

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

Varela Mato, V; O'Shea, O; King, J ; Yates, T; Stensel, D; Biddle, SJH; Nimmo, Myra; Clemes, S

License:

Creative Commons: Attribution-NonCommercial (CC BY-NC)

Document Version

Publisher's PDF, also known as Version of record

Citation for published version (Harvard):

Varela Mato, V, O'Shea, O, King, J, Yates, T, Stensel, D, Biddle, SJH, Nimmo, M & Clemes, S 2017, 'Cross-sectional surveillance study to phenotype lorry drivers' sedentary behaviours, physical activity and cardio-metabolic health', *BMJ open*.

[Link to publication on Research at Birmingham portal](#)

General rights

Unless a licence is specified above, all rights (including copyright and moral rights) in this document are retained by the authors and/or the copyright holders. The express permission of the copyright holder must be obtained for any use of this material other than for purposes permitted by law.

- Users may freely distribute the URL that is used to identify this publication.
- Users may download and/or print one copy of the publication from the University of Birmingham research portal for the purpose of private study or non-commercial research.
- User may use extracts from the document in line with the concept of 'fair dealing' under the Copyright, Designs and Patents Act 1988 (?)
- Users may not further distribute the material nor use it for the purposes of commercial gain.

Where a licence is displayed above, please note the terms and conditions of the licence govern your use of this document.

When citing, please reference the published version.

Take down policy

While the University of Birmingham exercises care and attention in making items available there are rare occasions when an item has been uploaded in error or has been deemed to be commercially or otherwise sensitive.

If you believe that this is the case for this document, please contact UBIRA@lists.bham.ac.uk providing details and we will remove access to the work immediately and investigate.

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

Veronica Varela-Mato,^{1,2} Orlagh O'Shea,³ James A King,^{1,2} Thomas Yates,^{2,4} David J Stensel,^{1,2} Stuart JH Biddle,⁵ Myra A Nimmo,⁶ Stacy A Clemes^{1,2}

To cite: Varela-Mato V, O'Shea O, King JA, *et al*. Cross-sectional surveillance study to phenotype lorry drivers' sedentary behaviours, physical activity and cardio-metabolic health. *BMJ Open* 2017;7:e013162. doi:10.1136/bmjopen-2016-013162

► Prepublication history and additional material are available. To view these files please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2016-013162>).

Received 2 July 2016

Revised 7 November 2016

Accepted 22 November 2016



CrossMark

¹School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, UK

²Lifestyle and Physical Activity Biomedical Research Unit, NIHR Leicester-Loughborough Diet, Loughborough, UK

³Centre for Health and Rehabilitation Technologies, Institute for Nursing and Health Research, Ulster University, Newtownabbey, UK

⁴Leicester Diabetes Centre, University of Leicester, Leicester, UK

⁵Institute of Sport, Exercise & Active Living (ISEAL), Victoria University, Melbourne, Australia

⁶College of Life and Environmental Sciences, University of Birmingham, Birmingham, UK

Correspondence to

Veronica Varela-Mato; v.varela-mato@lboro.ac.uk

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/m²) 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 lipoprotein 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/m²; 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 Crawford¹⁷ 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/m².

