SEDENTARY BEHAVIOURS, PHYSICAL ACTIVITY AND CARDIOVASCULAR HEALTH AMONGST BUS AND LORRY DRIVERS

By

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For “my drivers” who shared great stories and with whom I had great laughs during the very unsociable hours of my data collection!

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ABSTRACT

Prolonged time sitting has been linked to an increased risk of cardiovascular diseases (CVD), cardiovascular mortality (CVM), all-cause mortality, diabetes and some cancers. Workers in occupations where there is no alternative to sitting can best be defined as "compulsory sedentary workers", which involve bus and lorry drivers amongst others. Limited research is available on the health behaviours and health profiles of individuals working within these occupations. This thesis adopts a mixed methods approach and fits within the MRC framework for the development of complex interventions to specifically investigate bus and lorry drivers' sedentary behaviours and physical activity levels in association with their cardiovascular health. Chapter 3 describes a pilot study, which results showed bus drivers accumulate 12 hours sitting on workdays and presented higher than the recommended ranges for BMI, body fat, waist circumference and blood pressure. Chapter 4 explores the validity of using an ActiGraph accelerometer compared to the activPAL to assess bus drivers' sedentary behaviours. Results highlight that compared to the activPAL, the ActiGraph underestimates sedentary time during workdays (151minutes/day) and working hours (172min/day). Chapter 5 phenotypes UK lorry drivers' sedentary behaviours and non-sedentary behaviours during workdays and non-workdays and examines lorry drivers markers of cardiovascular health. Lorry drivers accumulate 13 hours sitting on workdays and 8 hours on non-workdays and presented an ill-cardiovascular profile. Chapter 6 examines the effects of an intervention designed to promote PA and reduce sedentary time on a range of cardiovascular risk factors in a sample of lorry drivers.

Chapter 7 presents a process evaluation of the Structured Health Intervention for Truckers (SHIFT) programme described in Chapter 6.

This thesis highlights that bus and lorry drivers accumulate the highest amount of sitting time reported up to date, together with high levels of physical inactivity and an ill-cardiovascular profile. However, positive changes in cardiovascular risk factors were observed when drivers increased their daily average of step counts. Overall, these results emphasise that targeting bus and lorry drivers’ health behaviours should be a public health priority.

Key words: Sedentary behaviours, physical activity, bus drivers, lorry drivers, cardiovascular health.

THESIS CONTRIBUTION

All work in this thesis was undertaken by the author under the supervision of Dr Stacy Clemes, Dr David Stensel and Dr Thomas Yates. In addition, during the initial stages of the thesis the author also received support from Prof Stuart Biddle. Dr James King supported the author throughout the work conducted with the lorry drivers. Dr Nick Caddick was involved in the second and third phases of the SHIFT Study as a qualitative researcher. One paper has been published based on this work, which is attached as an appendix (11.5). The author worked closely with the Leicester Diabetes Centre (LDC) to develop the education program of the SHIFT Intervention. Educators from LDC and the author conducted the education sessions at the beginning of the intervention. Several master students participated at different stages of the data collection within the SHIFT Study. All of the work presented in this thesis was conducted by the author, including establishing links with the bus company, developing the study concepts, intervention design, data collection (including night shifts), data entry and analysis.

PUBLICATIONS RELATED TO THIS THESIS

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- Caddick N, Varela-Mato V, Nimmo MA, Clemes S, Yates T, King JA. Understanding the health of lorry drivers in context: A critical discourse analysis. Health: 2016 Apr 21:1363459316644492.

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- Varela-Mato V & King J. The SHIFT Study. East Midlands Chamber Transport, Logistics and Infrastructure Forum – East Midlands Airport, March 2016
- Varela-Mato V. The SHIFT Study workshop. Women in Logistics Conference. PepsiCo Leicester, April 2015.
- Caddick N & Varela-Mato. Staying active and healthy in 2015. *Top tips and lessons from the SHIFT Study*. King Power Stadium, June 2015

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ABBREVIATIONS

The following abbreviations are used frequently throughout this thesis. All abbreviations are defined in the first instance they appear in each chapter.

BHF	British Heart Foundation
BMI	body mass index
BP	blood pressure
bpm	beats per minute
CHD	cardio heart disease
CPM	counts per minute
CVD	cardiovascular disease
CVM	cardiovascular mortality
DBP	diastolic blood pressure
DM	diabetes mellitus
DVT	deep vein thrombosis
DXA	dual energy x-ray absorption
FBG	fasting blood glucose
FFIT	football fans in trainning campaign
FTA	Freight Transport Association
HADS	Health Anxiety and Depression Scale
HDL	high density lipoprotein
HGV	heavy goods vehicle
HS-CRP	high sensitive c-reactive
HSQ	Health Scree Questionnaire
ICC	intraclass correlation coefficient
IHD	ischemic heart disease
IPAQ	International Physical Activity Questionnaire
IQR	interquartile range
LDL	low density lipoprotein
LPL	lipoprotein lipase
LPA	ligh physical activity
MET	metabolic equivalent of task
MI	myocardial infartaction
MVPA	moderate-to-vigorous physical activity
NHS	National Health Service
PA	physical activity
PAD	peripheral arterial disease
RCT	randomise control trial
RHD	rheumatic heart disease
RHR	resting heart rate
SB	sedentary behaviours
SBP	systolic blood pressure
SD	standard deviation
SHIFT	Structure Health Intervention for Truckers
T1DM	type 1 diabetes mellitus
T2DM	type 2 diabetes mellitus
TIA	transient ischemic attack
TC	total cholesterol
TG	triglyceride
WC	waist circumference
WHO	World Health Organisation
WHR	waist-hip ratio

CHAPTER ONE

Thesis overview

Workers from the transport industry face a greater risk of co-morbidities and mortality compared to the general population (Robinson and Burnett, 2005; Tse et al.,2006). Indeed, national statistics have shown that those in the transport sector have one of the lowest life expectancies in comparison with other sectors (Office for National Statistics, 2011). Undoubtedly, the environment, culture and job demands (long irregular hours, enforced sedentarism, high stress, sleep deprivation) within the transport industry constrain the enactment of healthy lifestyle behaviours which are responsible for high levels of obesity, metabolic syndrome and mental ill health (stress, depression, anxiety, fatigue). However, it is assumed these are more aggravated in bus and lorry drivers, compared to other workers from the transport sector whose working conditions are more regulated (eg. Train and tram drivers) or independent (eg. taxi drivers). Indeed, bus and lorry drivers exhibit higher than nationally representative rates of obesity, and obesity-related co-morbidities (Morris and Crawford, 1958; Tse et al., 2006; Thiese et al., 2015).

Bus and lorry drivers' lifestyle, in combination with their working environment embodies a constellation of risk factors for cardiovascular disease. Morris and colleagues highlighted in the 1950's the higher rates of cardiovascular disease seen amongst bus drivers in comparison to bus conductors (Morris et al., 1953). Studies conducted amongst American lorry drivers showed higher prevalence of unhealthy lifestyle behaviours, and increased risk factors for CVD than the general population (Thiese et al., 2015) and other occupational groups (Aronson et al., 1999; Hannerz & Tuchsen, 2001; Robinson & Burnett, 2005). However, they are currently an underserved population in terms of health promotion efforts (Ng et al., 2015).

Workers from the transport sector can be best defined as “compulsory sedentary workers” and whilst high volumes of sitting time are assumed, no studies have measured such behaviours. Increasing our understanding of the lifestyle behaviours, particularly sedentary behaviour and physical activity will help inform the development of interventions targeting improvements in these behaviours, in these occupational groups. If successful, such interventions, over the long term, could influence policy which will likely have important health implications.

The research presented in this thesis uses a mix-methods approach to increase our understanding of bus and lorry drivers’ lifestyle behaviours in association with CVD risk. This thesis contains 5 studies, detailing original research, which fit within the MRC framework for the development of complex interventions. The work detailed in this thesis explores sitting time and physical activity levels in association with CVD in bus and lorry drivers. Chapters 3 and 4 focus on a local sample of bus drivers, this work pilots the measurement methods used in later chapters of the thesis. During year 1 of the PhD links with a large transport company were established, the remainder of the PhD therefore focuses on lorry drivers from this company, with the measurement methods informed by the early work in bus drivers.

Chapter 3 presents a pilot study conducted in bus drivers aiming to ascertain the feasibility of using an activPAL inclinometer to directly measure drivers' sedentary and non-sedentary behaviours over the course of a week. In addition, this study intended to quantify the prevalence of these behaviours during and outside working hours. Lastly, this study aims to profile bus driver's basic cardio-metabolic health. Building on the findings and conclusions from Chapter 3, Chapter 4 broadens the investigation of the measurement of sedentary behaviour by assessing the validity of accelerometer-determined sedentary time compared to actviPAL-determined sedentary time under free-living conditions in the same sample of bus drivers.

The literature review in Chapter 2 highlighted the lack of available information on lorry drivers' sedentary and physical activity levels, hence Chapter 5 aimed to profile these two behaviours in association with cardiovascular health in a sample of 156 drivers. Moreover, this study intended to examine markers of cardiovascular health and to profile drivers' mental health and to explore any association between these and the lorry drivers' free-living activity behaviours. The results from this surveillance study in combination with qualitative research aiming to understand the barriers to a healthier lifestyle within lorry drivers working environments (data not included as a chapter, but as an appendix – 11.5) lead to Chapter 6. This chapter presents a pilot intervention, which aimed to reduce drivers sedentary time and increase their physical activity through step counts and ultimately to improve lorry drivers cardiovascular health. A full process evaluation was conducted on this intervention and this is presented in Chapter 7. Each chapter contributes to the overall structure of the thesis and builds on the previous study, yet they can be read in isolation. The studies presented in this thesis have been widely disseminated through conference presentations, press releases, meetings within different organisations within the transport sector and published papers (11.1-11.5).

CHAPTER TWO

Literature review

Chapter overview

This chapter focuses on three major topics that together encapsulate the rational for this thesis. Section one defines sedentary behaviour and provides information regarding the prevalence of sedentary behaviours in working adults. The links between both sedentary behaviour, physical activity and health are explored. In addition, an overview of the different methods used to assess physical activity and sedentary behaviour is provided. Section two, provides an overview of the literature exploring links between bus and lorry drivers' lifestyle behaviours and health. Section three gives an overview of CVD's, along with risk factors for CVD. The chapter concludes by presenting a list of aims to be achieved within this thesis.

2.1 SECTION ONE: SEDENTARY BEHAVIOURS, PHYSICAL ACTIVITY AND HEALTH

2.1.1 Sedentary behaviour - an introduction

Whilst the health benefits of regular physical activity (PA) are widely acknowledged (Chief Medical Office, 2011; WHO, 2016), over the past 50 years, we have engineered regular PA out of our daily lives. Technological advances, societal influences and environmental changes have had a negative impact on the way we spend our time at work, travelling and during leisure activities. We have also modified the way we behave at home, with our peers and in our communities. Our modern lifestyle has resulted in drastic reductions of PA levels globally (Brownson et al., 2005; Knuth and Hallal, 2009, Kohl et al., 2012) and it is assumed that these reductions in PA are accompanied by parallel increases in sedentary behaviour (Owen et al., 2010b and Thorp et al., 2011).

The Latin root of the word sedentary (seder) literally means to sit (Tremblay et al., 2010); thus sedentary behaviour (SB) has been defined as "any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture" (Sedentary Behaviour Research Network, 2012). Common sedentary behaviours include sitting in motorised transport, at school/work, whilst watching television, reading and screen-based entertainment (Pate et al., 2008). The term sedentary behaviour has historically been used as an equivalent of lack of physical activity (SBRN, 2012), yet these two terms are not the same, since an individual can meet or exceed the public health guidelines for PA (150 minutes of moderate intensity physical activity per week, or 75 minutes of vigorous intensity activity a week; Chief Medical Officers recommendations, 2015) and still spend a considerable amount of time sitting (Sugiyama et al. 2008; Edwardson et al. 2012) Figure 2.1 from Saunders et al. (2014) summarises how different levels of sedentary behaviour can co-exist with different levels of physical activity. In fact, the Sedentary Behaviour Research Network have recommended that the term “physically inactive” is only used to describe those people who do not meet the PA guidelines. Several epidemiological studies have indicated that sedentary behaviour and PA have independent impacts on health (Katzymarzyk et al. 2009; Matthews et al. 2012; van der Ploeg et al. 2012; Biswas et al., 2015). Evidence suggests that even in those sufficiently active, prolonged time sitting increases the risk of CVD, cardiovascular mortality (CVM), all-cause mortality, diabetes and some cancers (Wilmot et al., 2012; de Rezende et al., 2014)

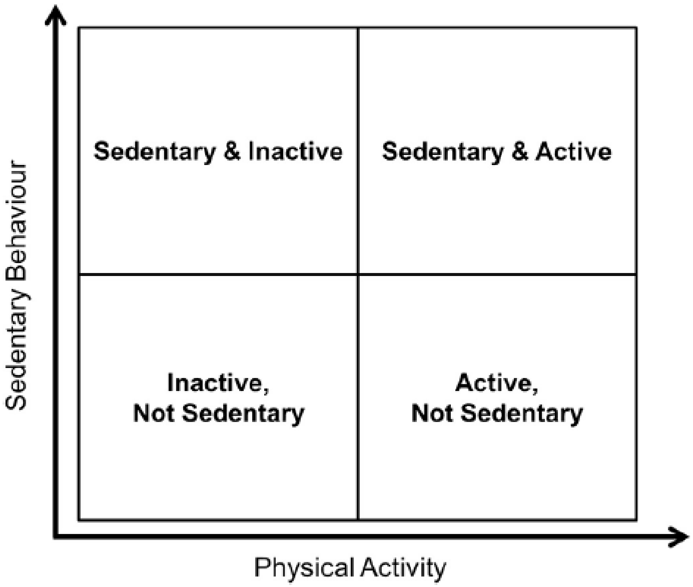

Figure 2.1. Sedentary behaviour and physical activity as distinct constructs. This figure categorises individuals into one of 4 groups: 1) those who are not sedentary (i.e. do not spend long periods of time sitting) but also not sufficiently active to meet physical activity guideline (inactive, non sedentary); 2) those who do sufficient physical activity to meet guidelines and also spend limited amounts of time sitting (active, not sedentary); 3) those who spend long periods of time sitting and also do insufficient

2.1.2 MEASUREMENT OF SEDENTARY BEHAVIOUR

Within a behavioural epidemiological framework, development of accurate methods to measure sedentary behaviour and physical activity are a priority (Owen et al., 2010; Marshall & Ramirez, 2011). High-quality assessment of these behaviours is of essence to identify causal associations with health outcomes, to quantify precisely the magnitude of the association and to describe dose–response relationships (Wareham et al., 1998; White et al., 2008; Hutcheon et al., 2010). Furthermore, accurate measures are needed to be able to profile patterns and changes in sedentary behaviour and physical activity over time. The most accurate instruments which measure energy expenditure associated with sedentary behaviour and physical activity (e.g. room calorimetry and doubly-labelled water) provide a valid measure of energy expenditure, but do not measure the behaviour itself. These measures are traditionally used in laboratory-based settings to validate more practical tools for the assessment of free-living sedentary behaviours and PA. These instruments are described below and classified as:

a) Subjective measures, typically involving self-report measures, including questionnaires and diaries.

b) Objective measures, including accelerometers and posture monitors.

