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Cross-sectional surveillance study to phenotype lorry drivers' sedentary behaviours, physical activity and cardio-metabolic health

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ABSTRACT

Objectives Elevated risk factors for a number of chronic diseases have been identified in lorry drivers. Unhealthy lifestyle behaviours such as a lack of physical activity (PA) and high levels of sedentary behaviour (sitting) likely contribute to this elevated risk. This study behaviourally phenotyped UK lorry drivers' sedentary and non-sedentary behaviours during workdays and non-workdays and examined markers of drivers cardio-metabolic health.

Setting A transport company from the East Midlands, UK.

Participants A sample of 159 male heavy goods vehicle drivers (91% white European; (median (range)) age: 50 (24, 67) years) completed the health assessments. 87 (age: 50.0 (25.0, 65.0); body mass index (BMI): 27.7 (19.6, 43.4) kg/m^2) provided objective information on sedentary and non-sedentary time.

Outcomes Participants self-reported their sociodemographic information. Primary outcomes: sedentary behaviour and PA, assessed over 7 days using an activPAL3 inclinometer. Cardio-metabolic markers included: blood pressure (BP), heart rate, waist circumference (WC), hip circumference, body composition and fasted capillary blood glucose, triglycerides, high-density lipopreotein cholesterol, low-density lipoprotein cholesterol (LDL-C) and total cholesterol (TC) levels. These cardio-metabolic markers were treated as secondary outcomes.

Results Lorry drivers presented an unhealthy cardio-metabolic health profile (median (IQR) systolic BP: 129 (108.5, 164) mm Hg; diastolic BP: 81 (63, 104) mm Hg; BMI: 29 (20, 47) kg/m^2; WC: 102 (77.5, 146.5) cm; LDL-C: 3 (1, 6) mmol/L; TC: 4.9 (3, 7.5) mmol/L). 84% were overweight or obese, 43% had type 2 diabetes or prediabetes and 34% had the metabolic syndrome. The subsample of lorry drivers with objective postural data (n=87) accumulated 13 hours/day and 8 hours/day of sedentary behaviour on workdays and non-workdays (p<0.001), respectively. On average, drivers accrued 12 min/day on workdays and 6 min/day on non-workdays of moderate-to-vigorous PA (MVPA).

Conclusion Lorry drivers demonstrate a high-risk cardio-metabolic profile and are highly sedentary and physically inactive. Interventions to reduce sitting and increase MVPA during breaks and leisure time to improve cardio-metabolic health are urgently needed. Educational

Strengths and limitations of this study

► This study is the first to explore sedentary behaviour, physical activity and cardiovascular health among lorry drivers.
► The use of the latest objective monitor to measure sedentary and upright postures during workdays and non-workdays.
► The cross-sectional design that prevents us from making conclusions about causative links between sitting time and cardio-metabolic health.

programmes to raise awareness about diet and exercise are recommended.

INTRODUCTION

Lorry driving has been considered as one of the most hazardous occupations worldwide.[1–3] Long working hours, irregular working patterns and pressures to meet delivery schedules are typical in this occupation, which contribute to psychological stress and sleep deprivation.[4] Furthermore, unhealthy lifestyle behaviours such as poor diet, lack of physical activity (PA), smoking, high volumes of alcohol consumption and irregular sleeping patterns are highly prevalent among this occupational group.[5–7] These features contribute to an increased risk of overweight and obesity, diabetes, hypertension, heart disease, cancer, fatigue, stress, sleep disturbance, musculoskeletal disorders[2 6 8 9] and reduced life expectancy in lorry drivers in comparison with other occupational groups.[10–12]

Sedentary behaviours defined as 'any waking behaviour characterised by an energy expenditure ≤1.5 metabolic syndrome while in a sitting or reclining posture'[13] are prevalent in most working-aged adults, particularly in those with driving occupations.[14] It has been established that these act as an independent

risk factor for increased risk of cardiovascular disease (CVD), cardiovascular mortality, all-cause mortality, diabetes[15][16] and some cancers.[16] Links between poor cardio-metabolic health and occupational driving date back to the 1950s when Morris and Crawford[17] observed higher rates of cardiovascular events and obesity in sedentary bus drivers in comparison with active conductors.