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 calculator²⁶ 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 confounding 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/m²). 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/m²). 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/m²), 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 isothermal 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 isothermal 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)			Differences (p value)	Differences (p value)
	Workdays	Non-workdays	Non-workdays	Working hours	Non-working hours	Non-working hours		
Sleep time (mins/day)	399.8 (158.0, 774.3)	576.8 (258.6, 886.9)	576.8 (258.6, 886.9)	<0.001	<0.001	<0.001	<0.010	
Waking time (mins/day)	1040.1(813.4, 1395.4)	861.2 (465.6, 1181.3)	861.2 (465.6, 1181.3)	<0.001	<0.001	628.8 (344.7, 838.1)	421.4 (136.1, 770.1)	
Time spent sitting (mins/day)	749.5 (493.5, 1179.9)	463.1 (258.0, 787.9)	463.1 (258.0, 787.9)	<0.001	<0.001	491.5 (148.6, 678.2)	239.9 (101.8, 600.4)	
Time spent standing (mins/day)	188.7 (83.3, 414.2)	226.8 (85.7, 501.9)	226.8 (85.7, 501.9)	<0.001	<0.001	70.4 (24.6, 284.1)	105.5 (27.6, 302.5)	
Time in light PA (mins/day)	85.3 (48.0, 169.2)	97.6 (27.2, 317.2)	97.6 (27.2, 317.2)	<0.01	<0.01	39.7 (8.2, 95.8)	47.0 (9.6, 118.6)	
Time in MVPA (mins/day)	12.6 (1.4, 103.5)	6.0 (0.0, 84.4)	6.0 (0.0, 84.4)	<0.001	<0.001	4.4 (0.3, 26.2)	5.8 (0.0, 96.0)	
Total steps per day	8074.9 (3411.3, 21 420.0)	7854.8 (1008.0, 23 308.0)	7854.8 (1008.0, 23 308.0)	0.656	0.656	3659.9 (2148.4, 9177.9)	4324.5 (634.0, 17 469.0)	
Number of transitions from sitting to standing per waking hour	2.8 (1.4, 7.9)	2.9 (1.2, 8.4)	2.9 (1.2, 8.4)	0.231	0.231	2.7 (1.0, 8.4)	3.1 (0.5, 9.0)	

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, 12516.4)	8083.2 (4824.7, 11895.0)	9010.0 (5999.2, 15618.5)	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 (13hours/day). These are slightly higher than those seen in bus drivers (12hours/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 (8hours/day vs 13hours/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 3.8–5.2hours 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 established¹⁶; 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 isothermal 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 isothermal substitution on non-workdays in a sample of lorry drivers from East Midlands, UK

	Sedentary to standing	p Value	Sedentary to light stepping non-workdays	p Value	Sedentary to moderate or vigorous stepping non-workdays	p Value	Sedentary to sleep 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.

Acknowledgements The authors would like to thank all the drivers who participated in this study. The authors wish to acknowledge the efforts of all of the managers that made the recruitment possible. This research was supported by the National Institute for Health Research (NIHR) Diet, Lifestyle & Physical Activity Biomedical Research Unit based at University Hospitals of Leicester and Loughborough University. The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health.

Contributors VV-M and SAC conceived the study. MAN and JAK established the partnership between the university and the local company. VV-M, OO and JAK designed and implemented the data collection. SAC, TY, SJHB and DJS overviewed the data collection. All authors contributed to writing and interpretation of the results.

Disclaimer The authors wish to state that all drivers participating in this study were medically fit to drive and comply with the DVLA requirements.

Competing interests None declared.

Ethics approval Loughborough University Ethical Advisory Committee.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No data is available for sharing with research teams.

Open Access This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

© Article author(s) (or their employer(s) unless otherwise stated in the text of the article) 2017. All rights reserved. No commercial use is permitted unless otherwise expressly granted.