2.1.2.1 Subjective measures of sedentary behaviours

This questionnaire contains a single item measure of total daily sitting time, which has generally been shown to have moderate reliability (Spearman's p = 0.8), but moderate to poor convergent validity (p= 0.30) when compared with accelerometer-determined sedentary time (Craig et al., 2007). This was a convergent validity study because the ActiGraph does not directly measure posture, refer to section 2.1.2.2 for a full description of the ActiGraph .Thus, Chastin et al have shown the IPAQ underestimates sedentary behaviour by approximately 2 hours a day in comparison with the activPAL (efer to section 2.1.2.2 for a full description of the activPAL), which is a direct measure of sitting (Chastin et al., 2014).

Recent research has attempted to develop more refined measurement tools to provide contextual information by assessing multiple sedentary behaviours (e.g. TV viewing, reading, socializing) and/or domain-specific behaviours (e.g. sitting at work or at home and motorized travel) (Marshall et al., 2010; Clark et al., 2011). Thus, Clemes et al., (2012) highlighted that when compared with accelerometer-assessed sedentary time, a single-item question significantly underestimated sitting time, whereas a domain-specific questionnaire, with multiple items, assessed more accurately total daily sitting time. The most widely used domain-specific measure is the Marshall

Sitting time questionnaire (Marshall et al., 2010), which assesses time spent sitting on weekdays and weekend days in different domains including: 1) traveling to and from places, 2) at work, 3) watching television, 4) using a computer at home, and 5) for leisure, not including television viewing. Compared to accelerometry, the convergent validity coefficients of this short questionnaire were high for weekday sitting time at work, watching television, and using a computer at home (r = 0.84-0.78) but lower for weekend days across all domains (r = 0.23-0.74). In addition, the convergent validity coefficients were highest for weekday sitting time at work and using a computer at home (r = 0.69-0.74). Whilst mean differences between total daily sedentary time reported from the domain-specific questionnaire and accelerometer on weekdays and weekend days were small (mean differences equalled 14 minutes on weekdays and 4 minutes on weekend days), the limits of agreement between these measures were large (weekday = -382.0 to 354.6 minutes; weekend day = -578.5 to 570.2 minutes).

Smaller limits of agreement were observed when comparing a single item “specific day” sitting time questionnaire to accelerometry (weekday = -401.6 to 55.6 minutes; weekend day = -509.6 to 72.4 minutes), (Clemes et al., 2012); possibly because fewer responses are required and it refers to a specific day of the week inducing less recall-bias. This suggests that whilst the single-item specific day questionnaire significantly underestimates sitting time on both weekdays and weekend days relative to accelerometer-determined sedentary time, it seems that this occurs with a certain degree of consistency. Given the smaller limits of agreement between the single-item specific day questionnaire compared to accelerometer-determined sedentary time

(Clemes et al., 2012), it is suggested that a single-item specific day question may be more sensitive than the domain-specific questionnaire at detecting changes in sitting time. This indicates that more detailed questionnaires may be required for sedentary behaviour prevalence and surveillance studies, whereas single-item questionnaires may be more appropriate for health-related epidemiological research, where ease of use and the ability to rank behaviours of interest prevail.

Whilst self-report measures are inexpensive and feasible for use as a surveillance tool in large scale studies, they have demonstrated consistently poor validity, which is highly affected by recall-bias associated with self-report questionnaire (Atkin et al., 2012). Other subjective measurement tools such as diaries, in person and telephone interviews, self-administered questionnaires have been used in research, yet less often than researcher-administered questionnaires (Atkin et al., 2012).

2.1.2.2 Objective measures of sedentary behaviour

Accelerometers and inclinometers have become more accessible due to reduced costs and are increasingly being used to assess posture and body movements for prolonged periods of time during free-living activities (Healy et al, Atkin et al., 2012). These objective measures overcome the limitations of recall bias common with self-report measures.

The activPAL has been shown to be a valid measure of time spent sitting, standing and walking in adults compared to direct observation (Grant et al., 2006; Grant et al., 2008; Kozey-Keadle et al., 2011). The activPAL3 is the upgraded version of the traditional activPAL. This is a tri-axial accelerometer, which outputs a different range of raw acceleration data and uses a higher sampling frequency and subsequently different hardware filtering compared to the earlier version of the activPAL. It has been assumed that the demonstrated validity and reliability of the previous version would apply to the activPAL3, yet limited studies demonstrate this (Berendsen et al. 2014; Stansfield et al., 2015; Sellers et al., 2016). In fact, Sellers et al. (2016) highlighted that the activPAL3 misclassifies some activities of daily living (ADL) due to seat-perching, kneeling and crouching. Despite showing good accuracy for standardised walking activities, Sellers et al (2016) also highlight that the proportion of steps detected seems to decrease as the cadence increases. The research available (Berendsen et al. 2014; Stansfield et al., 2015; Sellers et al., 2016) however has shown that the activPAL3 is still highly accurate when assessing posture and purposeful stepping at low speed, making it a valid tool to assess sedentary behaviour and walking activity, particularly in sedentary populations like bus and lorry drivers (Harrington et al., 2011) (Table 2.1).

The use of inclinometers is becoming more popular for the measurement of sedentary behaviour specifically but also to assess physical activity by using the step counts feature. The most popular tool is the activPAL, which is a small, lightweight device worn on the front of the thigh. This contains a uni-axial accelerometer which responds to signals related to gravitational forces and provides information on thigh inclination, hence detecting posture (Atkin et al., 2012). The activPAL summarises the data in terms of time spent sitting and lying, standing and walking; information on sit-to-stand and stand-to-sit transitions, step counts and step rate (cadence) is also provided (Ryan et al., 2006; Grant et al., 2006; Harrington et al., 2011; Maddocks et al., 2010; Plasqui et al., 2013). Due to the information on step cadence, stepping time can be further classified into intensities of physical activity. Moderate-to-vigorous PA is calculated by summing the minutes in which participants accumulated >100steps/minute (Marshall et al., 2009; Rowe et al., 2011) and light activity by taking away the MVPA time from the overall stepping time output provided by the activPAL. This cut-point was derived from working out a gender-weighted average related to different strides lengths (Tudor-Locke et al., 2005) in very controlled lab experiments (Rowe et al., 2010). Therefore, no studies have been performed under free living conditions or different terrains, in which the stepping pace might be slower due to the ground steepness. Thus, this threshold should not be used as a precise criterion for determining moderate-intensity walking as step rate is not an accurate proxy measure for METs. However, there is sufficient evidence for step rate to be used as a heuristic method with which to promote physical activity, similarly to the physical activity recommendations (PHE, 2015).

The use of accelerometry to provide an objective estimate of sedentary time, in addition to physical activity, has been widespread in adults, with the ActiGraph being one of the most widely used measurement tools within the literature. The ActiGraph is a small lightweight device that traditionally has been worn on an elastic belt on the hip.

This integrates a tri-axial sensor to measure acceleration in three axes from 0.05 to ±8 g at a sampling rate of between 30 to 100 Hz. The ActiGraph provides raw acceleration data by capturing the frequency and amplitude of the acceleration of the body segment to which it is attached (Atkin et al., 2012) and it has been defined as the most reliable monitor to measure physical activity (Esliger et al., 2006). Once the monitoring period is finished, these data can be clustered into sedentary, light, moderate and vigorous activities during the post-processing analysis (Atkin et al., 2012). Traditionally a cut point of <100 counts per minute (cpm) has been applied to estimate sedentary time. This cut point has also been proposed for the classification of sedentary behaviour using the Actical activity monitor (Mini-Mitter, Bend, OR, USA) (Wong et al., 2011). However, despite its widespread use, this was not empirically derived and studies showing its validity are limited (Matthews et al., 2008; Tremblay et al., 2011). Kozey-Keadle and colleagues (2011) assessed the criterion validity of a number of ActiGraph (GT3X) cut points (50, 100, 150, 200 and 250 cpm) for defining sedentary time compared to direct observation and highlighted that the cut point of 150 cpm performed the best compared to the other cut points overestimating sitting time by 1.8% (Table 2.1). In comparison Hart et al (2011) have recommended a cut point of <50 cpm, as the ActiGraph output was more consistent with the activPAL, when assessing free-living sedentary behaviours using this cut-point instead of any of the above mentioned (Table 2.1). However, a lack of consensus as to the most appropriate cut points remain in the literature, which limits comparability between studies and hinders evidence synthesis. Despite the lack of consensus of the most valid cut-point, a cut-point of <100cpm is the most widely used to date.

NHANES researchers have assessed the performance of the wrist-worn ActiGraph using the <100cpm to determine sedentary time (Rosenberger et al., 2013), yet their research highlighted the unique challenges in classifying activities into type and intensity categories, and estimating activity energy expenditure (AEE) using this location compared to waist-worn accelerometers. Some of the issues mentioned by Rosenberger et al. (2013) include: at the wrist, motion can be quite high with little or no increase in AEE; greater inter-person variability in wrist movements during sedentary behaviour (e.g. moving hands greatly when talking), resulting in more misclassification compared to waist-worn accelerometers. Therefore, accurately identifying sedentary behaviour from a lack of wrist motion is not possible yet; recent studies (Montoye et al., 2016) using pattern recognition have shown that waist-worn devices are more accurate at picking up activity classification in comparison to wrist-worn devices.

Accelerometers do not measure posture and sedentary time is estimated through a lack of movement counts (Chen & Bassett, 2005). Thus, standing activities below 100 cpm may be misclassified as sedentary (Atkin et al., 2012). The latest ActiGraph models contain an inclinometer algorithm to try overcoming this issue. The new integrated algorithm classifies the individuals posture into sitting, lying, standing or device off, yet research to examine the validity of this new feature is needed (Carr et al., 2012). Compared with the activPAL, recent research however has highlighted low reproducibility (kappa value 0.75 versus kappa value 0.99, $p<.001$) and validity (kappa value 0.29 versus kappa value 0.99, $p<.001$) of posture classification, using this algorithm in laboratory and free-living conditions (Berendsen et al., 2014)(Table 2.1). In addition, Berendsen and colleagues (2014) indicated that type of misclassification varied across participants, for instance, in one participant 83.2% of sitting time was classified correctly, while sitting time in other participants was never classified correctly, which could be influenced by the point of attachment (McMahon et al., 2010). Although, it has been suggested that even when attaching the ActiGraph to the low back or upper leg, the ActiGraph does not accurately identify sedentary behaviours (McMahon et al., 2010). Thus, it is possible that the accuracy of the ActiGraph to determine sedentary behaviours is dependent of additional factors, such as levels of adiposity (Carr and Mahar, 2012) and this should be explored further. However, given the basic principal of the ActiGraph, it seems plausible to think that independently on where the ActiGraph is going to be worn; this device will never accurately identified sedentary time as it does not measure posture, but lack of movement.

Table 2.1 Description of the studies exploring the validity of the activPAL and the ActiGraph to measure sedentary behaviours compared to gold standard measures.

Author, publication and date	**Type of sample participating in the study and sample size**	**Measure of sedentary behaviour (A)**	**Method applied to determine sedentary time (ie. cut-points)**	**Gold standard to which the measure of sedentary behaviour was compared against (B)**	**Duration of the study and conditions in which the experiment was conducted under**	**Results**	**Statistical difference of the measures of sedentary behaviour compared with the gold standard**
Grant et al., 2006	N= 10 adults university staff and students (6 female,4 males); Mean(SD) age 43(10.6) years Mean(SD) weight 73.7(10.1) kg	***activPAL***	3 activPAL monitors (One monitor was placed Mid-thigh and a second positioned immediately distally. A third activPAL was placed on top of the distal monitor)	Direct observation	19 min performing standardised activities 20 min performing activities of the daily living (ADL) Both in a controlled laboratory environment.	Inter-observer reliability ICC 0.97 for all individual postures (sitting, standing and walking) interdevice reliability ICC 0.99 for sitting/lying, standing, walking and upright	Standardised activities: Mean time difference spent sedentary of 0.19%(LoA 20.68% - 1.06%) ADL: Mean time difference spent sedentary of 1.4% (LoA, 26.2% to 9.1%) Overall second-by-second level of agreement between activPAL and DO 95.9%.

						activities	Sensitivity analysis for sitting time in: controlled conditions 99.7%, predicted value 99.8% ADL 99.4%, predicted value 99.5%.
Kozey-Keadle et al., 2011	N=20, office workers (5 males and 15 females). Mean(SD) age 46.5(10.7)years Mean BMI (SD) 33.7(5.7) kg/m^2	***ActiGraph GT3X***	<100 cpm <150 cpm	Direct observation	6-h period during free-living conditions (working-hours)	<100cpm, Bias -16.9min SE 8.5 min (95% CI -33.6, -0.3 min).	$R^2 = 0.39$
						<150cpm, Bias -0.9 min, SE 7.7min, (95% CI -15.9, 14.1 min)	$R^2 = 0.40$
		activPAL				activPAL, Bias -7.7 min SE 2.5 min, (95% CI -12.5, -2.9 min)	$R^2 = 0.94$

Hart et al., 2011	N=29 university students and staff. (13 males and 16 females); Mean(SD) age 28.9(6.2) years Mean(SD) BMI 23.9 (3.1) kg/m2	***ActiGraph 7164***	<50 cpm <100 cpm <259 cpm	Direct observation (DO) in lab condition	Waking hours of 1 full day (involving direct observation and free-living Conditions) Direct observation 3 min per condition		compared with the activPAL sedentary time was different (p< .001) for each cut-point: <50cpm, 331.2(73.2) (95% CI: 153.0–559.0) <100 cpm, 361.9(71.6) (95% CI: 196.0–594.0) <259 cpm, 409.6(65.4) (95% CI: 282–655)
		Intelligent Device for Energy Expenditure and Physical Activity (IDEEA) ***activPAL***		activPAL in free-living condition		Both IDEEA and AP detected the 3-minute timed and scripted bouts of sitting and standing without error activPAL identify 100%	Mean(SD) identified sedentary time during free living condition 308.1(83.7) (95% CI: 122.5–490.4) Mean(SD) identified sedentary time during free living condition 313.6 (92.7) (95% CI :121.2–561.2)

Ridgers et al., 2012	N= 48 children (26 boys, 22 girls) Mean(SD) age 10.3(1.2) years	***ActiGraph GT1M***	From <50cpm up to <850cpm (a total of 17 cut-point)	activPAL	Participants wore an ActiGraph and activPAL simultaneously for two consecutive school days.	The smallest mean bias between activPAL and ActiGraph-determined sedentary time was AG150 for class time (3.8 Minutes; 95% LoA, -47.3 to 54.8), AG50 for break time (-0.8 minutes; 95% LoA, -25.5 to 23.9), and AG100 for school hours (95% LoA,-5.2 minutes; -77.6 to 67.1)	ROC analysis showed an optimal cut-point to determine sedentary time of <96cpm (AUC = 0.75), sensitivity value of 71.7% and specificity value of 67.8%.