Lorry drivers' lifestyle, in combination with their working environment, embodies a constellation of risk factors for CVD. While high volumes of sedentary time are assumed within this population, no study has specifically measured sedentary behaviour on workdays and non-workdays in lorry drivers. Furthermore, our knowledge related to lorry drivers' cardio-metabolic health has been derived from studies undertaken in other countries, no information currently exists on lifestyle behaviours (including sitting time and PA) and their relation to health in UK lorry drivers. It is essential to understand the habitual lifestyle behaviours of lorry drivers if we are to develop effective and tailored interventions to reduce the risk of the chronic diseases seen within this high-risk group. The primary aim of this study therefore was to behaviourally phenotype UK lorry drivers in terms of time spent in sedentary and non-sedentary behaviours during workdays and non-workdays and working hours and non-working hours. A secondary aim was to examine markers of cardio-metabolic health and to profile drivers' mental health.

METHODS

Study design and participants

This cross-sectional surveillance study was undertaken at a large UK-based transport company from the East Midlands. The present study is part of a programme of research undertaken in partnership with the company. This partnership was instigated by the company themselves who were seeking to better engage their drivers within the company's comprehensive health and well-being programme. Data collection took place between May and August 2014. A volunteer sample of 159 long-distance heavy goods vehicle drivers was recruited, representing 58% of the driving workforce. Drivers were recruited across all shift patterns: morning (06:00–14:00), afternoon (14:00–22:00) and night (22:00–06:00) on any day of the week. Participants without current CVD, haemophilia and any blood-borne viruses were included in the analysis. Ethical approval was obtained from the local Ethical Advisory Committee, and all participants provided written informed consent.

Measurements

Participant's self-reported their age, ethnicity and average weekly working hours. Drivers were asked to complete a Health Screen Questionnaire, in which they recorded any medical problems, medication, average daily intake of fruit and vegetables, average weekly alcohol intake and smoking status (current smoker, ex-smoker and amount

per week). Anxiety and depression were assessed using the Hospital Anxiety and Depression Scale.[18] Scores between 8 and 10 were considered borderline, and those scoring 11 or over were considered as clinical 'caseness' for anxiety or depression.[18]

Resting blood pressure (BP) and heart rate were measured using the validated Omron Intellisense M7 Upper Arm monitor (Omron, UK),[19] following recommendations of the European Hypertension Society.[20] BP was classified as normal (systolic blood pressure (SBP) <120 mm Hg and diastolic blood pressure (DBP) <80 mm Hg) prehypertension (SBP 120–139 mm Hg OR DBP 80–89 mm Hg) and hypertension (SBP >140 mm Hg OR DBP >90 mm Hg).[21] Height was measured without shoes using a portable stadiometer (Seca 206, Oxford, UK). Waist circumference was assessed using anthropometric tape at the midpoint between the upper edge of the iliac crest and the inferior border of the last palpable rib. Hip circumference was measured around the widest part of the buttocks, with the tape parallel to the floor. The waist–hip ratio was subsequently calculated. Body composition and weight were assessed using a Tanita BC-418 MA Segmental Body Composition Analyzer (Tanita UK). Percent body fat measured using the Tanita BC-418 has been shown to correlate highly with the reference measure of dual-energy X-ray absorptiometry.[22] Body mass index (BMI) was calculated as kg/m^2.

A fasted (≥8 hours) capillary (fingertip) blood sample was taken for the analysis of fasting blood glucose (FBG), triglycerides (TGs), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C) and total cholesterol (TC) after heating the hand for 5 min. A drop of blood was taken directly from the heated finger to be analysed for FBG and TGs using the Accutrend Plus Complete System (Roche Diagnostics, Mannheim, Germany) and HDL-C and TC using the Cardiochek PA Blood Analyser (Medisave, Dorset, UK). Both devices have been validated previously.[23][24] LDL-C was estimated from quantitative measurements of total and HDL-C and plasma TGs using the empirical relationship of Friedewald et al.[25]

Fasting capillary blood glucose samples were converted to fasting plasma glucose using the Diabetes UK calculator[26] and further classified as normal (<6.1 mmol/L), prediabetes (6.1–6.9 mmol/L) and diabetes (≥7.0 mmol/L).[26] Metabolic syndrome was defined according to the International Diabetes Federation as central obesity (waist circumference ≥102 cm) plus any two of the following risk factors: raised BP (systolic ≥130 or diastolic ≥85 mm Hg), raised TGs (≥1.7 mmol/L), reduced HDL-C (<1.0 mmol/L in males and 1.3 mmol/L in females) and raised fasting plasma glucose (≥5.6 mmol/L).[27] Ten-year CVD risk was calculated using the QRISK calculator (http://www.qrisk.org/).[28]