REFERENCES

1. Apostolopoulos Y, Sönmez S, Shattell MM, *et al.* Health survey of U.S. long-haul truck drivers: work environment, physical health, and healthcare access. *Work* 2013;46:113–23.
2. Wong WC, Tam SM, Leung PW. Cross-border truck drivers in Hong Kong: their psychological health, sexual dysfunctions and sexual risk behaviors. *J Travel Med* 2007;14:20–30.
3. Sieber WK, Robinson CF, Birdsey J, *et al.* Obesity and other risk factors: the national survey of U.S. long-haul truck driver health and injury. *Am J Ind Med* 2014;57:615–26.
4. Caddick N, Varela-Mato V, Nimmo MA, *et al.* Understanding the health of lorry drivers in context: A critical discourse analysis. *Health* 2017;21:38–56.
5. Bigert C, Gustavsson P, Hallqvist J, *et al.* Myocardial infarction among professional drivers. *Epidemiology* 2003;14:333–9.
6. Apostolopoulos Y, Shattell MM, Sönmez S, *et al.* Active living in the trucking sector: environmental barriers and health promotion strategies. *J Phys Act Health* 2012;9:259–69.
7. G. Passey D, Robbins R, T. Hegmann K, *et al.* Long haul truck drivers' views on the barriers and facilitators to healthy eating and physical activity. *Int J Workplace Health Manag* 2014;7:121–35.
8. Whitelegg J. *Health of professional drivers: a report for the Transport & General Workers Union*. Lancaster: Eco-Logica, 1995.
9. Caruso C, Hitchcock E, Dick R, *et al.* *Overtime and extended work shifts: recent findings on illnesses, injuries, and health behaviors*. 143. Cincinnati: US CDC-NIOSH, 2004.



