptions of Interpersonal Events in Adults with Fibromyalgia. *Health Psychol.* 2014 Sep;33(9):929–37.
53. Amireault S, Godin G. The Godin-Shephard Leisure-Time Physical Activity Questionnaire: Validity Evidence Supporting its Use for Classifying Healthy Adults into Active and Insufficiently Active Categories. *Percept Mot Skills.* 2015 Apr 1;120(2):604–22.
54. Rice D, Nijs J, Kosek E, Wideman T, Hasenbring MI, Koltyn K, et al. Exercise-Induced Hypoalgesia in Pain-Free and Chronic Pain Populations: State of the Art and Future Directions. *J Pain.* 2019 Nov 1;20(11):1249–66.
55. Barger LK, Wright KP, Hughes RJ, Czeisler CA. Daily exercise facilitates phase delays of circadian melatonin rhythm in very dim light. *Am J Physiol Regul Integr Comp Physiol.* 2004 Jun;286(6):R1077-1084.
56. Buxton OM, Lee CW, L'Hermite-Baleriaux M, Turek FW, Van Cauter E. Exercise elicits phase shifts and acute alterations of melatonin that vary with circadian phase. *Am J Physiol Regul Integr Comp Physiol.* 2003 Mar;284(3):R714-724.
57. Geneen LJ, Moore RA, Clarke C, Martin D, Colvin LA, Smith BH, et al. Physical activity and exercise for chronic pain in adults: an overview of Cochrane Reviews. *Cochrane Database Syst Rev [Internet].* 2017 Apr [cited 2020 Apr 29];2017(4). Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5461882/>
58. Puhkala J, Kukkonen-Harjula K, Mansikkamäki K, Aittasalo M, Hublin C, Kärmeniemi P, et al. Lifestyle counseling to reduce body weight and cardiometabolic risk factors among truck and bus drivers--a randomized controlled trial. *Scand J Work Environ Health.* 2015 Jan;41(1):54–64.
59. Kredlow MA, Capozzoli MC, Hearon BA, Calkins AW, Otto MW. The effects of physical activity on sleep: a meta-analytic review. *J Behav Med.* 2015 Jun;38(3):427–49.
60. Silva GE, Goodwin JL, Sherrill DL, Arnold JL, Bootzin RR, Smith T, et al. Relationship between reported and measured sleep times: the sleep heart health study (SHHS). *J Clin Sleep Med.* 2007 Oct 15;3(6):622–30.
61. Schaller A, Rudolf K, Dejonghe L, Grieben C, Froboese I. Influencing Factors on the Overestimation of Self-Reported Physical Activity: A Cross-Sectional Analysis of Low Back Pain Patients and Healthy Controls. *BioMed Res Int.* 2016;2016:1497213.
62. Huijnen IPJ, Verbunt JA, Peters ML, Delespaul P, Kindermans HPJ, Roelofs J, et al. Do depression and pain intensity interfere with physical activity in daily life in patients with Chronic Low Back Pain?: *Pain.* 2010 Jul;150(1):161–6.
63. Wadley AL, Mitchell D, Kamerman PR. Resilience does not explain the dissociation between chronic pain and physical activity in South Africans living with HIV. *PeerJ.* 2016 Sep 13;4:e2464.

634 64. Greenfield R, Busink E, Wong CP, Riboli-Sasco E, Greenfield G, Majeed A, et
635 al. Truck drivers' perceptions on wearable devices and health promotion: a
636 qualitative study. BMC Public Health. 2016 Jul 30;16:667.

637

638