Sitting, standing and PA

Sitting, standing and stepping time were measured objectively using an activPAL3 accelerometer, shown to be a

valid measure of time spent sitting/lying, standing and walking in adults.[29 30] The activPAL3 is a small device, worn on the front of the right thigh, containing a tri-axial accelerometer that responds to signals related to gravitational forces related to thigh inclination.[31] The activPAL3 was waterproofed using a nitrile sleeve and attached to the leg using a waterproof hypoallergenic medical dressing (BSN Hypafix). This enabled participants to wear it continuously for 24 hours/day over 7 days, following their health assessments. Participants were asked to complete a daily-log book where they recorded the time they went to bed and woke up on workdays and non-workdays. Information about any non-wear time was also recorded.

Data processing

Data from the activPAL were downloaded using activPAL Professional V.7.2.29 software (device firmware V.3.107) and processed manually using a customised Microsoft Excel macro. Information on sitting, standing and stepping time, including average number of transitions from sitting to standing per waking hour, number of steps and average cadence, was extracted. To be included in the analyses, participants were required to have provided at least four full days (>600 min of wear and >500 steps/day) of data (including at least three workdays and one non-workday). Sleeping time was identified as the last transition from standing to sitting/lying and the first transition from sitting/lying to standing during the time that best matched the participants' daily log. For each identified sleeping bout, data were explored 60 min before and after and included as sleeping time if sitting/lying time was ≥30 min and <20 steps were recorded. If any standing time with <20 steps was found during sleeping hours, this was considered as sleeping time. To control for errors associated with self-reported diary data, non-wear time was considered as time spent in either a sitting/lying or standing position for ≥3 hours, with no transitions. This cut-point was established based on checks conducted in the dataset and techniques described elsewhere.[32]

For each participant, the number of minutes spent sitting, standing and stepping and average number of transitions from sitting to standing during waking hours on workdays and non-workdays were extracted based on times derived from participants' logs. Stepping time was further classified into moderate-to-vigorous PA (MVPA) (by summing the minutes in which participants accumulated >100 steps/minute)[33 34] and light physical activity (LPA, stepping time minus MVPA). Those accumulating ≤30 minutes/day of MVPA were considered physically inactive.[35]

Data analysis

Statistical analyses were conducted using SPSS V.22. All variables were checked for normality using the Shapiro-Wilk Test, which confirmed that all data were not normally distributed. Thus, non-parametric statistical tests were used throughout. Median and IQR values were computed as descriptives for all variables. Wilcoxon-signed rank tests were used to compare the absolute time spent sitting, standing and time in LPA and MVPA, total steps and average number of transitions from sitting to standing between workdays and non-workdays and working hours and non-working hours. Differences in outcomes between the three shift patterns (morning: 06:00–14:00; afternoon: 14:00–22:00 and night: 22:00–06:00) were explored using Kruskal-Wallis tests. On the result of a significant Kruskal-Wallis test, Bonferroni-corrected post hoc tests were conducted using a series of Mann-Whitney U tests to ascertain where the significant differences lay.

Data were further explored using linear regression models adopting an isotemporal substitution approach to quantify the association of substituting sitting behaviour with sleeping time, LPA or MVPA on cardio-metabolic markers. Prior to running the models, all behaviours (sleep, sitting, standing, LPA and MVPA) were divided by a constant of 30, which was considered as a unit of time equivalent to 30 min (this was chosen to comply with PA guidelines).[35] Consequently, every unit increase represents 30 minutes/day of any of the behavioural variables. This is a novel approach that takes into account a finite amount of time and has been recommended when assessing PA and sitting behaviours.[36–38]

The isotemporal substitution models were fitted to explore the impact of interchanging units of time spent sitting by any intensity of PA or sleeping on cardio-metabolic markers. Consequently, average wear time, sleeping time, time in LPA and MVPA were entered concurrently into a linear regression model. This was further adjusted to control for potential cofounding variables such as age, ethnicity, education levels, shift pattern, smoking, alcohol intake and fruit and vegetable consumption. Results were also adjusted by BMI. The linear coefficient for sleeping, LPA and MVPA represents the association of substituting a given unit of sitting time into each category, respectively.[36]

RESULTS

Participants

A sample of 159 male lorry drivers participated in the health assessments (median (IQR): age 50.0 (24.0, 67.0) years; BMI 29 (20, 47) kg/m^2). Out of the main cohort (n=159) a subsample of 87 lorry drivers (55%) provided additional valid activPAL data (age 50.0 (25.0, 65.0) years; BMI 27.7 (19.6, 43.4) kg/m^2). Those not complying with the activPAL protocol for valid data (n=72; age 52.0 (24.0, 67.0) years) had significantly higher waist–hip ratio (0.96 (0.81, 1.15)), percentage body fat (27.1 (15.4, 44.5) %), BMI (29.9 (19.9, 47.2) kg/m^2), FBG (5.7 (4.0, 9.1) mmol/L) and lower alcohol consumption (units of alcohol 7.9 (1.0, 23.0)) in comparison with those providing valid activPAL data.