10. Aronson KJ, Howe GR, Carpenter M, *et al.* Surveillance of potential associations between occupations and causes of death in Canada, 1965-91. *Occup Environ Med* 1999;56:265-9.
11. Hannerz H, Tüchsen F. Hospital admissions among male drivers in Denmark. *Occup Environ Med* 2001;58:253-60.
12. Robinson CF, Burnett CA. Truck drivers and heart disease in the United States, 1979-1990. *Am J Ind Med* 2005;47:113-9.
13. Sedentary Behaviour Research Network. Letter to the editor: standardized use of the terms "sedentary" and "sedentary behaviours". *Appl Physiol Nutr Metab* 2012;37:540-2.
14. Varela-Mato V, Yates T, Stensel DJ, *et al.* Time spent sitting during and outside working hours in bus drivers: a pilot study. *Prev Med Rep* 2016;3:36-9.
15. Wilmot EG, Edwardson CL, Achana FA, *et al.* Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia* 2012;55:2895-905.
16. Biswas A, Oh PI, Faulkner GE, *et al.* Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Ann Intern Med* 2015;162:123-32.
17. Morris JN, Crawford MD. Coronary Heart disease and physical activity of work. *BMJ* 1958;2:1485-96.
18. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand* 1983;67:361-70.
19. El Feghali RN, Topouchian JA, Pannier BM, *et al.* Validation of the OMRON M7 (HEM-780-E) blood pressure measuring device in a population requiring large cuff use according to the International Protocol of the European Society of hypertension. *Blood Press Monit* 2007;12:173-8.
20. Parati G, Stergiou G, O'Brien E, *et al.* European Society of hypertension practice guidelines for ambulatory blood pressure monitoring. *J Hypertens* 2014;32:1359-66.
21. Blood Pressure Association UK. Blood pressure chart. 2008 <http://www.bloodpressureuk.org/BloodPressureandyou/Thebasics/Bloodpressurechart>.
22. Pietrobelli A, Rubiano F, St-Onge M-P, *et al.* New bioimpedance analysis system: improved phenotyping with whole-body analysis. *Eur J Clin Nutr* 2004;58:1479-84.
23. Scafoglieri A, Tresignie J, Proyvyn S, *et al.* Reproducibility, accuracy and concordance of Accutrend® Plus for measuring circulating lipid concentration in adults. *Biochem Med* 2012;22:100-8.
24. Panz VR, Raal FJ, Paiker J, *et al.* Performance of the CardioChek PA and Cholestech LDX point-of-care analysers compared to clinical diagnostic laboratory methods for the measurement of lipids. *Cardiovasc J S Afr* 2005;16:112-7.
25. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin Chem* 1972;18:499-502.
26. Alberti KGMM, Eckel RH, Grundy SM, *et al.* Harmonizing the metabolic syndrome: a Joint Interim Statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the study of obesity. *Circulation* 2009;120:1640-5.
27. Hippisley-Cox J, Coupland C, Vinogradova Y, *et al.* Predicting cardiovascular risk in England and Wales: prospective derivation and validation of QRISK2. *BMJ* 2008;336:1475-82.
28. Grant PM, Ryan CG, Tigbe WW, *et al.* The validation of a novel activity monitor in the measurement of posture and motion during everyday activities. *Br J Sports Med* 2006;40:992-7.
29. Kozey-Keadle S, Libertine A, Lyden K, *et al.* Validation of wearable monitors for assessing sedentary behavior. *Medicine & Science in Sports & Exercise* 2011;43:1561-7.
30. Atkin AJ, Gorely T, Clemes SA, *et al.* Methods of Measurement in Epidemiology: sedentary Behaviour. *Int J Epidemiol* 2012;41:1460-71.
31. Winkler EAH, Bodicoat DH, Healy GN, *et al.* Identifying adults' valid waking wear time by automated estimation in activPAL data collected with a 24 h wear protocol. *Physiol Meas* 2016;37:1653-68.
32. Marshall SJ, Levy SS, Tudor-Locke CE, *et al.* Translating physical activity recommendations into a Pedometer-Based step goal. *Am J Prev Med* 2009;36:410-5.
33. Rowe DA, Welk GJ, Heil DP, *et al.* Stride rate recommendations for moderate-intensity walking. *Med Sci Sports Exerc* 2011;43:312-8.
34. Department of Health. Physical activity guidelines for adults aged 19-64 years old. 2015 <https://www.gov.uk/government/publications/uk-physical-activity-guidelines>.
35. Mekary RA, Willett WC, Hu FB, *et al.* Isotemporal substitution paradigm for physical activity Epidemiology and Weight Change. *Am J Epidemiol* 2009;170:519-27.
36. Mekary RA, Lucas M, Pan A, *et al.* Isotemporal substitution analysis for physical activity, television watching, and risk of depression. *Am J Epidemiol* 2013;178:474-83.
37. Buman MP, Winkler EAH, Kurka JM, *et al.* Reallocating Time to Sleep, sedentary behaviors, or active behaviors: associations with Cardiovascular Disease Risk biomarkers, NHANES 2005-2006. *Am J Epidemiol* 2014;179:323-34.
38. French SA, Harnack LJ, Toomey TL, *et al.* Association between body weight, physical activity and food choices among metropolitan transit workers. *Int J Behav Nutr Phys Act* 2007;4:52.