Decker et al., 2013	N= 44, 4- to 6-yr-old pre-schoolers (22 boys and girls). Mean(SD) age 5.49(0.59) years. Mean(SD) BMI 15.18(2.78) kg/m2	***ActiGraph***	<100cpm	Direct observation	1 hour of video recording in the preschool class Free-living conditions for 4 days (2 weekdays and 2 weekend days)	Compared with the activPAL during the free living conditions ActiGraph Mean(SD) sedentary time was 420.49(86.42) (p<0.05)	Compared with direct observation ActiGraph ROC-AUC 0.59 Sensitivity of 58.50% (95% CI 56.00–60.90) Specificity of 61.16% (95% CI 59.30–63.009
		activPAL				activPAL mean(SD) sedentary time was 360.35(105.8) Mean bias (SE) between the ActiGraph and the activPAL -7.71% (10.87%) (95% CI 29.01% 13.6%)	Compared to direct observation activPAL ROC-AUC 0.61 Sensitivity 53.80% 95% CI 51.90–55.70 Specificity 67.50% 95% CI 51.90–55.70

Berendensen et al., 2014	Laboratory condition: N=5 (4male, 1 female) Mean(SD) age 22.4(2.2) years Mean (SD) BMI 22.3(1.8) kg/m2 Free-living condition N=9 (4 males, 5 females), Mean(SD) age 27.2(8.3) years Mean (SD) BMI 21.3(1.8).	***ActiGraphGT3X***	<100cpm	Direct observation	Laboratory assessment 2x19.5 minutes session within 24 hours Participants wore the three activity monitors simultaneously for at least 3 days plus activity diary every 15 minutes from waking up till going to bed.	In laboratory conditions; percentage of time in which sitting/lying, standing and walking time were correctly identified by ActiGraph: 33.9% kappa value of 0.29 (p < 0.001)	In laboratory conditions Test-retest reproducibility for posture classification function were: activPAL K= 0.99, ActiGraph k=0.75 CAM k=0.95 (p < 0.001). In free-living conditions, ICC of the AP with the original and corrected diary outcomes was 0.98 (95% CI: 0.94, 0.99) ICC of the CAM was 0.98 (95% CI 0.95,0.99).
		activPAL3				activPAL3 100.0% kappa-value of 0.98 (p < 0.001)	ICC of the ActiGraph <100 cpm was 0.96 (95% CI: 0.88, 0.98)
		CAM				CAM 100.0% kappa-value of 0.99 (p < 0.001).	ICC of the ActiGraph inclinometer function was 0.59 (95%CI 0.22,0.81)

Sellers et al., 2016	Adults N=20 (9 males, 11 females) Median(IQR) age 27.6 (22.6) years, Median(IQR) BMI 24.6 (3.2 kg/m^2) Young people N=8 Median(IQR) age 12.0(4.1) years, Median (IQR) weight 42.3(16.4)kg	***activPAL3***	Direct observation (video recording)	Standardised activities Indoors—8 tasks, 2 min each Outdoors—6 tasks Activities of daily living (ADL) Adults—6 tasks (2–5 min) Young People—6 tasks (1–4 min)	High level of second by second agreement between activPAL3 and video observation for standardised activities for adults (97.9% min) and young people (95.0% min) Bland-Altman plots percentage mean difference sedentary time between activPAL and direct observation: Standardised activities in	Second-by-second sitting time agreement Standardized activities in adults: 99.8% Sensitivity value 99.2% PPV% 100.0% ICC 0.99 (95% CI, 0.99, >0.99) In young people 99.5% Sensitivity value 97.0 PPV%100.0 ICC 0.98 (95% CI 0.90, >0.99) ADL activities in adults: 97.0% Sensitivity value 98.3% PPV% 96.9% ICC 0.99 (95% CI, 0.98, >0.99) In young people

adults Mean -0.07 (LoA,-0.28, 0.15) Young people -0.28 (-1.23, 0.66) ADL in Adults 0.53 (-0.96, 2.02) In young people -2.84 (-124.98, 130.67)	86.8% Sensitivity value 84.2 PPV% 89.6 ICC, 0.91 (95% CI, 0.77, 0.98)

PPV positive predicted value, LoA limits of agreement, ADL activities of daily living, ICC intraclass correlation, SD standard deviation, IQR interquartile range,

2.1.3 Prevalence of sedentary behaviour

Several studies have highlighted the trend towards lower overall levels of physical activity (Brownson et al., 2005; Knuth and Hallal, 2009; Kohl et al., 2012; Sallis et al., 2006) including occupational physical activity over the past 50 years (Church et al., 2011; Graff-Iversen et al., 2001). Despite the presumed inverse relationship between physical activity and sedentary behaviour (Owen et al., 2010b and Thorp et al., 2011), a recent epidemiological study across 27 countries suggested that self-reported sedentary times (using IPAQ-determined sedentary time) have remained relatively stable over the past decade within the European region (316 minutes per day in 2002; 312 minutes per day in 2005; 292 minutes per day in 2013) (Milton et al., 2015). These results are similar to those found in earlier epidemiological studies across 32 European countries (Bennie et al, 2013) and 20 different countries worldwide (Bauman et al, 2011), which showed that overall adults (aged >15years) typically spend about 300 minutes (5 hours) siting per day. Although, Bennie et al. (2013) highlighted that these values varied regionally and adults from the north-western European countries accumulated greater sitting per day (420–960 minutes per day) than those from the other regions (Bennie et al., 2013). However, these large-scale epidemiological studies (Bauman et al., 2011; Milton et al., 2015; Bennie et al., 2013) assessed sedentary time using from a self-report survey (IPAQ). Although the IPAQ is a validated tool, with the question on sitting time demonstrating better validity coefficients than the physical activity questions (Craig et al., 2003 and Rosenberg et al., 2008), all self-report tools are subject to social desirability and recall biases (Shephard, 2003). Previous research suggests that participants are likely to under-estimate the time that they spend sitting when completing self-report surveys (Clemes et al., 2012), but there is no information on whether this bias is differential over time. In addition, it is likely that increased media attention on sedentary behaviour has led to increased public awareness of the issue. Resulting in either individuals sitting less or under-reporting their sitting time, the latter being the most likely. This supports the need for objective population-level estimations of sedentary behaviour.

Data collected using the ActiGraph accelerometer indicates that the average adult spends 50–60% of their waking day sedentary (Healy et al., 2011). Many studies have shown that office workers spend between 65% to 82% of their working hours sedentary (Clemes et al., 2014; Thorp et al., 2012; Ryan et al., 2011; Brown et al., 2013; Parry and Straker, 2013;), which accounts for 63% of their total daily sedentary time on work days (Clemes et al., 2014). Therefore, when combining time spent sedentary at work and during leisure time office workers accrued approximately 10 hours per day of sedentary time (Clemes et al., 2014), which is greater than that reported in the international epidemiological studies mentioned above. Given these findings recent interventions have started to utilise adjustable desks to reduce sitting time at work (Healy et al., 2013; MacEwen et al., 2015; Mansoubi et al., 2016). However, this is not feasible in some occupations such as drivers.

When looking at other occupational settings, very limited evidence is available about professional drivers' sedentary behaviours (Morris and Crawford, 1958; French et al., 2007; Wong et al., 2014), who can be best defined as "compulsory sedentary workers" as they have no choice but to sit, usually for long periods of time. Given the nature of their job, it would be expected that occupational drivers would accumulate high volumes of sedentary time. Of interest using the IPAQ, French and colleagues (2007) reported that transit workers spent just over 9 hours per day sedentary, which is much higher than the epidemiological data reported in section 2.1.3.

Data collected amongst Australian bus drivers using the ActiGraph accelerometer (Wong et al., 2014) showed they spent approximately 90% of their waking time sedentary or in very light activity on workdays and even more time sedentary on non-work days. In addition, 60% of their non-working time was spent sedentary (Wong et al., 2014). This supports recent evidence, which suggest that those who spend prolonged time sitting at work do not compensate for their sitting behaviour by becoming more active or sitting less during their non-working hours (Parry and Straker, 2013; Clemes et al., 2014a, b).

2.1.4 Sedentary behaviour and Health

In the 1950s Morris and Crawford (1958) observed higher rates of cardiovascular events in sedentary bus drivers in comparison to active conductors. They concluded that there was a noticeable association between physical activity/inactivity and cardiovascular health. Whilst jobs requiring high amounts of physical activity had a protective effect on health, low occupational physical activity was associated with increased odds of cardiovascular risk factors (Morris and Crawford, 1958). Since then, there has been a growing body of evidence suggesting the immediate and long term negative effects of prolonged time sitting on health.

2.1.4.1 Observational data on sedentary behaviour and health

Evidence from observational studies suggests that prolonged time spent sedentary is associated with an increased risk of obesity (Thorp et al, 2005; Chau et al., 2012), diabetes (Dunstan et al., 2004; Krishnan et al., 2009; van Uffelen et al, 2010; Mathews et al., 2012), some cancers (Lynch et al, 2010; Dallal et al, 2012), cardiovascular disease (Stamatakis et al., 2011; Hawkes et al., 2011; Manson et al., 2002), cardiovascular mortality (Mathews et al., 2012; Katzmarzyk et al., 2009; Warren et al., 2010; Proper et al., 2011; Chau et al., 2013) all-cause mortality (Proper et al., 2011; Chau et al., 2013) and the metabolic syndrome (Dunstan et al. 2005, Healy et al. 2011). A meta-analysis conducted by Wilmot and colleagues (2012) highlighted that high volumes of sedentary behaviour were associated with increasing risk of suffering from CVD by 147%, cardiovascular mortality (CVM) by 90%, all-cause mortality by 49% and type 2 diabetes by 112%. Of these associations, the strongest link was shown between sedentary behaviour and diabetes. This meta-analysis included 18 studies, of which two were cross-sectional and 16 were prospective cohort studies from a number of countries including Australia, England, Canada, Germany, Japan, Scotland and the USA, involving 794,577 participants aged between 38 and 63 years. All of the studies included in this analysis used a self-report measure of sedentary behaviour and 10 out of the 18 papers controlled for physical activity. Wilmot's et al. (2012) meta-analysis added further weight to the concept of sedentary behaviour as a distinct behaviour independent of physical activity, as these associations were only present in those accruing the highest volumes of sedentary time compared with the lowest. The main strengths of this meta-analysis are the large sample and the fact the authors controlled for a number of variables (including all the confounders from the most adjusted model identified across the observational studies and BMI and waist circumference) in their analyses. However, this study based its findings on self-reported sedentary times, which as mentioned previously can be limited through problems with recall and recall bias, thus weakening the associations with health outcomes (Clark et al., 2009). Not all of the studies included in this meta-analysis controlled for physical activity, therefore the extent to which levels of physical activity may have potentially modified associations between sedentary time and health outcomes were not fully examined. In addition, due to observational nature of the data, it is difficult to infer the temporal association between a risk factor and an outcome. Therefore, no causation can be inferred from these results and reverse causality remains a possibility.

A recent systematic review and meta-analysis performed by Biswas et al (2015) showed stronger evidence of the deleterious effects of prolonged time sitting on health (independent of physical activity) than those presented by Wilmot et al. (2012). In this review only studies that adjusted for physical activity were included (N=47) and 44 of the 47 were longitudinal studies. This review observed that compared to those with the lowest amount of sedentary time, those accumulating the highest amount of time spent sitting had a 13% increased risk of cancer incidence, a 14% increased risk of cardiovascular disease incidence, a 17% increased risk of cancer mortality, a 18% increased risk of cardiovascular disease mortality, a 24% increased risk of all-cause mortality and a 81% increased risk of type 2 diabetes incidence. Whilst this review showed that the deleterious effects of sedentary behaviour seem to be attenuated slightly in the most active; the authors concluded that the negative effects of prolonged time sedentary on health are independent of physical activity; as suggested by Wilmot et al., 2012. Overall, similar limitations as to Wilmot et al's (2012) study can be associated with this meta-analysis, as all but one study used self-report methods to measure sedentary behaviour and physical activity. However, this study suggested that the association between sedentary behaviours and adverse health outcomes may vary according to the level of physical activity, which became less pronounced as participation in physical activity increased.

Indeed a meta-analysis published by Ekelund et al.,(2016), which included 16 studies involving a sample of over a million individuals, who were follow up for 2 to 18.1 years, showed a clear dose-response association with an almost curvilinear increased risk for all-cause mortality with increased sitting time in combination with lower levels of activity. These results indicated that high levels of physical activity (60-75 minutes/day of MVPA) seem to eliminate the increased mortality risks associated with high total sitting time, as those who sat >8 hours daily in the high activity grouphad a significantly lower risk of dying during follow-up than those who sat for less than 4 hours in the least active quartile (about 5 minutes/day of MVPA) ((HR 1·04, 95% CI 0·99–1·10) versus (HR 1·27, 1·22–1·30), p<0·0001). Although these findings are limited to those older than 45 years (as per average age of the individuals included in the studies of this meta-analysis) and sedentary time and physical activity were extracted from self-report data, subgroup analyses were conducted to examine possible bias from any single study and the results seemed to remained. In addition, the observation that physical activity might eliminate the detrimental association between daily sitting time and mortality is biologically plausible (Van Dijk et al., 2013; Kim et al., 2014). Undertaking >1 hr of MVPA/day is a lot of activity, and given the majority of the population fail to reach the PA guidelines (Department of Health, 2015) which equates to roughly 30 minutess/day of MVPA, this study highlights the importance of targeting both reducing sedentary time, particularly in those with occupations that require them to sit for long periods, and increasing time spent in MVPA daily

2.1.4.2 Experimental data on sedentary behaviour, breaks in sedentary time and health

As mentioned in the previous section there is a large body of literature showing strong associations between sedentary behaviour and a number of health outcomes (Wilmot et al., 2012, Biswas et al., 2015). However, data from observational studies also suggests that breaking up long periods spent sedentary is associated with improved cardio-metabolic risk factors (Healy et al., 2008,2011; Saunders et al., 2013) and decreased all-cause mortality risk (Katzmarzyk et al., 2015), even after accounting for MVPA (Bankoski, 2011). However, due to the characteristics of observational data a causal relationship between total volume of sedentary time and health, and breaks in sedentary time and health outcomes cannot be provided.

Evidence drawn from experimental research shows that breaks in sedentary time are associated with lower BMI and waist circumference as well as other beneficial cardio-metabolic risk profiles (Henson et al., 2016). Brief interruptions to sitting with a minimum of light-intensity physical activity such as walking have been shown to attenuate post-prandial glucose and insulin levels in overweight and obese adults (Dunstan et al., 2012). Dunstan and colleagues (2012) were the first to demonstrate in a laboratory setting that when compared to 7 hours of uninterrupted sitting, breaking up prolonged sitting during the post-prandial phase with 2-minutes bouts of light-intensity walking every 20 minutes for 5 hours reduces the glycaemic and insulinemic responses to a liquid meal test in 19 physically inactive non-diabetic overweight and obese middle age individuals. Along these lines, Peddie et al. (2013) showed that bouts of 1 minutes and 40 seconds of light to moderate physical activity (45%-60% VO_{2max}) every 15 minutes during 9 hours of sitting lowered the postprandial insulin and glucose responses when compared with 9 hours of uninterrupted sitting in physically inactive young normal-weight individuals. These results showed that regular activity breaks were more effective (with a 39% reduction in the glucose area under the postprandial curve) than continuous physical activity at decreasing postprandial glycaemia levels. In addition, Howard et al. (2013) showed that breaking up sitting time with either low or moderate-intensity physical activity attenuated the increase in haematocrit, haemoglobin and red blood cell count and the decrease in plasma volume observed during uninterrupted sitting. Interestingly, It has been shown that moderate-intensity (50% VO_{2max}) or vigorous intensity (65% VO_{2max}) exercise bouts (~350kcal) performed after 7 hours prolonged sitting did not induce any changes in glucose and insulin responses to a meal immediately after the exercise, although it increased insulin sensitivity the next day when compared to 8 hours of uninterrupted sitting in obese physically inactive adults (Newsom et al., 2013. Furthermore, Larsen et al. (2014) have highlighted that short active breaks (light and moderate intensity walking) from sitting every 20 minutes lowers systolic blood pressure by 2-3mmHg and diastolic blood pressure by 2mmHg. When extrapolating the clinical implications of this finding, a sustained systolic blood pressure drop of this magnitude could reduce the relative risk of stroke mortality by 6–8%, of coronary artery disease by 4–5%, and of all-cause mortality by 3–4% (Whelton et al., 2002), having important implications for overweight and obese individuals.