Cardio-metabolic health profile

Table 1 displays participants' sociodemographic information, medical information and cardio-metabolic markers measured for the whole sample (n=159) and for the

Table 1 Participants' demographic information. Median and IQR values are shown for the body measurements, blood pressure, blood markers and lifestyle factors for the whole sample of UK lorry drivers (n=159) and the subsample (n=87) who provided activity data

	Total sample (median (range)/number (%))	Subsample (median (range)/number (%))	Differences (p value)
Age (years)	50.0 (24.0, 67.0)	50.0 (25.0, 65.0)	0.504
Average working hours (hours/week)	48.0 (27.0, 70.0)	48.0 (27.0, 60.0)	0.198
Ethnicity			0.259
White European	91.0	95.5	
Asian/Asian British	4.5	1.1	
Black Caribbean	2.5	2.3	
Other	2.0	1.1	
Highest level of education			0.019
GCSEs	71.0	94.0	
A-levels	9.0	2.3	
Other	11.0	4.5	
Medical information			0.833
CV-related medication (BP, thrombosis, cholesterol)	12.4	11.4	
Anxiety (borderline/abnormal)	31.0	35.2	0.314
Depression (borderline/abnormal)	15.5	17.0	0.872
Body composition			
% Body fat	26.0 (12.2, 44.5)	24.8 (12.2, 43.3)	0.200
Waist circumference (cm)	102.1 (77.5, 146.5)	100.9 (77.5, 141.0)	0.412
Waist–hip ratio (cm)	0.95 (0.8, 1.1)	0.93 (0.8, 1.1)	0.100
BMI (kg/m^2)	28.8 (19.6, 47.2)	27.7 (19.6, 43.4)	0.176
Blood pressure			
Systolic blood pressure (mm Hg)	129.0 (108.5, 164.0)	129.0 (108.5, 155.0)	0.574
Diastolic blood pressure (mm Hg)	81.0 (63.0, 104.0)	81.0 (65.0, 104.0)	0.362
Heart rate (beats/min)	62.0 (42.0, 89.0)	61.0 (42.0, 89.0)	0.292
Blood markers (mmol/L)			
FBG	5.4 (3.7, 12.7)	5.1 (3.7, 12.7)	0.491
HDL-C	1.4 (0.6, 2.6)	1.4 (0.9, 1.7)	0.578
LDL-C	3.0 (1.0, 5.7)	3.2 (1.0, 5.4)	0.151
TGs	1.5 (0.1, 6.9)	1.5 (0.7, 4.3)	0.142
TC	4.9 (2.6, 7.5)	5.1 (2.6, 7.3)	0.107
Lifestyle behaviours			
Average fruit and vegetables /day	5.0 (0.0, 15.0)	4.3 (0.0, 11.5)	0.465
Alcohol units/week (n=111; subsample n=88)	9.0 (1.5, 60.0)	10.0 (5.0, 60.0)	0.129
Cigarettes/week (n=89; subsample n=55)	122.5 (2.0, 700.0)	140.0 (20.0, 700.0)	0.291

BMI, body mass index; BP, blood pressure; CV, cardiovascular; FBG, fasting blood glucose; GCSEs, General Certificate of Secondary Education; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; TGs, triglycerides.

subsample (n=87). Significant differences between the main cohort and the sub-cohort were only found for education levels. Although lorry drivers participating in this study were classed as medically fit to drive, the sample displayed a high-risk cardio-metabolic profile (table 1). Out of 159 drivers, 84% were overweight or obese, 10% had diagnosed type II diabetes, 29% had prediabetes, 4% had undiagnosed diabetes, 34% had the metabolic syndrome, 27% were prehypertensive, 29% were hypertensive, 24% possessed >10% risk of having a cardiovascular event in the next ten years and 15% were current smokers. In addition, of those who provided activPAL data (n=87), 87% were classified as physically inactive.

activPAL-determined sitting, standing, LPA and MVPA

Participants providing valid activPAL data wore the device continuously (24 hours per day) for at least 4 days; overall, this sample had a median wear duration of 6.5 (0.7) days. Median activPAL-determined waking hours were greater for workdays than for non-workdays (p<0.001). Participants' accumulated significantly greater amounts of sitting time on workdays compared with non-workdays and during working hours compared with non-working hours (table 2). Consequently, drivers accrued more standing time and time in LPA on non-workdays and during non-working hours. Nevertheless, participants acquired double the amount of time in MVPA (p<0.001) on workdays than non-workdays and broke up their sitting time more often non-working hours compared with working hours (p=0.031) (table 2).