39. Wong JYL, Gilson ND, Bush RA, *et al.* Patterns and perceptions of physical activity and sedentary time in male transport drivers working in regional Australia. *Aust N Z J Public Health* 2014;38:314-20.
40. Teychenne M, Costigan SA, Parker K. The association between sedentary behaviour and risk of anxiety: a systematic review. *BMC Public Health* 2015;15:513.
41. Edwardson CL, Gorely T, Davies MJ, *et al.* Association of Sedentary Behaviour with metabolic syndrome: a Meta-Analysis. *PLoS One* 2012;7:e34916.
42. Balkin T, Thorne D, Sing H, *et al.* Effects of sleep schedules on commercial motor vehicle driver performance (DOT-C-00-133). Washington, DC, 2000. <https://ntl.bts.gov/lib/11000/11100/11127/ESS.pdf>.
43. Dinges DF, Maislin MS, Krueger GA, *et al.* Pilot test of fatigue management technologies (FMCSA-RT-05-002). 2005 www.fmcsa.dot.gov/facts-research/research-technology/publications/pilot-test/pilottest-fmt-finalreport.htm.
44. Lee I-M, Shiroma EJ, Lobelo F, *et al.* Effect of physical inactivity on Major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *The Lancet* 2012;380:219-29.
45. British Heart Foundation. Heart statistics. 2015 <https://www.bhf.org.uk/research/heart-statistics>.
46. Public Health England. Public Health England's priorities for 2013 to 2014. 2013 <https://www.gov.uk/government/publications/public-health-englands-priorities-for-2013-to-2014>.
47. Public Health England. Health Survey for England (HSE). 2010 https://www.noo.org.uk/data_sources/adult/health_survey_for_england.
48. Aguilar M, Bhuket T, Torres S, *et al.* Prevalence of the metabolic syndrome in the United States, 2003-2012. *JAMA* 2015;313:1973-4.
49. Leischik R, Foshag P, Strauß B, *et al.* Aerobic capacity, physical activity and metabolic risk factors in firefighters compared with police officers and sedentary clerks. *PLoS One* 2015;10:e0133113.
50. Anderson JE, Govada M, Steffen TK, *et al.* Obesity is associated with the future risk of heavy truck crashes among newly recruited commercial drivers. *Accident Analysis & Prevention* 2012;49:378-84.
51. Shattell M, Apostolopoulos Y, Collins C, *et al.* Trucking Organization and Mental Health Disorders of Truck Drivers. *Issues Ment Health Nurs* 2012;33:436-44.
52. Bruner EJ, *et al.* Is the effect of work stress on cardiovascular mortality confounded by socioeconomic factors in the Valmet study? *Journal of Epidemiology & Community Health* 2004;58:1019-20.
53. Pan A, Sun Q, Okereke OI, *et al.* Depression and risk of stroke morbidity and mortality: a meta-analysis and systematic review. *JAMA* 2011;306:1241-9.
54. Grenon SM, Hiramoto J, Smolderen KG, *et al.* Association between Depression and peripheral artery disease: insights from the Heart and Soul Study. *J Am Heart Assoc* 2012;1:e002667.
55. Thiese MS, Moffitt G, Hanowski RJ, *et al.* Commercial driver medical examinations: prevalence of Obesity, Comorbidities, and certification outcomes. *J Occup Environ Med* 2015;57:659-65.
56. Cutler DM, Lleras-Muney A. Education and health: evaluating theories and evidence. *National Bureau of Economic Research* 2006.
57. Pampel FC, Krueger PM, Denney JT. Socioeconomic disparities in Health Behaviors. *Annu Rev Sociol* 2010;36:349-70.
58. Apostolopoulos Y, Sönmez S, Shattell MM, *et al.* Worksite-Induced morbidities among Truck Drivers in the United States. *AAOHN Journal* 2010;58:285-96.
59. Office for National Statistics. Trend in life expectancy at birth and at age 65 by socio-economic position based on the National Statistics Socio-economic classification, England and Wales: 1982-1986 to 2007-2011. 2015.
60. Mk N, Yousuf B, Bigelow PL, *et al.* Effectiveness of health promotion programmes for truck drivers: a systematic review. *Health Educ J* 2014;74:270-86.
61. Carson V, Wong SL, Winkler E, *et al.* Patterns of sedentary time and cardiometabolic risk among canadian adults. *Prev Med* 2014;65:23-7.

BMJ Open

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

Veronica Varela-Mato, Orlagh O'Shea, James A King, Thomas Yates, David J Stensel, Stuart JH Biddle, Myra A Nimmo and Stacy A Clemes

BMJ Open 2017 7:

doi: [10.1136/bmjopen-2016-013162](https://doi.org/10.1136/bmjopen-2016-013162)

Updated information and services can be found at:
<http://bmjopen.bmj.com/content/7/6/e013162>

These include:

References

This article cites 50 articles, 14 of which you can access for free at:
<http://bmjopen.bmj.com/content/7/6/e013162#BIBL>

Open Access

This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

Email alerting service

Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Topic Collections

Articles on similar topics can be found in the following collections
[Public health](#) (2153)

Notes

To request permissions go to:
<http://group.bmj.com/group/rights-licensing/permissions>

To order reprints go to:
<http://journals.bmj.com/cgi/reprintform>

To subscribe to BMJ go to:
<http://group.bmj.com/subscribe/>