Similarly, in a randomized crossover trial involving 24 inactive overweight/obese adults with type II diabetes, Dempsey et al. (2016) showed that mean resting systolic and diastolic blood pressure were significantly reduced (mean: -14 ± 1/-8 ± 1 mmHg) when breaking up sitting every 30 minutess with 3 minutess of light-intensity walking (3.2 km/h) and when breaking up sitting every 30 minutess with 3 minutess of resistance activities (-mean: 16 ± 1/-10 ± 1 mmHg). In addition, mean plasma noradrenaline and heart rate reduced under both conditions compared to sitting uninterruptedly for 8 hours (Dempsey et al., 2016).

There is also emerging evidence that interrupting prolonged sitting with periods of static standing ranging from five minutes every 30 minutes (Henson et al., 2016) to 30 minutes every hour (Thorp et al., 2014) can reduce post-prandial glucose concentrations. For instance, Thorp et al. (2014), showed that the post-prandial glucose curve was 11% lower when alternating 30-minute bouts of sitting with standing whilst using a sit-stand desk, when compared with prolonged sitting, in overweight/obese office workers during an 8-hour working day. However, these findings do not seem to be repeated when replicating similar protocols with healthy and younger individuals (Miyashita et al., 2013; Bailey and Locke, 2015). Despite the interesting results presented by these studies, in all of them sedentary time was replaced by standing or walking leading to a reduction in total time spent sedentary. Instead, Hawari et al. (2016) found no significant differences for blood glucose, insulin and triglycerides amongst three different experiments in which sitting time remained constant in young overweight/obese, normoglycaemic men. In this study participants underwent three different laboratory conditions: 1) uninterrupted sitting (SIT) for 4 hours; 2) prolonged standing trial (PRO-Stand): participants alternated sitting and standing stationary time every 15 minutes. Overall participants spent 4 hours sitting and 4 hours standing and did 16 sit-to-stand transitions and 16 stand-to-sit transitions; 3) Intermittent standing trial (INT-Stand): participants sat for 5 minutes; then undertook 10 cycles of standing for 90 seconds followed by sitting for 30 seconds (20 minutes in total); then sat for 5 minutes. Thus they stood for 15 minutes and sat for 15 minutes every 30 minutes, but the standing occurred in 10 x 90-second blocks, rather than a single 15-minute block. Thus, over the 8-hour observation period they stood for 4 hours and sat for 4 hours, with 160 sit-to-stand and 160 stand-to-sit transitions. Whilst increasing the frequency of breaks in sedentary time induced no significant changes in blood glucose, insulin and triglycerides, Hawari et al. (2016) showed breaking up sitting time significantly increased energy expenditure and fat oxidation over an 8-hour postprandial observation period. This was particularly significant in the INT-Stand protocol (eg. energy expenditure 20% higher than in the SIT condition), which could be a result of concentric and eccentric muscular activity associated with the larger number of sit-to-stand transitions (Hawari et al., 2016).

Therefore, it appears that it is not only the total volume of sedentary time that is important, but how it is accumulated. Indeed, breaking up prolonged periods of sitting could be a feasible avenue to improve people’s health; as evidence suggest that increasing the number of breaks in sitting time per day is linked to improved cardiometabolic health (Swartz et al, 2011; Gilson et al, 2012) or more energy expenditure (Hawari et al., 2016). Benatti & Ried-Larsen (2015) conducted a meta-analysis, which included 16 prospective intervention studies evaluating the effects of explicitly replacing sitting time with physical activity (including standing) on metabolic parameters as outcomes. This review indicated that the type, intensity and frequency of the physical activity breaks necessary to effectively counteract the detrimental effects of prolonged sitting may differ according to subjects’ characteristics, especially with respect to their habitual physical activity level or disease burden. However, despite these findings, it seems that the metabolic benefits of standing are more evident in older populations. In addition, the cross-sectional design of these studies prevents us from confirming the causality and direction of these associations. Finally, despite these health benefits, breaking up prolonged time sitting with such a frequency of breaks (i.e. every 20 to 30 minutes) is not feasible in some occupational groups, such as “compulsory sedentary workers”.

2.1.5 Mechanisms underlying the relationship between sedentary time and health

Interestingly, both reviews of predominantly observational prospective studies discussed in section 2.1.4.1 (Wilmot et al., 2012; Biswas et al., 2015) highlighted the strong relationship between prolonged time sedentary and type 2 diabetes. Diabetes and impaired glucose tolerance are characterised by peripheral insulin resistance. Skeletal muscle accounts for 80% of insulin-stimulated glucose disposal and it is therefore the largest insulin-sensitive organ in the body (Bey & Hamilton, 2003). Insulin sensitivity in skeletal muscles is dynamic and studies conducted on rats demonstrate that skeletal muscle disuse quickly leads to significant peripheral resistance to insulin (Bey & Hamilton, 2003; Seider et al., 1982). Indeed, both LPL and intracellular LPL activities seem to decrease mono-exponentially in the soleus and the red quadriceps after a 4 hours of inactivity in the tested rats (Bey & Hamilton, 2003). However, LPL and residual LPL activity seemed to return to baseline levels when the 12 h hind-limb unloaded rats were reloaded with 4 hours of standing and slow walking on a treadmill.

Alibegovic et al. (2010) also showed that healthy carriers of the T allele of the TCF7L2 gene (the most significant type 2 diabetes susceptibility gene) are particularly susceptible to the negative effects of lack of movement, as they fail to increase their insulin secretion to overcome the insulin resistance induced by muscular inactivity. This finding can be explained by an impairment of non-oxidative glucose metabolism in carriers of the T allele of the TCF7L2 gene with a major defect of muscle glycogen storage rate in response to physical inactivity (Mikines et al., 1991), which in turn may be due to reduced muscle GLUT-4 content and activity and, thus, an impairment of glucose transport into the cell (Handberg et al., 1996). The lack of musculoskeletal activity in the large skeletal muscles in the legs, back and trunk during sitting has also been related to substantial reductions in muscle Lipoprotein Lipase (LPL) activity (Hamilton et al., 2004). This enzyme binds to circulating lipoproteins when present on the vascular endothelium and is essential for the hydrolysis of the triglyceride contained in lipoproteins. Therefore, the loss of LPL activity at the vascular endothelium impairs optimal tissue-specific uptake of lipoprotein-derived fatty acids, which may contribute to the risks associated with metabolic diseases such as obesity, type II diabetes or CHD. It is suggested that even partial reductions in LPL activity increase the odds ratio by up to 5 fold for death and CHD in human studies with healthy controls (Wittrup et al., 1999). Several studies have prevented weight-bearing activity in the hind limbs of rats and found a substantial reduction in LPL activity in skeletal muscles after short periods of immobilisation of the legs (Bey & Hamilton, 2003; Zderic & Hamilton, 2006). This reduction seems more evident in the capillary beds of oxidative muscle sections that are known to be activated at the lower intensities frequently occurring in everyday life (Bey & Hamilton, 2003;). Indeed, LPL seems to reduce its activity to 10% of its normal function during both acute and chronic inactivity (Hamilton et al., 2007). Plasma lipids must past through the endothelium to be taken-up by the muscle cells for fuel. Given this fact, and that the endothelium is the site for LPL regulation (Saxena et al., 1989; Peterson et al., 1990), it has been suggested that the exposure of inactive skeletal muscle tissue to even moderate concentrations of plasma lipids can exert a negative effect on LPL activity and thereby minimize the uptake of TG-derived fatty acids during periods of low fatty acid utilization (Bey and Hamilton, 2003). Therefore, it seems that the detriment of LPL activity during prolonged time sedentary is associated with a large decrease in plasma triglyceride uptake locally in the skeletal muscle, a diminution in High Density Lipoprotein (HDL) cholesterol concentration and elevated postprandial lipids (Reymer et al., 1995; Hamilton et al., 2007). In addition, plasma and muscle lipids have been associated with muscle insulin resistance, which significantly increases the odds for the metabolic syndrome (Hamilton et al., 2004). In addition, to this systemic effects on plasma lipoprotein concentrations, the local regulation of LPL activity in individual microvascular beds is a means to generate a concentrated source of fatty acids and other lipoprotein-derived lipids associated with obesity, type 2 diabetes and coronary heart disease (CHD) (Miles et al., 2004). However, it has been shown that these negative mechanistic reactions can be prevented and reversed by even the non-fatiguing contractions associated with low-intensity ambulatory activity; as up to 95 % of the endothelial-enriched LPL activity is normally present in the capillaries of muscles activated in low-contractile activity (Bey and Hamilton, 2003) Despite these findings, these studies have been conducted in rats and not in humans; yet bed rest studies have confirmed the deleterious metabolic effect of prolonged time sedentary (Alibegovic et al., 2009; Højbjerre et al., 2010). Further research should aim to replicate similar studies in humans using muscle biopsies and in more every-day living conditions, for a more in-depth knowledge of the physiology of physical inactivity and sedentary time.

The links between sedentary behaviour and cancer risk have been explored by Lynch et al. (2010), who highlighted a potential biological pathway that may partially explain the associations observed between sedentary behaviours and cancer. In this review the authors suggest that this association may be mediated by adiposity, which is more common amongst those highly sedentary (Thorp et al., 2011) and can have a direct negative effect on sex hormones, inflammation and vitamin D, increasing the risk of some cancers such as colon, breast, endometrial, kidney and esophageal cancers (Lynch et al., 2010). Therefore, it seems that there is not only a metabolic pathway but also gene interaction (Alibegovic et al., 2010) between prolonged time sitting and health issues. Although more mechanistic studies in humans are required to further understand the links between sedentary time and poor health outcomes.

2.1.6 Physical activity and health

Physical activity is defined by the World Health Organisation (WHO) as any bodily movement produced by skeletal muscles that require energy expenditure. Knowledge of the health benefits of PA is well supported by a strong scientific background for over 60 years (Bouchard et al., 1994; Bauman et al., 2004; Katzmarzyck et al. 2010). Thus, it has been concluded that physical activity is essential in the prevention of chronic disease and premature death (Warburton et al., 2006). According to the national physical activity guidelines and the WHO, adults (19-64 years) should aim to be active daily and accumulate at least 150 minutes (2 hours and 30 minutes) of moderate-intensity aerobic activity such as cycling or fast walking over the course of a week; in combination with 2 or more days a week of muscle-strengthening activities (exercising with weights or carrying or moving heavy loads such as groceries) that work all major muscle groups. Alternatively, adults could accrue 75 minutes (1 hour and 15 minutes) of vigorous-intensity aerobic activity such as running or a game of squash every week, and muscle-strengthening activities on 2 or more days a week that work all major muscle groups. Instead an equivalent mix of moderate- and vigorous-intensity aerobic activity every week, and muscle-strengthening activities on 2 or more days a week that work all major muscle groups will have the same beneficial effects on health (Chief Medical Officers of England, Scotland, Wales & Northern Ireland, 2011). In addition, these guidelines recommend the reduction of time spent sedentary for extended periods for better health outcomes.

Despite the generic character of these guidelines, as they have been developed to apply to all adults aged between 19 to 64 years, independent of sex, ethnicity and occupational background; Li and Siegrist (2012) concluded that high levels of leisure time PA and moderate levels of occupational PA reduce the risk of incident coronary heart disease and stroke amongst both male and females between 20 to 30% and 10 to 20%, respectively. Higher levels of PA were also associated with lower mortality risk in individuals with diabetes, even in those undertaking moderate amounts of PA (Sluik et al., 2012). A more recent meta-analysis involving 71 studies conducted by Li and colleagues (2015) concluded that complying with the current physical activity recommendations reduces cancer mortality in both the general population and cancer survivors by 13%. Positive results were also found in a meta-analysis led by Niedermaier et al. (2015), in which they assessed physical activity levels and risk of adult meningioma. Rosenbaum et al. (2014) also concluded in their meta-analysis that PA is associated with less depressive symptoms in people with mental illness.

The mechanisms underlying the health benefits of physical activity in the prevention of chronic disease and premature death have been summarised by Warburton et al. (2006). In this study, the authors concluded that there is a curvilinear relationship between the volume of PA and health status with those who are more active being at lower risk. Physical activity has been shown to reduce abdominal adiposity and improve weight control, enhance lipid lipoprotein profiles (e.g. reduced triglyceride levels, increased HDL cholesterol levels and decreased low-density lipoprotein [LDL]-to-HDL ratios) improve glucose homeostasis and insulin sensitivity, reduce blood pressure, improve autonomic tone, reduce systemic inflammation, decrease blood coagulation, improve coronary blood flow, augment cardiac function and enhance endothelial function (Warburton et al., 2006). Chronic inflammation, detected by elevated circulating levels of inflammatory mediators such as C-reactive protein, is strongly related with chronic diseases, mainly CVD morbidity and mortality, yet is inversely related to physical activity levels (Warburton et al., 2006).

2.1.7 Light physical activity and health

Despite the original idea that only MVPA is beneficial for health, Warburton et al. (2006) have highlighted the curvlinear relationship between the volume of PA and health status. Although, activities at the higher end of the intensity continuum have stronger health benefits (Katzmarzyk et al., 2009, Biswas et al., 2015) compared to physical activities in the lower intensities. The increasing use of objective measures of physical activity in the past 5 to 10 years, has allowed us to increase our understanding of the health benefits of the different levels of physical activity. Thus, recent research has highlighted that light physical activity (low-light and high-light PA) was positively associated with physical health and well-being in older adults. It has been shown that replacing 30 minutes per day of sedentary time by an equal amount of light physical activity was associated with a higher physical health score (Buman et al., 2010). Further evidence suggests that time spent in light physical activity can have a beneficial impact on several biomarkers. Indeed, Alkhajah et al. (2012) highlighted that the overall amount of light-intensity physical activity accumulated during non-exercise related tasks has a positive impact on metabolic health. Thus, engagement in light PA is related to improved blood glucose levels in adults (Healy et al. 2007) and has been linked to lower diastolic blood pressure and higher HDL-cholesterol in adolescents (Carson et al. 2013). In addition, Gando et al. (2010) established that longer durations spent in light physical activity is associated with attenuation of arterial stiffening. A more recent study by Khoja et al., (2015) showed that very light and light intensity PA were inversely associated with cardiovascular markers, disability and diseases. Also this study indicated that associations between PA and cardiovascular risk markers were equal or stronger at very light and light intensities of activity rather than at moderate intensity physical activity (Khoja et al, 2015).

The development of new technologies has enabled people to reduce physically demanding work throughout their daily routine, resulting in higher levels of physical inactivity and ultimately more sedentary behaviours. With the availability of new devices many working environments have become highly sedentary and in order to comply with the physical activity guidelines, individuals have to purposely seek opportunities for MVPA elsewhere. In light of this scenario, shifting sedentary behaviours to light physical activity whilst at work seems more natural than shifting to MVPA (e.g. breaking sedentary time at work to walk for a tea break). Evidence shows that sedentary behaviour is inversely associated with time spent in light physical activity, such as light ambulation, in contrast evidence suggest no associations between MVPA and sedentary behaviour (Healy et al., 2008; Mansoubi et al., 2014). Similar results were observed by Clemes and colleagues (2014), who indicated that light intensity activities offset sedentary behaviours, when analysing the daily routine of office workers hour by hour. In this respect, Stamatakis et al (2015) highlighted that replacing one hour of sitting time with walking and one hour of screen time with walking, was associated with 17% and 15% lower risk of all-cause mortality, respectively. Several studies have also shown improved postprandial blood glucose and energy expenditure when replacing sitting with light-intensity walking (Dunstan et al., 2012). Evidence therefore is starting to suggest the public health impacts which could be gained from regularly breaking up sitting with light movement.