Table 3 displays sociodemographic information, BMI and activity data on workdays' for each shift pattern. Morning shift workers had greater sleeping times and lower sedentary times on workdays compared with the other shift groups. Afternoon shift workers accumulated less transitions from sitting to standing compared with morning and night workers during non-workdays (afternoon shift 31.5 (21.0, 63.0); morning shift 47.5 (16.0, 100.0);night shift (46.0 (21.0, 91.0); p<0.05) and during non-working hours compared with night workers (afternoon shift 16.9 (8.0, 51.0); night shift (25.2 (14.0, 37.0); p<0.01) No other significant differences were observed between shift groups on workdays (table 3) or non-workdays (data not shown).

Tables 4 and 5 show the results of the isotemporal substitution models that examined the impact of interchanging units of time spent sitting with LPA, MVPA or sleep on cardio-metabolic markers on workdays and non-workdays. Substituting 30 min of sitting for MVPA was associated with a significant reduction in waist circumference, TGs and HDL-C on workdays (table 4). These results remained significant after adjusting for BMI. No significant associations were observed in relation to substituting sitting time for light activity or sleep on workdays. No significant associations were observed when substituting 30 min of sitting for light activity or MVPA on non-workdays. Yet, a negative association was found between substituting 30 min of sitting with sleep on BMI on non-workdays (table 5).

DISCUSSION

This cross-sectional study highlights the high-risk cardio-metabolic health profile and the high levels of objectively measured sitting time and low levels of MVPA among a sample of UK lorry drivers. This study is the first of its kind to objectively measure lorry driver's sedentary behaviours using inclinometry, which were particularly high on workdays (13 hours/day) compared with non-workdays (8 hours/day). Using an isotemporal modelling approach, this study indicates that reallocating 30 min of sedentary time to moderate-to-vigorous

Table 2 Sleeping, sitting, standing, light PA and MVPA and transitions from sitting to standing during workdays and non-workdays and working hours to non-working hours in a sample of lorry drivers from the East Midlands, UK (n=87)

	All days (median±IQR)			Work days only (median±IQR)		
	Workdays	Non-workdays	Differences (p value)	Working hours	Non-working hours	Differences (p value)
Sleep time (mins/day)	399.8 (158.0, 774.3)	576.8 (258.6, 886.9)	<0.001			
Waking time (mins/day)	1040.1(813.4, 1395.4)	861.2 (465.6, 1181.3)	<0.001	628.8 (344.7, 838.1)	421.4 (136.1, 770.1)	<0.010
Time spent sitting (mins/day)	749.5 (493.5, 1179.9)	463.1 (258.0, 787.9)	<0.001	491.5 (148.6, 678.2)	239.9 (101.8, 600.4)	<0.001
Time spent standing (mins/day)	188.7 (83.3, 414.2)	226.8 (85.7, 501.9)	<0.001	70.4 (24.6, 284.1)	105.5 (27.6, 302.5)	<0.001
Time in light PA (mins/day)	85.3 (48.0, 169.2)	97.6 (27.2, 317.2)	<0.01	39.7 (8.2, 95.8)	47.0 (9.6, 118.6)	<0.050
Time in MVPA (mins/day)	12.6 (1.4, 103.5)	6.0 (0.0, 84.4)	<0.001	4.4 (0.3, 26.2)	5.8 (0.0, 96.0)	<0.010
Total steps per day	8074.9 (3411.3, 21420.0)	7854.8 (1008.0, 23308.0)	0.656	3659.9 (2148.4, 9177.9)	4324.5 (634.0, 17 469.0)	0.052
Number of transitions from sitting to standing per waking hour	2.8 (1.4, 7.9)	2.9 (1.2, 8.4)	0.231	2.7 (1.0, 8.4)	3.1 (0.5, 9.0)	<0.031

MVPA, moderate-to-vigorous physical activity; PA, physical activity.