2.2 SECTION TWO: CARDIOVASCULAR DISEASES (CVD)

Cardiovascular disease (CVD) has been considered the number one killer worldwide, representing 31% (17.5million) of all deaths in 2012 (WHO, 2015) and CVD is expected to remain the leading cause of death until 2030 (Mathers and Loncar, 2006). Thus, CVD represents the main cause of death and a major cause of disability in Europe, yet the European Heart Network suggest that 80% of cases could be prevented (2011). Overall, in the UK CVD was the second main cause of mortality accounting for 28% of all deaths in 2012 (29% of all deaths were cancer-related) (BHF, 2014). However, when broken down by gender, CVD remains the main cause of mortality for British women (28%), but not for men (cancer represents 32% of all deaths versus 29% due to CVD) (BHF, 2014). Therefore, in 2012 CVD was responsible for 161,252 deaths, of which nearly 42,000 were premature (aged <75 years); costing the NHS over £6.8bn (averaging £127.5 per head) in England alone (BHF, 2014). In addition there is good evidence that the prevalence of CVD associated comorbidities and mortality are heavily related to socioeconomic status and occupational background (Kivimäki et al., 2008; CDC, 2010; Tracey et al., 2015); however, interventions aiming at improving cardiovascular health in at risk occupational groups are limited (Groeneveld et al., 2011; Ohta et al., 2015; Janczura et al., 2015; Kouwenhoven-Pasmooije et al., 2015), particularly amongst compulsory sedentary workers (Ng et al., 2015).

2.2.1 Atherosclerosis (Atherogenesis)

Atherosclerosis refers to the development of atheromas in the arterial wall of humans and other mammals. Atheromas consist of plaque material that develop just beneath the intima (the endothelial lining) of arteries. These fibrofatty plaques have a lipid core of cholesterol and cholesterol derivatives covered by a fibrous cap of smooth muscle (Robbins and Cotran, 1979). Atherosclerosis has been defined as the underlying pathology of CVD, as it is characterized by endothelial dysfunction, vascular inflammation, and the build-up of lipids, cholesterol, calcium and cellular debris within the walls of large and medium size arteries, blocking the blood flow in these (Hadi et al., 2013). Indeed, Steinberg (2005) postulated that atherosclerosis evolves as follows: 1) Hypercholesterolaemia (in particular, high LDL), which induces adhesion of leukocytes to the arterial endothelium, 2) circulating monocytes and lymphocytes penetrate into the subendothelial space, 3) oxidised LDL accumulates beneath the endolthelium, 4) macrophages are attracted to the developing lesion and become engorged with oxidised LDL to form “foam cells”, 5) the sustained presence of oxidised LDL and macrophages, which proliferate in the intima, stimulate a vicious cycle of recursive inflammation, 6) focal areas of cell necrosis ensue, and 7) smooth muscle cells grow over the lesion producing a fibrous plaque. The site of the lesion can also become calcified, reducing the artery’s elasticity. Atherosclerosis therefore develops over many years and is influenced by lifestyle choices, by the time it is detected it is usually in an advanced stage, normally in middle age (WHO, 2007). Atherosclerosis has been defined as the major cause of death worldwide, as it instigates the development of ischaemic heart disease (IHD) (Mueller et al., 2014). Lifestyle behaviours such as physical inactivity, sedentary behaviours, unhealthy diet and smoking are strongly related to adverse cardio-metabolic and inflammatory biomarkers, resulting in atherosclerosis. Despite the reduction of CVD mortality over the last few years due to combined efforts in terms of medical advances and increased awareness of the importance of cardiovascular health (BHF, 2014), the prevalence of CVD and premature mortality within Westernised society remains high (European Society of Cardiology, 2012). However, interventions aiming to improve the cardiovascular risk profile of at-risk occupational groups by lifestyle changes are scarce.

2.2.2 Types of CVD

Cardiovascular diseases are defined by the WHO (2016) as a group of disorders of the heart and blood. The British Heart Foundation (2014) highlights that the main forms of CVD are:

2.2.2.1 Coronary heart disease (CHD)

Coronary heart disease (also referred to as ischaemic heart disease, IHD): Ischaemia means lack of oxygen, thus coronary heart disease is the collective term for all diseases affecting the blood vessels supplying the heart muscle. This occurs when the flow of oxygen-rich blood to the heart is blocked or reduced by a build-up of fatty material (atheroma) in the coronary arteries. Therefore the blood supply to the heart is restricted, which can cause angina (chest pain) or heart attack (or myocardial infarction). Myocardial infarction is caused by acute obstruction of a coronary artery, usually one in which blood flow is already compromised by the presence of significant atherosclerosis. CHD alone is the biggest cause of mortality in the UK accounting for

46% of all cardiovascular deaths, distributed differently between males and females, 16% (42,819) and 10% (30,861) of deaths respectively (BHF, 2014).

2.2.2.2 Cerebrovascular disease or stroke

These are the collective terms for all diseases affecting the blood vessels supplying the brain, in which the blood supply to the brain is acutely disrupted due to either blockage (ischaemic stroke) or rupture of a blood vessel (haemorrhagic stroke). Straight away the brain cells begin to die, which can cause brain damage and possibly death. As with ischaemic heart disease, strokes are usually caused by atherosclerotic plaque either developing in place or dislodged from a larger (upstream) artery. Stroke is the second major form of CVD accounting for 26% of all cardiovascular deaths in the UK, with higher prevalence in males than females when <75 years of aged. At this point the situation reverses and the prevalence of stroke becomes higher in females than males. Overall the prevalence of stroke is distributed as follows: females: 9% (25,202) versus males: 6% (16,196) (BHF, 2014).

Other forms of CVD include peripheral arterial disease (PAD), atrial fibrillation, rheumatic heart disease (RHD), congenital heart disease, congestive heart failure, pulmonary embolism and deep vein thrombosis (DVT) and hypertensive heart disease, which account for 16% of all CVD deaths in the UK (BHF,2014).

2.2.3 Risk factors for CVD

The World Health Organization -WHO- (2015) and the National Institute of Health -NIH- (2014) have clustered CVD risk factors into two categories: modifiable and non-modifiable. Non-modifiable risk factors include family history of heart disease, ethnic background (African-Americans, American Indians, and Mexican-Americans are more likely to have heart disease than Caucasians), sex (men are more likely to develop CVD at an earlier age than women), older age (after age 55, the risk of CHD increases for both males and females), post-menopause (estrogen acts as a protective hormone against CHD in females before menopause) and how well stress is managed. Modifiable risk factors can be further clustered into behavioural risk factors including smoking, unhealthy diet, physical inactivity and harmful use of alcohol (WHO, 2015) and biomedical risk factors. These are described below.

2.2.3.1 Behavioural risk factors

a) Smoking

Epidemiological studies representing over 30 million people around the world highlight the strong link between smoking and coronary heart disease. Despite the socioeconomic, genetic and environmental differences in the population tested, the findings consistently demonstrate two to four fold increases in mortality from coronary heart disease in chronic smokers compared to non-smokers (Reports of Surgeon General, 1983, 1988, 2004). Indeed, the Framingham study, which involved 2282 middle-aged men, showed that after 10 years of follow-up, the relative risk of CHD mortality was twofold higher among men who smoked up to 20 cigarettes a day and threefold higher amongst those smoking over 20 cigarettes per day (Kannel, 1964). This was further supported by a meta-analysis of 20 prospective studies of patients with a diagnosis of CHD, which showed a 36% reduction in the relative risk of mortality amongst those who quit smoking compared to those who continued smoking (Critchley and Capewell, 2004)

b) Unhealthy diet

Sub-optimal diet has been defined as the leading risk factor for death and disability in the United States and worldwide (Lim et al., 2012; US Burden of Disease Collaborators, 2013). A meta-analysis conducted by Mente et al. (2009) identified strong evidence of causal relationships between protective factors such as intake of vegetables, nuts and monounsaturated fatty acids (i.e. the intake of a Mediterranean diet) and harmful factors involving intake of trans-fatty acids and foods with a high glycaemic index and cardiovascular diseases. Further evidence was summed up by Mozaffarian (2016) in a comprehensive review which highlighted strong evidence that cardio-metabolic diseases such as CHD, stroke, type 2 diabetes mellitus and obesity are diet-related (Mozaffarian, 2016). Mozaffarian (2016) highlighted in his comprehensive review of the literature that the most well-studied dietary patterns are traditional Mediterranean and DASH diets, of which a modified DASH diet higher in vegetable fats an lower in carbohydrates (more similar to Mediterranean diet) seem to have the larger cardio-metabolic benefits. Both of these two diets seem to improve blood pressure, glucose-insulin homeostasis, blood lipids and lipoproteins, inflammation, endothelial function, arrhythmic risk, and possibly coagulation/thrombosis, paraoxonase 1 activity, and the gut microbiome (Mozaffarian, 2014; Lou-Bonafonte et al., 2015; PHE, 2016). These benefits are therefore associated with an improved range of risk factors, reduce long-term weight gain and lower risk of cardiovascular events and diabetes mellitus (Estruch et al., 2013; Salas-Salvadó et al., 2014). For long-term weight gain, food rich in refined grains, starches, and sugar appear to be major culprits (Mozaffarian et al., 2011; Smith et al., 2015). Excessive salt, saturated fats and trans-fatty acids have also been associated with poor health, particularly with CHD (WHO, 2016). Low fruit and vegetable consumption have been related with increased risk for cardiovascular diseases, stomach cancer and colorectal cancer. Indeed, approximately 16.0 million (1.0%) disability adjusted life years (DALYs, a measure of the potential life lost due to premature mortality and the years of productive life lost due to disability) and 1.7 million (2.8%) of deaths worldwide are attributable to low fruit and vegetable intake (WHO, 2016).

c) Physical inactivity

Physical inactivity, defined as an activity level insufficient to meet public health guidelines (Department of Health, 2015), has been identified as the fourth leading risk factor for global mortality (6% of deaths globally), accounting for deaths related to CHD, type 2 diabetes and breast and colon cancers (Lee et al., 2012; WHO, 2015). The WHO (2015) indicates that physical inactivity is estimated to be the main cause for approximately 30% of ischaemic heart disease burden. In addition, estimates indicate that this unhealthy behaviour was related to 9% (5.3 million) of premature mortality worldwide in 2008 (WHO, 2011).

d) Harmful use of alcohol

Despite the inverse correlation between moderate alcohol consumption and CHD mortality (Albert et al., 1999; Belleville, 2002; Klatsky, 2002; Rimm et al., 1999), excessive amounts of alcohol can be harmful for health. Strong evidence has shown a dose-response relationship between volume of alcohol consumed and disease risk, which is defined by a J-shaped curve (Corrao et al., 2000). This shows that low-to-moderate levels of consumption of alcohol (fewer than 2 drinks per day) are associated with lower CHD incidence and mortality; yet for higher average volumes of alcohol consumption, the risk relation reverses (Rehm et al., 1997; Corrao et al., 2000; Bau et al., 2007). Thus, heavy drinking is associated with increased clotting, lowered threshold for ventricular fibrillation, and elevation of low density lipoproteins (Mckee & Britton, 1998; Rehm et al., 2003), increasing the risk of CHD, sudden cardiac death and other cardiovascular events (Wannamethee & Shaper 1992; Kauhanen et al., 1997).

2.2.3.2 Biomedical risk factors

a) High blood pressure

High blood pressure is defined as constant systolic and diastolic blood pressure (BP) above 140/90mmHg (BHF, 2015). Higher systolic BP levels may reflect the progressive stiffening of the arterial wall, changes in the vascular structure and the development of atherosclerosis (Carethers and Blanchette, 1989). This may cause an enlargement of the heart, which can lead to heart failure. Men and women with hypertension will have an increased risk of heart failure by 2-fold and 3-fold, respectively (Levy et al., 1996). However, data from observational studies have highlighted that the risk of cerebrovascular diseases and IHD increases progressively from suboptimal levels of systolic BP (SBP >115mmHg and diastolic BP (DBP) >75mmHg) (Lewington et al., 2002) (Figure 2.2, 2.3). In fact, the WHO (2002) indicates that a SBP >115mmHg is responsible for 62% of cerebrovascular disease and 49% IHD worldwide, with little variation by sex (WHO, 2002). Thus, suboptimal BP was defined as the major attributable risk factor for CVD death (WHO, 2002). In addition, higher risk has been identified in those aged between 40 and 89 years, as for every 20 mmHg systolic or 10 mmHg diastolic increase in BP there is a doubling of mortality from both stroke and IHD (Figure 2.2; 2.3) (Lewington et al., 2002). Based upon this evidence blood pressure has been classified as represented in Table 2.2.

Table 2.2. Classification of Blood Pressure

Category	**SBP mmHg**		**DBP mmHg**
Normal	<120	And	<80
Prehypertension	120-139	Or	80-89
Hypertension, Stage 1	140-159	Or	90-99
Hypertension Stage 2	≥160	Or	≥100

National Heart, Lung, and Blood Institute, 2004

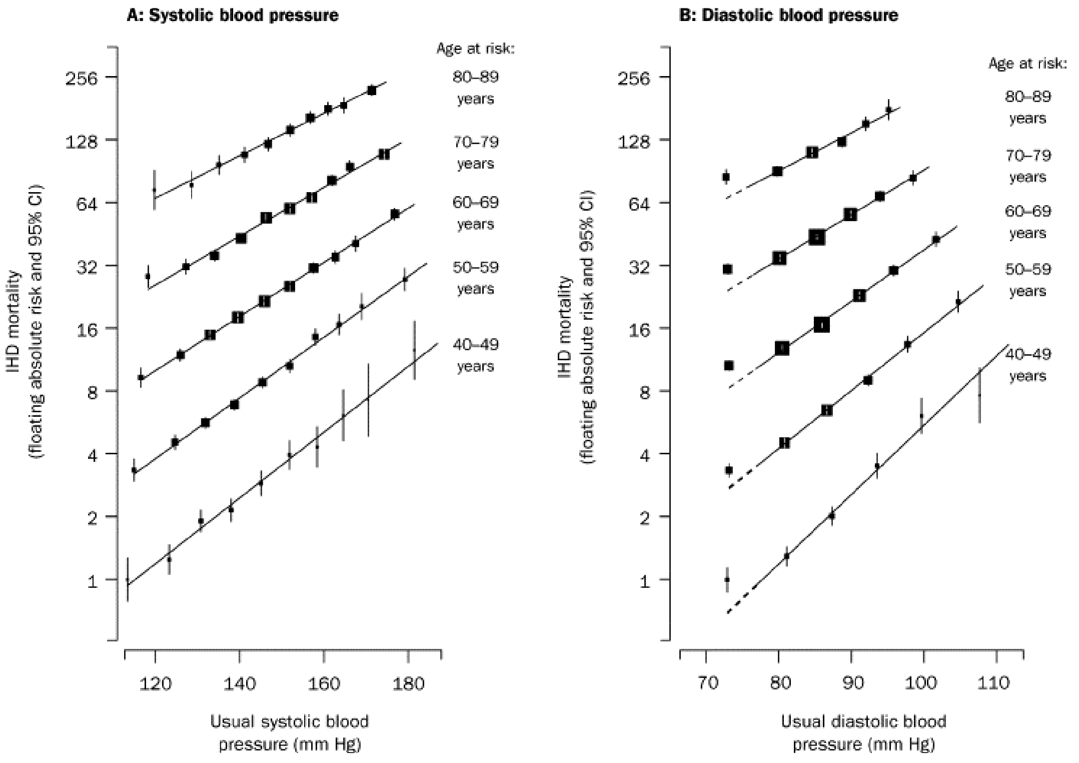

Figure 2.2. Ischaemic heart disease (IHD) mortality rate in each decade of age versus usual blood pressure at the start of that decade- (Lewington et al., 2002)