Table 3   Median and range values for age, average working hours, BMI and activity data on workdays by shift pattern in a sample of lorry drivers from the East Midlands, UK (n=87)

	Morning shift Median (range) n=42	Afternoon shift Median (range) n=21	Night shift Median (range) n=24	Differences (p value)
Age (years)	51.0 (27.0, 65.0)	48.0 (28.0, 58.0)	49.5 (25.0–60.0)	0.471
Average working hours (hour/day)	10.15 (5.46, 12.5)	10.5 (9.2, 14.24)	10.2 (9.3, 14.33)	<0.050
BMI (kg/m^2)	27.8 (22.0, 38.7)	30.2 (27.7, 43.4)	27.4 (19.6–38.6)	0.507
Sleep time (mins/day)	461.3 (342.3, 626.6)	316.1 (157.9, 774.3)	329.9 (232.2–462.3)	<0.001
Waking hours (mins/day)	995.0 (813.4, 1116.7)	1063.2(942.2, 1395.4)	1095.7(977.7, 1207.8)	<0.001
Time spent sitting (mins/day)	682.5 (493.5, 853.9)	779.9 (556.1, 1179.9)	785.9 (680.3–884.1)	<0.001
Time spent standing (mins/day)	177.6 (91.62, 339.6)	174.6 (90.0, 414.2)	194.0 (133.3, 269.3)	0.243
Time in light PA (mins/day)	82.1 (48.0, 169.2)	81.9 (48.7, 149.4)	94.8 (66.7, 140.5)	0.166
Time in MVPA (mins/day)	12.6 (1.4, 103.5)	10.0 (2.0, 53.7)	15.2 (3.5, 72.0)	0.961
Total steps per day	7551.6 (4136.7, 12 516.4)	8083.2 (4824.7, 11 895.0)	9010.0 (5999.2, 15 618.5)	0.141
Transitions from sitting to standing per waking hours	2.8 (0.8, 0.9)	2.6 (1.8, 7.8)	2.9 (2.0, 4.7)	0.774

BMI, body mass index; MVPA, moderate-to-vigorous physical activity; PA, physical activity.

stepping, during workdays, and sleeping time, on non-workdays, was linked to favourable levels of TGs, HDL-cholesterol, BMI and waist circumference.

Sitting, standing and movement patterns in lorry drivers compared with other occupational drivers and the general population

Occupational drivers can be defined as 'compulsory sedentary workers', yet limited research has directly examined sedentary time in this occupational group and of the research available,[14 17 39 40] only one study used similar methods.[14] Prolonged time sitting has been strongly related to higher rates of overweight and obesity, adverse cardiovascular biomarkers, premature mortality, the metabolic syndrome and depression.[15 41 42] The present findings suggest that lorry drivers accumulate the highest sitting time volumes on workdays reported up to date (13 hours/day). These are slightly higher than those seen in bus drivers (12 hours/day), who have been found to be highly sedentary, compared with the general population.[14] This sample of drivers spent less time sedentary on non-workdays compared with workdays (8 hours/day vs 13 hours/day), which could in part be explained by the observation that drivers accumulated more sleeping time during non-workdays (576.8 (258.6, 886.9) min) than workdays (399.8 (158.0, 774.3) min). This could be understood as a compensational behaviour for the shortage of sleep during workdays induced by the shift patterns and long hours at work. Indeed, several studies have shown that lorry drivers are a sleep-deprived group due to their shift patterns and work duration, averaging 3.8–5.2 hours of sleep daily.[43 44] This research also highlighted the high prevalence of physical inactivity, which has been defined as one of the major

contributors to ill-health.[45] Indeed, only 13% of the present sample were considered physically active, which is similar to lorry drivers from other countries.[1 5 12]

Using isotemporal substitution modelling, our findings indicate that interchanging 30 minutes/day of sedentary time with moderate-to-vigorous stepping had positive associations with some cardio-metabolic risk markers. The protective effects of MVPA on health have previously been established[16]; these results suggest that only substituting time spent sedentary for MVPA, and not standing time or light activity, will have beneficial effects on health parameters within this population. Further research should confirm these findings.

Cardio-metabolic health profile in lorry drivers compared with other occupational drivers and the general population.