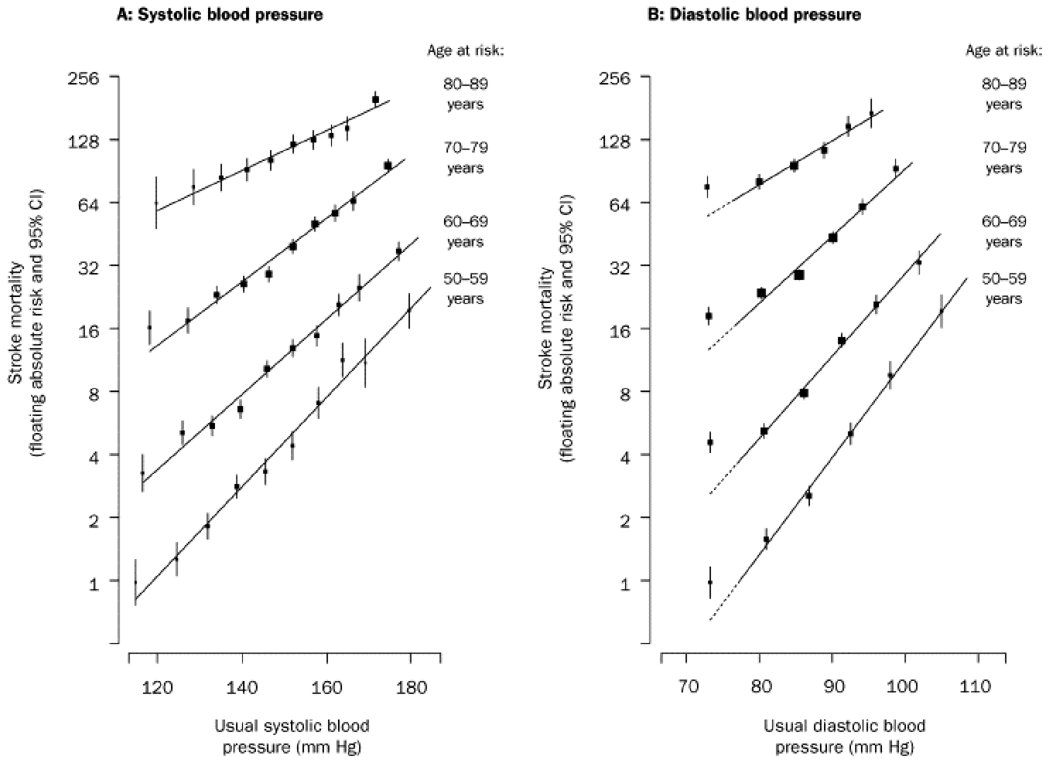

Figure 2.3. Stroke mortality rate in each decade of age versus usual blood pressure at the start of that decade - (Lewington et al., 2002)

b) High resting heart rate

Resting heart rate (RHR) is considered one of the simplest cardiovascular parameters, which usually varies between 60 to 80 beats per minute (bpm), but can sometimes exceed 100bpm in unfit and sedentary individuals (Cook et al., 2006). Elevated RHR could be a reflection of increased sympathetic nervous system activity, and decreased parasympathetic tone, resulting in a negative force-frequency response of failing myocardium and worsening myocardial ischaemia (Mulieri et al., 1992; Wallhaus et al., 2001; Custodis et al., 2008). Furthermore, increased RHR has been associated with increased systemic inflammation and endothelial dysfunction (Nanchen et al., 2013). Large epidemiologic studies have confirmed that resting heart rate is a predictor of cardiovascular and all-cause mortality independent of currently accepted risk factors in men and women, with and without diagnosed CVD in Western societies (Fox et al., 2007). In fact a linear relationship was shown by the Framingham Study, in a cohort of 5070 individuals, who were free from CVD at baseline. In this study CV and coronary mortality increased progressively with increases in RHR (Kannel et al., 1987). An increase in RHR of 10 beats per minute (bpm) is associated with an increase in the risk of cardiac death by at least 20%, which is equivalent to the effects of an increase of 10mmHg in systolic blood pressure (Benetos et al., 1999). Elevated RHR is often concomitant with arterial hypertension (Benetos et al. 1999; Morcet et al., 1999; Gillum et al., 1991); yet it remains an independent risk factor for cardiovascular morbidity after adjusting for blood pressure levels (Gillman et al., 1993). Several studies have also shown that high RHR is associated with metabolic disturbances such as increased glycaemia, triglycerides, BMI and total cholesterol (Perret-Guillaume et al., 2009). Therefore it seems that rapid RHR is not an indicator of pre-existing illness, but an independent risk factor for CVD mortality (Martin et al., 2004). However, there is a lack of studies exploring the beneficial effects of lowering resting heart rate in at-risk occupational groups, particularly in people with hypertension, dyslipidaemia or diabetes. Further research is therefore needed.

c) High blood cholesterol

This is often called "the silent killer". Cholesterol is a fatty substance carried by proteins through the body. High cholesterol can cause atherosclerosis, limiting blood flow through the arteries and increasing the risk of chest pain, heart attack and stroke (BHF, 2015; Heart UK, 2015). To establish risk status for CVD, it is necessary to explore the standard lipid profile including:

I. Low-density lipoprotein (LDL-C) or “bad” cholesterol: Raised LDL-plasma concentration is a major risk factor for atherosclerotic CVD (Upadhyay, 2015). Recommended levels should be 3 mmol/L or less and ≤2mmol/L if at risk of heart and circulatory disease (World Heart Federation, 2016).

II. High-density lipoprotein (HDL-C) or “good” cholesterol: HDL cholesterol has an inverse relationship with the risks of atherosclerosis and CVD (Feitosa et al., 2014). HDL-C appears to progressively protect against atherosclerosis as a result of elevated LDL-C levels (Kontush and Chapman, 2006). In fact, it has been shown that each 0.03mmol/L increment in HDL-C is associated with a 2-3% decrement in risk (Gordon et al., 1989). Recommended levels should be over 1mmol/L in men and over 1.2mmol/L in women (World Heart Federation, 2016).

III. Triglyceride-rich lipoproteins (TG): Raised triglyceride concentrations are strongly associated with low concentrations of HDL (Varbo et al., 2013). Triglyceride concentrations greater than 1mmol/L increase the risk of CVD by 32% in men and 76% in women; independent of HDL-C levels (Hokanson and Austin, 1996). Recommended levels should be less than 1.7mmol/L (World Heart Federation, 2016).

IV. Total Cholesterol (TC): this is the total amount of cholesterol in the blood. Recommended levels should be 5 mmol/L or less or ≤4 mmol/L if at risk of heart and circulatory disease (World Heart Federation, 2016).

V. Non HDL-Cholesterol: this is the total cholesterol minus HDL-cholesterol and is the sum all the low-density cholesterols added together (including LDL cholesterol) – Recommended levels should be 4mmol/L or less.

VI. TG/HDL-C Ratio: This is the most powerful independent predictor of CHD development (Da luz et al., 2005). This atherogenic index is related to the severity of vessel compromise. Thus this ratio is a valid method of predicting the presence and extent of coronary atherosclerosis (Da Luz et al., 2008). Ideal scores for this ratio should be less than 0.87mmol/L (Diabetes.co.uk, 2016).

e) Overweight or obesity

Obesity is a disease characterized by both fat deposition of new fat cells and an increase in the size of existing cells that endangers health (Formiguera & Cantón, 2004). Obesity induces several cytokines and inflammatory markers that contribute to a sub-optimal cardio-metabolic profile and an increase in associated diseases (Vinciguerra et al., 2013), co-morbidities and musculoskeletal disorders including T2DM, CVD, hypertension, dyslipidaemia, arthritis, obstructive sleep apnoea and non-alcoholic fatty liver disease (Guh et al., 2009). Obesity is also a major component of the metabolic syndrome, a cluster of metabolic and clinical conditions associated with elevated CVD risk and diabetes (Kelly et al., 2008; Oda, 2012).

Despite obesity's negative impact on health, modern changes to occupational settings, economic and industrial innovation favour increasing rates of obesity worldwide (Kelly et al., 2008). Indeed, obesity and its associated comorbidities have become a normalised health condition amongst certain occupational groups such as "compulsory sedentary workers"; yet very little action to reduce the prevalence of obesity amongst drivers from the transport sector has been taken.

Excess body weight has traditionally been assessed using BMI, which is defined as weight in kilograms divided by the square of the height in meters (kg/m^2) (WHO, 2006). Thus, individuals with a BMI of between 25 to 29.9 kg/m^2 would be considered overweight and those with a BMI of ≥30kg/m^2 obese (Table 2.3). Although, BMI classifications are slightly different for Asian populations as listed in Table 2.4 (WHO, 2004). BMI does not distinguished between muscle mass, adipose tissue or bone, yet research highlights that for each unit of BMI increment there is an 8% increased risk of CHD (li et al., 2006; Prospective Studies Collaboration, 2009). Higher BMIs are also related to reductions in life expectancy, with 3 years lower life expectancy if moderately obese (BMI 30–35 kg/m^2) or 10 years if extremely obese (BMI 40–50 kg/m^2), respectively (Prospective Studies Collaboration, 2009). Overall, increased risk of CHD, hypertension and dyslipidaemia has been shown to have a direct relationship with BMI (Rim et al., 1995).

On the basis that not only body fatness is important, but how fat is distributed, the National Obesity Forum (2015) and the WHO (2011) also recommend the assessment of waist circumference (WC). Waist circumference is a proxy measure of central adiposity and has been shown to be a superior measure of CVD risk compared to BMI (Yusuf et al., 2005). Yusuf and colleagues (2005) demonstrated that the relationship between BMI and CVD risk is attenuated when adjusting for WC, but it was unaffected when the opposite was applied. The cut off levels for WC presented in Table 2.3 are currently used by the National Cholesterol Education Program for the diagnosis of the metabolic syndrome; whilst the European Group for the Study of Insulin Resistance use lower thresholds ≥80 and ≥94 cm, in women and men respectively, yet both cut-points have shown similar associations with risk (Ford, 2005).

Overall, abnormal central adipose tissue is related to a range of metabolic abnormalities such as glucose intolerance, reduced insulin sensitivity, adverse lipid profiles and hypertension, acting therefore as an independent risk factor for CVD (particularly myocardial infarction), type 2 diabetes and death (Després et al., 2001; Bigaard et al., 2005; Huxley et al., 2010). De Koning et al. highlighted in their meta-analysis that a 1 cm increase in WC and 0.01 cm increase in waist-to-hip ratio (WHR) was associated with a 2% and 5% increased risk of a CV event, respectively, with similar impact in males and females (De Koning et al., 2007); yet it has been suggested that this might vary between ethnic groups (Vazquez et al., 2004; Yusuf et al., 2005).

Table 2.3: Body mass index (BMI) and waist circumference used to classify risk of disease for hypertension, CVD and type 2 diabetes

Classification	**BMI (kg·m^2)**	**Men, ≤102 cm Women, ≤88 cm**	**Men, >102 cm Women, >88 cm**
Underweight	< 18.50	-	-
Normal range	18.50 – 24.99	-	-
Overweight	≥ 25.00	Increased	High
Pre-obese/at risk	25.00 – 29.99		
Obese	≥ 30.00		
Obese class I	30.00 – 34.99	High	Very High
Obese class II	35.00 – 39.99	Very High	Very High
Obese class III	≥ 40.00	Extremely High	Extremely High

KEY: kg·m^2: kilogram per metre squared. (NHLBI Obesity Education Initiative, 2000)

Table 2.4: The WHO’s BMI classifications for Asian adults. (WHO, 2008)

Classification	**BMI (kg·m^2)**
	Principal cut-off points
Underweight	< 18.50
Normal range	18.50 – 22.99
Overweight	≥ 23.00
Pre-obese/at risk	23.00 – 24.99
Obese class I	25.00 – 29.99
Obese class II	≥ 30.00

KEY: kg·m^2: kilogram per metre squared.

f) Diabetes Mellitus (DM)

Diabetes Mellitus is defined as a metabolic condition in which the pancreas does not produce sufficient insulin to regulate blood glucose levels or where the insulin produced is unable to work effectively (WHO,1999). As a consequence blood glucose becomes so elevated that the glucose “spills over” into the urine. Despite these high blood glucose levels, cells “starve” since insulin-stimulated glucose entry into cells is impaired. Hence, raised blood glucose is the common effect of uncontrolled diabetes and if left untreated might have serious effects on the heart, blood vessels, eyes, kidneys and nerves. In the UK it is estimated that 3.9 million people have DM, out of which 3.3million are diagnosed (Diabetes UK, 2014). There are two main types of DM defined below:

I. Type 1 diabetes mellitus (T1DM) is an autoimmune condition in which the pancreas beta cells that produce insulin are destroyed, preventing the body from being able to produce enough insulin to adequately regulate blood glucose. T1DM is the major form of diabetes in children and young adults and accounts for 10% of those with diagnosed diabetes (PHE, 2014; Diabetes UK, 2016). People with T1DM require lifelong treatment of insulin to prevent death; strict balanced diet and physical activity regimes are also required. See Table 2.5 for blood sugar level classifications.

II. Type 2 diabetes mellitus (T2DM) is characterised by a combination of insulin resistance (IR) and beta cell failure to produce enough insulin. As a result, blood glucose is much higher than normal, particularly after a meal. The hyperglycaemia that accompanies IR induces the pancreatic beta cells to increase their production of insulin. Yet the high basal level of insulin secretion diminishes the ability of the beta cells to respond to further increases in blood glucose. Consequently hyperglycaemia and its attendant complications tend to worsen overtime. Therefore, the condition is progressive and it is highly related to westernized lifestyles, high-fat diets, physical inactivity, sedentary lifestyles and smoking, which lead to increasing levels of overweight or obesity, compensatory hyperinsulinaemia and, ultimately, T2DM (Ryén et al., 2013). Moreover, non-modifiable factors such as family history of DM, older age and ethnicity also increase the risk of diabetes. Thus, T2DM is up to 3 to 6 times more prevalent in people of African or Africa-Caribbean and South Asian origin, respectively (Stratton et al., 2000). Whilst T2DM was traditionally a disease of mid-older age, its age of onset is falling and some cases have been reported in obese children (Dabelea et al., 2014) T2DM is more common than T1DM and it is estimated that 1 in 16 people in the UK have T2DM (diagnosed or undiagnosed) (Diabetes UK, 2016); comprising over 90% of adults with DM (WHO, 1999).

Table 2.5. Blood sugar levels used in diagnosing diabetes. Ranges for capillary blood test in mmol/L.

	Normal	**Prediabetes (Impaired fasting glucose)**	**Diabetes**
Random	<11.1mmol/L	N/A	≥11.1mmol/L
Fasting	<6.1mmol/L	6.1 to 6.9mmol/L	≥7.0mmol/L
2 hour post-prandrial	<7.8mmol/L	7.8 to 11.0mmol/L	≥11.1mmol/L

Diabetes UK, 2016.

The risk of CVD increases continuously with rising fasting plasma glucose levels, even before being considered as diabetic (Danaei et al., 2006). Chronic hyperglycaemia, dyslipidaemia, and insulin resistance cause arterial dysfunction of multiple cell types, including the endothelium, smooth muscle cells, and platelets, which ultimately increase the risk of CVD through atherosclerosis (Beckman et al., 2002). A meta-analysis published in 2010 (Sarwar et al., 2010) revealed that DM increases the risk of CHD, stroke and death attributed to other cardiovascular causes between 2 to 5 fold, depending on sex and ethnicity (Kannel et al., 1979; Peter et al., 2014). Indeed, it has been suggested that females with DM have a 40% greater risk of incident CHD compared to males with DM (Peters et al., 2014). However, a more recent review specified that DM is more strongly related to peripheral arterial disease and heart failure (Dinesh Shah et al., 2015), and in particular to fatal myocardial infarction (MI) compared to non-fatal MI (Sarwar et al., 2010). In fact, it has been suggested that 10% of all CVD deaths in the last decade could be DM-related (Sarwar et al., 2010).

g) Metabolic Syndrome (MetS)

Metabolic syndrome is understood as a constellation of interrelated metabolic risk factors for CVD and diabetes (Oda et al., 2012). The MetS is characterised by a clustering of numerous atherosclerotic and cardiovascular risk factors. Originally it was thought that the major driving force for the MetS was insulin resistance (Reaven, 1988), yet more recent studies seem to agree that central obesity is the key determinant of the MetS (Lemieux et al., 2007). Therefore, the MetS has been defined as central adiposity (waist circumference; males ≥102cm; females ≥88cm – these are country and population specific) plus two of the following risks factors: high fasting blood glucose (FBG) (≥5.6 mmo/L), high blood pressure (BP≥130/85mmHg), elevated triglyceride levels (TG≥1.7 mmol/L) and low, high-density lipoprotein cholesterol levels (HDL-C males<1.0; females <1.3 mmol/L) (Alberti et al., 2009). It is interesting to point out that in this classification the individual thresholds are lower than those required for medical treatment. This is due to the higher likelihood of cardiovascular events happening in individuals with slightly unhealthy levels of multiple risk factors rather than in those with an individual very unhealthy risk level (Dahlöf, 2010). Taking this into account, the MetS has been referred as to a systemic pre-disease state beyond T2DM and CVD, in which inflammatory processes such as atherosclerosis and high CRP concentrations become the underlying mechanisms for the development of CVD and diabetes (Ridker et al., 2004; Oda, 2008; Oda and Kawai, 2010). Thus, individuals with MetS have twice the risk of developing CVD over the next 5 to 10 years, compared to those without the MetS (Gami et al., 2007). Furthermore, individuals with the MetS are at increased risk of diabetes (Ford, 2005), chronic kidney disease (Kurella et al., 2005; Luk et al., 2008), CHD and all-cause mortality (Malik et al., 2004).

2.3 SECTION THREE: PROFESSIONAL DRIVERS HEALTH

2.3.1 Professional drivers' sedentary behaviours and physical activity.

It has been reported that lorry drivers can work up to 84 hours a week (14h/day) (Apostolopoulos et al. 2012), of which up to 56 hours could be spent driving (Vehicle & Operator Services Agency, 2011). Within the European Union (GOV.UK, 2015), drivers are allowed to spend up to 9 hours a day driving, which can be extended to 10 hours twice a week. However, when taking into account the loading and unloading time in the warehouses, the time spent in traffic jams and the compulsory breaks, lorry drivers' shifts have been reported to last for up to 14 to 15 hours per day (Apostolopoulos et al. 2012; Caddick et al., 2016). The EU regulations (GOV.UK, 2015) establish that lorry drivers must have at least a 45 minute break (exclusively for recuperation) per working day that can be distributed as follows:

a) After driving for a period of no longer than 4.5 hours, drivers must take an uninterrupted break of 45 minute, unless he/she takes a rest period (doing other work but driving).

Driving 4.5 hours	Break 45 minutes

Driving 2.5 hours	Other work 1 hour	Driving 2.5 hours	Break 45 minutes

b) Alternatively, a full 45-minute break can be replaced by one break of at least 15 minutes followed by another break of at least 30 minutes. These breaks must be distributed over the 4.5-hour period. The EU rules will only allow a splitbreak pattern that shows the second period of the break being at least 30 minutes, such as in the following examples:

Driving 2 hours	Break 15 minutes	Driving 2.5 hours	Break 30 minutes

Driving 2.5 hours	Break 34 minutes	Driving 2.5 hours	Break 30 minutes

*The breaks distribution will follow this pattern in the second lot of 4.5 hours up to 9 hours a day or 10 hours twice a week.

It is interesting to highlight that this break pattern conflicts with the UK Highway Code recommendations, which suggest drivers should take a 15-minute break every two hours (Department for Transport, 2016).

Based on these working patterns, professional drivers can best be described as “compulsory sedentary workers”, as they don’t have any other choice but to sit during their working day. In the 1950’s Morris et al. observed that bus drivers’ were highly inactive compared to bus conductors (Morris et al., 1953). This was the first study that explored the harmful effects of bus driver’s sedentary lifestyle on health, who sat for 90% of their shift, compared to their more active peers. Therefore they highlighted that drivers of London’s double-decker buses had double the incidence of sudden death from coronary thrombosis than the bus conductors, who climbed around 600 stairs per working day (Morris et al. 1953). However, since this early research, bus drivers have received very limited attention in sedentary behaviour research (Morris and Crawford, 1958; French et al., 2007; Wong et al., 2014) and no studies have examined lorry drivers’ sedentary time.

Whilst no studies have specifically examined lorry drivers' sedentary time, some studies have assessed lorry drivers' PA levels (Ng et al., 2015; Robinson & Burnett, 2005; Krueger, 2007; Passey et al., 2014). Lorry drivers work within intertwined mechanisms of government regulations, corporate policies, the transport-sector operations and a built environment that significantly impacts their lifestyle, particularly food purchasing choices, sleeping time and PA levels (Apostolopoulos et al., 2010). Within this work environment, it has been reported that only 8% of the driver population exercise regularly (Robinson & Burnett, 2005; Krueger, 2007) accumulating an average of 283±365 minutes of total PA per week (Passey et al., 2014). However, this information has been gathered using non-validated self-report questionnaires, which are subject to recall bias and overestimation of PA levels, besides there has been no reference to intensity of PA. Despite bus and lorry drivers' unhealthy lifestyle, limited knowledge is available about their patterns of sedentary behaviours and PA. In addition, despite of the strong evidence of the association between sedentary behaviours and health, no research has explored this in lorry drivers. Therefore, there is an urgent need for scientific research amongst this occupational group to further understand their health profile. There is a need for research to explore bus and lorry drivers' sedentary time using objective monitors that directly measure posture, to overcome the limitations of self-report instruments and to provide accurate results.

2.3.2. Lorry drivers cardiovascular health in relation to their job demands

Lorry drivers are exposed to a multitude of risk factors associated with their occupation, including long and variable working hours, prolonged periods of sedentary behaviour and tight schedules which contribute to psychological stress and sleep deprivation (Caddick et al., 2016); yet lorry driving is one of the most common occupations worldwide (Apostolopoulos et al., 2010). Estimates from the Labour Force Survey showed that in 2014 there were 285,000 Heavy Goods Vehicle (HGV) drivers in the UK alone. However, research on cardiovascular health amongst this occupational group is limited. Their working environment provides limited opportunities for a healthy lifestyle and unhealthy lifestyle behaviours such as poor diet, lack of physical activity, smoking, high volumes of alcohol consumption, and irregular sleeping patterns are highly prevalent among this occupational group (Bigert et al., 2003; Apostolopoulos et al., 2012;Passey et al., 2014). This contributes to an increased risk of overweight and obesity, metabolic syndrome, diabetes, hypertension, heart disease, cancer, fatigue, stress, sleep disturbance, sleep deprivation and musculoskeletal disorders (Whitelegg, 1995; Bigert et al., 2003; Robinson & Burnett, 2005; Poirier et al., 2006; Frank et al., 2007; Wong et al., 2012; Apostolopoulos et al., 2013).

Cohort studies in North American lorry drivers have highlighted the greater risk of co-morbidities and premature mortality in this occupational group compared to the general population (Aronson et al., 1999; Hannerz & Tuchsen, 2001; Robinson and Burnett, 2005). In fact, a large US cohort study (Laden et al., 2007) demonstrated the elevated standardised mortality ratios (SMR) for ischaemic heart disease (IHD) mortality (SMR=1.41; 95% CI 1.33 to 1.49) amongst workers from the transport sector compared to other occupational groups. Hart and colleagues (2011) found that the highest standardised mortality ratios (SMR=1.41; 95% CI 1.19 to 1.66) were amongst long haul lorry drivers compared to other workers from the transport sector. They also highlighted that increasing years of work in this sector were associated with increases in IHD mortality, yet these results were not statistically significant. Prolonged sitting associated with driving has been reported to increase the odds of obesity by 6% per hour of driving (Frank et al., 2007; Tse et al., 2006) and the chances of heart problems by 67% when working for 11 hours or more per day (Kivimaki et al., 2011). In addition, several studies have shown that lorry drivers are a sleep deprived group, averaging 3.8 to 5.2 hours of sleep daily (Balkin et al., 2000; Dinges et al., 2005). Shortage of sleep and altered circadian rhythms (prevalent in shift workers) are linked to greater weight gain and obesity, alter hunger and food preferences, and may influence leptin, ghrelin, insulin, and gut-peptide concentrations (Mozaffarian et al., 2011; Gonnissen et al., 2013).

Within this working environment it has been reported that about 85% of lorry drivers are overweight or obese and 44% are hypertensive (Robinson & Burnett, 2005; Krueger, 2007; Apostopoulos et al., 2012; Thiese et al., 2015). American lorry drivers' life expectancy had been reported to be 12 years lower than that of the general population (Saltzman & Belzer, 2007). No comparable data has been found for UK lorry drivers, yet national statistics indicate that transport workers have among the lowest life expectancy compared to other professional groups (Office for National Statistics, 2011). Given the chronic and prevalent poor health conditions and mortality rates seen in drivers, lorry driving has been identified as one of the most hazardous working professions (Apostolopoulos et al., 2013), yet research aiming to improve lorry drivers health behaviour is scarce.

It is also important to mention that lorry drivers' health is a road safety concern, affecting the general public (Ng et al., 2015). Of concern, obese lorry drivers are 55% more likely to have an accident than normal weight drivers (Rowe et al., 2011). Long distance drivers are also an ageing workforce; in UK lorry drivers the average age is 53 years (FTA, 2015). More than 300 fatal trailer-lorry accidents in Finland were investigated by Häkkänen and Summala (2001), who concluded that the probability of being responsible for an accident increased by a factor of 3.5 if the driver had a chronic illness. In fact, research has shown that obese lorry drivers fall asleep unintentionally more often and present higher rates of sleep apnoea than normal weight drivers (Thiese et al., 2015). Jovanoic et al. (1998) also reported that drivers with CVD had a 2-fold increased risk of having an accident and be at fault than their healthy peers. Similar results have been reported for diabetic HGV drivers compared to non-diabetic drivers (Laberge-Nadeau et al., 2000). A recent UK report prepared by an All Party Parliamentary Group for Freight Transport has highlighted the "demographic time bomb" the UK logistics industry is currently facing and the health impact of an ageing, at-risk, workforce "driving a vehicle often referred to as 'a 40-tonne missile'" (FTA, 2015). However, despite this evidence limited efforts from the transport sector and governmental bodies have been exhibited to improve lorry drivers' health.

2.3.3 Health interventions to improve lorry drivers health

Lorry drivers' working environments are not conducive to a healthy lifestyle. They are currently an underserved occupational group in terms of health promotion efforts, yet exhibit higher than nationally representative rates of obesity and related co-morbidities (Thiese et al., 2015). A recent systematic review examining health promotion interventions for lorry drivers, including only 8 studies, observed that the interventions generally led to favourable health and health behaviour outcomes over the short term (Ng et al., 2015). However, it was concluded that the strength of the evidence was limited due to poor study designs, encompassing no control groups, small sample sizes and no or limited post intervention follow-up (Ng et al., 2015). To date, one of the most successful pilot studies was conducted by Olson and colleagues (2009) in the US, who piloted a 6 month weight loss and health promotion program for lorry drivers that combined competition, computer-based training, behavioural self-monitoring and motivational interviewing. Overall, the 29 drivers that participated in this study lost on average 3.5kg of weight by reducing the consumption of high calorie foods and drinks. A larger scale study was conducted at Con-Way Freight in USA using wellness coaching and competition as a motivational tool. In this study, participants (N=1890 participants) lost on average 5.0kg of weight (Osland et al., 2011). However, this study was aimed at reducing accident rates, sick leave and workplace injuries and used economic incentives to encourage workers participation, limiting the sustainability of the project over time. In addition, no accurate assessments of PA and sedentary behaviours were performed (Osland et al., 2011).

Since the publication of the systematic review (Ng et al., 2015) further research has examined the impact of a weight loss intervention on US lorry drivers (Thiese et al., 2015a) and the impact of a smartphone application on PA and diet in Australian lorry drivers (Gilson et al., 2015). Thiese and colleagues (2015a) developed a 12 week intervention for long-haul truck drivers using weekly health coaching and driver specific materials focused on healthy eating tools, exercise equipment and tips for a healthy lifestyle. 12 drivers out of 13 completed this program, which required them to participate in 10 coaching sessions; drivers average weight loss was 5.1kg from baseline to the end of the study; one month after the program was finished the overall weight loss was 6.1kg. Overall feedback from the drivers indicated the benefits of health coaching and the exercise equipment.

Gilson et al. (2015) conducted a 20 week intervention involving 44 drivers (only 19 completed the study), in which drivers were provided with an activity tracker connected to a smartphone application to log their activity and dietary choices. The main aim of this study was to assess drivers' engagement with smartphone technology during the intervention period to monitor PA and dietary choices. During this time drivers were encouraged to identify and target opportunities for increasing their physical activity and improve their diet choices over the working day. On average drivers using the activity tracker logged their step counts 6 days a week throughout the intervention. The median number of dietary logs decreased significantly from the start to the end of the intervention starting from 17 a week to 0 a week on average. This suggested that additional support and motivation for dietary monitoring was required, whilst the steps logging was automatic drivers had to input their dietary choices manually. Overall, whilst positive findings were observed in both studies, these are limited by small sample sizes and no control groups. Furthermore, despite the use of a complementary activity tracker to measure daily PA in Gilson et al’s. program (2015), PA was assessed by self-report questionnaires in both studies; which might lead to recall bias and overestimation of PA levels. In addition, sedentary behaviours were not assessed.

The UK Logistics sector is currently experiencing a short-fall in HGV drivers, estimated to be of the order of 50-60,000, with barriers to recruitment including the lack of roadside facilities, medical concerns and long hours of work (PPGFT, 2015). Recommendations on how to address this shortfall and attract younger employees to the sector made by the All Party Parliamentary Group for Freight Transport include increasing awareness within the industry of the need to address driver health risks and the improvement of facilities particularly during breaks (FTA, 2015). Whilst some international studies have examined the impact of health behaviour interventions on markers of adiposity, PA and nutrition in lorry drivers (MacLeod, 1991; Ng et al., 2015; Wawrzyniak et al., 2016), poor study quality limits the available evidence to date. In addition, no interventions have been conducted in the UK, hence the need of pilot work to generate knowledge on lorry drivers’ sedentary behaviours, PA and cardiovascular health followed by the assessment of the feasibility and effectiveness of health interventions targeting UK lorry drivers.

2.4 OBJECTIVES OF THE THESIS

This literature review highlights the harmful effects on health of prolonged time sitting, lack of physical activity and several cardio-metabolic risk factors. It also highlights the lack of research and health promotion efforts amongst bus and lorry drivers. Due to their working environment and lifestyle, lorry drivers in particular present a wide range of chronic conditions and premature mortality (Ng et al., 2015). Given the well-being of bus and lorry drivers can directly affect the safety of the general public and other road users, this thesis aimed to profile bus and lorry drivers lifestyle behaviours, with a specific focus on sitting time, physical inactivity and markers of cardiovascular health. This thesis was designed within the MRC framework (Figure 2.4) for the development of complex interventions, and using a mixed-methods approach the thesis objectives were to:

1. Ascertain the feasibility of measuring bus drivers sitting time using an activPAL inclinometer to directly measure drivers' sitting and non-sedentary behaviours over the course of a week.
2. Quantify the prevalence of bus drivers sitting and non-sedentary behaviours during and outside working hours.
3. Profile bus drivers' basic markers of cardio-metabolic health.
4. Explore the validity of accelerometer-determined sedentary time in comparison to activPAL measured sitting in a free-living sample of bus drivers
5. Behaviourally phenotype UK lorry drivers sedentary and non-sedentary behaviours during workdays and non-workdays.
6. Examine markers of cardiovascular health and to profile drivers' mental health.