CVDs are the largest cause of mortality in the UK accounting for 27% of all deaths.[46] Occupational demands and unhealthy lifestyle behaviours give lorry drivers a unique constellation of risk factors for CVD. Drivers from this study showed a higher prevalence of overweight and obesity compared with males aged 45–54 years in the UK (84% vs 79.4%).[47] Weight-related comorbidities such as type II diabetes, prediabetes, hypertension and metabolic syndrome were also higher in this sample compared with the general population[46–48] or other occupational groups.[49] The increased rates of overweight and obesity within this occupational group is a concern; given evidence suggests that obese lorry drivers are 55% more likely to have an accident than normal weight drivers.[50] In addition to this, 46% of the present sample were clustered as borderline or abnormal cases of anxiety and depression, which is higher than that seen in American

Table 4 Association of substituting 30 min of sedentary behaviour for LPA, MVPA or sleep time with measures of WC, BMI, BP, pulse, glucose, triglycerides, HDL, LDL and total cholesterol using isotemporal substitution on workdays in a sample of lorry drivers from East Midlands, UK

	Sedentary to standing	p value	Sedentary to light stepping workdays	p Value	Sedentary to moderate or vigorous stepping on workdays	p Value	Sedentary to sleep on Workdays	p Value
Waist Circumference	−0.1 (−1.4, 1.2)	0.870	−0.6 (−3.9, 2.7)	0.707	−6.5 (−11.0, −1.9)	<0.010	0.1 (−0.3, 0.5)	0.500
BMI	0.07 (−0.4, 0.6)	0.775	−0.7 (−1.9, 0.5)	0.247	−1.5 (−3.2, 0.2)	0.089	−0.0 (−0.2, 0.1)	0.970
Systolic BP	0.6 (−0.6, 1.9)	0.338	−1.9 (−5.1, 1.3)	0.232	−1.1 (−5.5, 3.3)	0.616	−0.3 (−0.4, 0.4)	0.885
Diastolic BP	0.6 (−0.5, 1.7)	0.313	−1.8 (−4.7, 0.9)	0.201	0.1 (−3.8, 4.0)	0.952	−0.2 (−0.5, 0.2)	0.280
Fasting glucose	−0.01 (−0.1, 0.1)	0.859	−0.04 (−0.3, 0.2)	0.774	−0.3 (−0.6, 0.1)	0.144	−0.04 (−0.1, 0.02)	0.137
Triglycerides	0.00 (−0.1, 0.1)	0.940	0.06 (−0.2, 0.3)	0.687	−0.4 (−0.8, 0.01)	0.051	0.02 (−0.01, 0.05)	0.286
HDL cholesterol	−0.02 (−0.06, 0.01)	0.247	−0.1 (−0.2, −0.01)	0.035	0.3 (0.1, 0.4)	<0.010	−0.01 (−0.02, 0.01)	0.314
LDL cholesterol	−0.04 (−0.2, 0.1)	0.559	0.2 (−0.1, 0.6)	0.209	−0.1 (−0.6, 0.5)	0.748	−0.02 (−0.07, 0.02)	0.281
Total cholesterol	−0.6 (−0.07, 0.02)	0.259	0.1 (−0.2, 0.5)	0.509	0.05 (−0.4, 0.6)	0.832	−0.2 (−0.07, 0.02)	0.259

Coefficients represent the factor by which the cardiovascular markers are multiplied by (95% CI) for a 30 min difference in the substituted physical activity behaviour.
BMI, body mass index; BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; LPA, light physical activity; MVPA, moderate-to-vigorous physical activity; WC, waist circumference.

Table 5 Association of substituting 30 min of sedentary behaviour for LPA, MVPA or sleep time with measures of WC, BMI, BP, pulse, glucose, triglycerides, HDL, LDL and total cholesterol using isotemporal substitution on non-workdays in a sample of lorry drivers from East Midlands, UK

	Sedentary to standing	p Value	Sedentary to light stepping on non-workdays	p Value	Sedentary to moderate or vigorous stepping on non-workdays	p Value	Sedentary to sleep on non-workdays	p value
Waist circumference	−0.4 (−1.2, 2.1)	0.428	0.4 (−1.3, 2.1)	0.612	−0.8 (−4.8, 3.2)	0.695	−0.4 (−1.1, 0.5)	0.215
BMI	0.1 (−0.5, 0.2)	0.369	−0.2 (−0.8, 0.4)	0.509	0.2 (−1.2, 1.7)	0.746	−0.3 (−0.5, −0.05)	0.019
Systolic BP	−0.3 (−1.1, 0.5)	0.497	0.3 (−1.3, 1.9)	0.683	−0.01 (−3.7, 3.7)	0.994	−0.6 (−1.2, 0.1)	0.076
Diastolic BP	−0.5 (−1.2, 0.2)	0.167	−0.5 (−1.9, 0.9)	0.462	0.3 (−2.9, 3.6)	0.839	−0.3 (−0.9, 0.2)	0.216
Fasting glucose	0.01 (−0.07, 0.1)	0.753	0.03 (−0.1, 0.2)	0.648	−0.3 (−0.7, 0.05)	0.090	−0.00 (−0.06, 0.06)	0.931
Triglycerides	−0.03 (−0.1, 0.04)	0.417	0.07 (−0.07, 0.2)	0.303	−0.2 (−0.5, 1.0)	0.380	−0.02 (−0.08, 0.04)	0.500
HDL cholesterol	0.02 (−0.01, 0.05)	0.281	−0.05 (−0.1, 0.01)	0.119	0.07 (−1.0, 0.2)	0.359	0.0 (−0.02, 0.03)	0.732
LDL cholesterol	−0.08 (−0.2, 0.01)	0.084	0.0 (−0.2, 0.2)	0.919	−0.01 (−0.5, 0.4)	0.946	−0.04 (−0.2, 0.04)	0.084
Total cholesterol	−0.08 (−0.2, 0.02)	0.100	−0.03 (−0.2, 0.1)	0.887	0.03 (−0.4, 0.5)	0.887	−0.03 (−0.1, 0.04)	0.368

Coefficients represent the factor by which the cardio-vascular markers are multiplied by (95% CI) for a 30 min difference in the substituted physical activity behaviour.
BMI, body mass index; BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; LPA, light physical activity; MVPA, moderate-to-vigorous physical activity; WC, waist circumference.

lorry drivers (41.5%).[51] Job-related constraints associated with lorry driving enhance continuous psychophysiological arousal at work, which has been linked to increased risk of ischaemic heart disease.[52–54]

Overall, the present findings are in-line with research conducted on US lorry drivers,[55] which demonstrate a high prevalence of unhealthy lifestyle behaviours and increased risk factors for CVD. Lorry drivers' health cannot only be explained by personal choices, but rather by a combination of lifestyle behaviours and environmental factors that encourage unhealthy diets and lack of exercise. Furthermore, lower levels of education, commonly observed within this profession, have also been linked with poor health.[56] In the present sample, 71% were educated only up to GCSE level. Lorry drivers are generally continuously exposed to unhealthy dietary adverts and messages, have less access to healthy options and have a lack of knowledge of the health impact of unhealthy lifestyle choices.[57 58] The combination of these factors (the environment, lifestyle choices and education) likely contribute towards lorry drivers' burden of disease. Indeed, US and UK data show that lorry drivers have a reduced life expectancy compared with other professions.[59] Despite the above evidence, lorry drivers are considered an underserved group in terms of health promotion efforts.[60]

Limitations and strengths

Limitations of the present study include the cross-sectional design that prevents us from making conclusions about causative links between sitting time and cardio-metabolic health. Second, the sample was recruited from one transport depot in the East Midlands, which makes it difficult to generalise findings across the UK or abroad. Third, the manual approach applied to the data analysis prevents us from further exploring sedentary time patterns and bouts, which have been shown to carry prognostic relevance.[61] Finally, data collection took place during summer time, which is the busiest time at this transport company. Exploring drivers' sedentary and PA behaviours' across all seasons is therefore recommended for future research. Despite these limitations, this is the first study to provide objective information on lorry drivers' sitting time during workdays and non-workdays. We utilised a novel sedentary and PA monitor that directly distinguishes between sedentary and upright postures, thus overcoming limitations of self-report measures or other types of accelerometer that do not directly measure posture. In addition, we explored lorry drivers' health from a holistic perspective for a better understanding of drivers' sitting time and cardio-metabolic health.

CONCLUSION

Results from this study provide new information on lorry drivers' lifestyle behaviours and health. The high prevalence of various risk factors put drivers at high risk of numerous health conditions and premature mortality. Occupational interventions are urgently needed to reduce excessive adverse health behaviours and fatalities within this high-risk workforce. Interventions should focus on reducing sitting and increasing MVPA during work breaks and leisure time. Within the present sample, and across the transport sector more broadly, our experience has shown that lorry drivers are an occupational group who have proven difficult to engage within health and well-being initiatives. Additional qualitative research is therefore a priority to identify effective strategies that are able to engage lorry drivers that will underpin the successfulness of future health promotion interventions.

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