7. Explore associations between time spent sitting and in non-sedentary activities (standing, light and MVPA) and cardiovascular health in lorry drivers.
8. Assess the effectiveness of an intervention designed to increase physical activity and reduce sitting time, on workdays and non-workdays, in a sample of lorry drivers.
9. Examine any preliminary effects of the intervention on lorry drivers' markers of cardiovascular health.
10. Assess the implications of setting up a health intervention in a transport company
11. Evaluate lorry drivers responses to the health intervention
12. Determine potential changes to the pilot study for future larger scale interventions

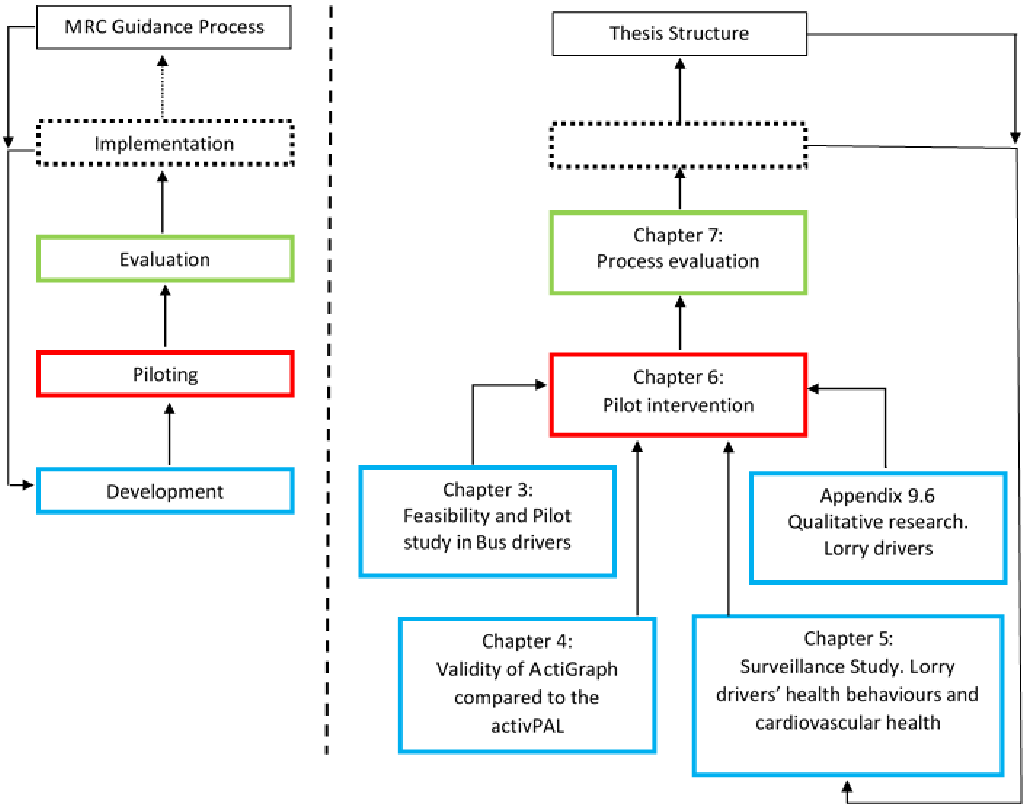
MRC Guidance Process
Implementation
Evaluation
Piloting
Development
Thesis Structure
Chapter 7:
Process evaluation
Chapter 6:
Pilot intervention
Chapter 3:
Feasibility and Pilot study in Bus drivers
Appendix 9.6
Qualitative research.
Lorry drivers
Chapter 4:
Validity of ActiGraph compared to the activPAL
Chapter 5:
Surveillance Study. Lorry drivers' health behaviours and cardiovascular health

Figure 2.4. Schematic representation of the thesis within the Medical Research Council framework for the development of complex interventions.

CHAPTER THREE

General methods chapter

Chapter overview

This chapter aimed to describe all the common methods used across Chapters 4,5,6 and 7. Description of the sociodemographic self-reported data and the cardio-metabolic risk factors measured across the 4 studies are included in this chapter. A description of how the activPAL data was extracted and processed is also included.

3.1 Socio-demographic self-reported data collected in Chapters 4, 5, 6 and 7

a) Age was self-reported by all participants

3.3.1 Self-reported data collected in the studies described in Chapter 6 and 7

a) Socio-demographic information: In addition to self-reported age, participants also self-reported their ethnicity and average weekly working hours. Drivers were asked to complete a Health Screen Questionnaire (HSQ), 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, amount per week).

b) Anxiety and depression were assessed using the Hospital Anxiety and Depression Scale (HADS) (Zigmond and Snaith, 1983). Scores between 8-10 were considered borderline and those scoring 11 or over were considered as clinical 'caseness' for anxiety or depression (Zigmond and Snaith, 1983).

3.4 Cardio-metabolic risk factors objectively measured in the studies described in Chapters 4, 5, 6 and 7

a) Resting blood pressure and heart rate were measured using the validated Omron Intellisense M7 Upper Arm monitor (Omron, UK Ltd)(El Feghali et al., 2007), following recommendations of the European Hypertension Society (O'Brien et al., 2005).

b) 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. BMI was calculated as kg/m^2.

c) Body composition and weight were assessed using a Tanita BC-418 MA Segmental Body Composition Analyzer (Tanita UK Ltd). 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 (DXA) (Pietrobelli et al., 2004). BMI was calculated as kg/m^2.

3.2.1 Cardio-metabolic risk factors objectively measured in the studies described in Chapters 6 and 7

a) In addition to waist circumference, participant's hip circumference was also measured around the widest part of the buttocks, with the tape parallel to the floor. The waist-hip ratio was subsequently calculated. This would add further knowledge about the lorry drivers' cardiovascular risk factor's profile.

b) Capillary blood samples were obtained instead of venous blood samples to reduce drop-out rates and due to feasibility issues related to field work (e.g. transportation of blood back to the laboratory, associated costs, health and safety standards in relation to storage of blood off site etc.). Therefore, a fasted (≥ 8 h) capillary (finger-tip) blood sample was taken for the analysis of fasting blood glucose (FBG), triglycerides (TGs), high-density lipoprotein Cholesterol (HDL), low density lipoprotein Cholesterol (LDL) and total-Cholesterol (TC) after heating the hand for 5 minutes. 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). LDL-cholesterol was estimated from quantitative measurements of total and HDL-cholesterol and plasma triglycerides using the empirical relationship of Friedewald et al. (1972). The Accutrend® Plus Complete System and Cardiochek PA Blood Analyser have been validated previously (Scafoglieri et al., 2012; Panz et al., 2005). The correlation coefficients between standard laboratory venous tests and the capillary sampling using the Cardiochek PA Blood Analyser to measure lipid concentration was >0.86 (Plüddemann, et al., 2012) and >0.94 when using the Accutrend Plus Complete System to measure glucose (Silva Coqueiro et al., 2013). It has been suggested that results from capillary blood samples tend to be 5% higher than those obtained from venous blood tests (Yang et al., 2012). However, this is recognised by the International Organisation for Standardisation (ISO) (2002), which states that 95% of results <4.2 mmol/L by point of care should be ±15% of the laboratory method and for results ≥4.2 mmol/L the difference should be ±20%, as these assessments are used as a screening measurement. Prior to any testing both devices were calibrated complying with the manufacturer’s instructions (Roche Diagnostics, Mannheim, Germany; Medisave, Dorset, UK). To ensure reproducibility of the assessment the finger prick test was conducted following the WHO Guidelines on drawing blood for capillary sampling to avoid haemolysis and clotting of the blood (WHO, 2010).

c) Metabolic syndrome was defined as central obesity (waist circumference ≥102cm) plus any two of the following risk factors: raised blood pressure (systolic ≥130 or diastolic ≥85mmHg), raised TGs (≥1.69mmol/l), reduced HDL-C (<1.03mmol/l in males and 1.3mmol/l in females) and raised fasting plasma glucose (≥5.5mmol/l) (International Diabetes Federation, 2006).

d) Ten year CVD risk was calculated using the QRISK calculator (http://www.qrisk.org/) (Hippisley-Cox et al., 2008). This index takes into account the person's age, sex, ethnicity, postcode, and clinical information such as: smoking and diabetes status, if the person had an angina or heart attack before 60 years of age, any chronic kidney disease (stage 4 or 4), artrial fibrillation, blood pressure treatment or rheumatoid arthritis. In addition, variables such as the cholesterol/HDL ratio, systolic blood pressure and body mass index have to be entered into the algorithm, which automatically works out risk of having a heart attack or stroke over the next ten years.

3.3 Sitting/lying, standing and stepping time objectively measured using the activPAL in the studies described in Chapters 4, 5, 6 and 7.

Sitting and up-right postures were measured objectively during waking hours over 7 days, using an activPAL3 accelerometer. The activPAL3 is a small, lightweight device worn on the front of the thigh. It contains a tri-axial accelerometer which responds to signals related to gravitational forces and provides information on thigh inclination (Atkin et al., 2012). Due to its precision to differentiate between postures in prolonged free-living activities (Godfrey et al., 2007), It has been shown to be a valid measure of time spent sitting, standing and walking in adults (Grant et al., 2006; Kozey-Keadle et al., 2011). This monitor has been used as the criterion measure in studies investigating the use of accelerometers for measuring sitting time (Oliver et al., 2010). The activPAL3 was therefore used as the criterion measure in this thesis. The activPAL3 was attached to the leg using a hypoallergenic medical dressing (BSN Hypafix), enabling participants to wear the device continuously, except for water-based activities, over the 7 day period.

Modification in Chapters 6 and 7

For the data collection conducted in lorry drivers, 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 seven 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, the times they started and finished work, along with break times were also recorded. Information about any non-wear time was also recorded in the diary.

Data from the activPAL were downloaded using activPAL Professional v.7.2.29 software (device firmware version 3.107) and processed manually using a customized

Microsoft Excel macro. Information on sitting, standing and stepping time, including number of steps and average cadence and sit-to-stand transitions was extracted. To be included in the analyses, participants were required to have provided at least four full days (>600 minutes of wear and >500 steps/day) of data (including at least 3 workdays and 1 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 minutes before and after and included as sleeping time if sitting/lying time was ≥30 minutes and <20 steps were recorded. If any standing time with <20 steps was found during sleeping hours, this was considered as sleeping time. Non-wear time was considered as time spent in either a sitting/lying or standing position for ≥3 hours, with no transitions.

For each participant, the number of minutes spent sitting, standing and stepping during waking hours on workdays and non-workdays were extracted based on times derived from participants' logs. Stepping time was further classified into MVPA (by summing the minutes in which participants accumulated >100steps/minute) (Marshall et al., 2009; Rowe et al., 2011) and light activity (LPA, stepping time minus MVPA). Those accumulating ≤30 minutes/day of MVPA were considered physically inactive (Department of Health, 2015).

CHAPTER FOUR

Time spent sitting during and outside working hours in bus drivers: a pilot study

This chapter specifically addresses thesis objectives:

1. Ascertain the feasibility of measuring bus drivers sitting time using an activPAL inclinometer to directly measure drivers' sitting and non-sedentary behaviours over the course of a week)
2. Quantify the prevalence of bus drivers sitting and non-sedentary behaviours during and outside working hours.
3. Profile bus drivers' basic markers of cardio-metabolic health.

Chapter overview

This chapter reports a pilot study in which sedentary behaviour was directly assessed in a sample of bus drivers using an activPAL inclinometer. The activPAL inclinometer had not been used in bus drivers previously; therefore the feasibility of using this monitor to ascertain bus drivers' sedentary behaviour is examined in this chapter. This chapter also profiles bus drivers' basic cardio-metabolic health. Data presented in this chapter reveal that bus drivers accumulate 12 hours/day of sedentary time on a workday and exhibit an unhealthy cardio-metabolic health profile. Compliance to the activPAL wear protocol was generally high amongst the sample of bus drivers studied. The work outlined in this chapter has been presented at an international conference and has been published in Preventive Medicine Reports.

- **Poster presentation:** “Time spent sitting and cardiovascular health amongst bus drivers: A pilot study”. Varela-Mato V, Yates T, Stensel D, Biddle S & Clemes SA. ISBNPA 2015, Edinburgh

- **Journal article:** Varela-Mato, V., Yates, T., Stensel, D. J., Biddle, S. J. H., & Clemes, S. A. (2016). Time spent sitting during and outside working hours in bus drivers: A pilot study. Preventive Medicine Reports, 3, 36–39. http://doi.org/10.1016/j.pmedr.2015.11.011

4.1 INTRODUCTION

Sedentary behaviour (SB), defined as “any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture” (Sedentary Behaviour Research Network, 2012), is prevalent amongst many working-aged adults. Prolonged time sitting has been linked to increased risk of cardiovascular disease, cardiovascular mortality, all-cause mortality and diabetes, independent of leisure-time physical activity (Wilmot et al., 2012). Adults typically spend between 50 and 60% of their waking hours in sedentary postures (Healy et al., 2011), with these figures increasing significantly amongst those with sedentary jobs. Studies carried out with office workers have shown they spend between 65% and 82% of their working hours sedentary (Clemes et al., 2014; Brown et al., 2013), with sitting at work accounting for over 60% of their total daily sitting time on workdays (Clemes et al., 2015). However, limited literature (Morris et al., 1953; Tse et al.,2006; French et al.,2007; Wong et al. 2014) has examined sedentary behaviour levels and patterns of individuals employed in occupations other than desk-based settings.

Driving as an occupation can best be described as a ‘compulsory sedentary occupation’ yet drivers have received limited attention in sedentary behaviour research (Wong et al. 2014), despite research by Morris and colleagues in the 1950s highlighting the higher rates of cardiovascular disease seen amongst bus drivers in comparison to bus conductors (individuals collecting fares and selling tickets on buses, up until the 1980s’) (Morris et al., 1953). A higher prevalence of obesity amongst bus drivers in comparison to those employed within other occupations was also reported (Morris and Crawford, 1958). These studies provided early evidence for the potential harmful consequences associated with driving occupations. It is now established that workers from the transport industry face a greater risk of co-morbidities and mortality compared to the general population (Robinson and Burnett, 2005; Tse et al.,2006). Indeed, national statistics have shown that those in the transport sector have one of the lowest life expectancies in comparison with other sectors (Office for National Statistics, 2011).

Interventions are therefore urgently needed to promote the health and wellbeing of those in driving occupations. In order to successfully intervene, it is important to first understand the prevalence and patterns of habitual lifestyle health-related behaviours, including sedentary behaviour and non-sedentary behaviours, in this occupational group. To date there are no published studies that have objectively quantified time spent sitting and standing across occupational and leisure time within drivers in the transport industry.

The aim of this pilot study was to ascertain the feasibility of using the activPAL inclinometer to directly measure driver’s sedentary and non-sedentary behaviours over the course of a week, and to quantify the prevalence of these behaviours during and outside working hours.

4.2 METHODS

4.2.1 Study design and participants

This cross-sectional pilot study was undertaken at a local bus company within the East Midlands, UK. Data collection took place between November 2013 and February 2014. A volunteer sample of 33 drivers aged 18 years and over was recruited, representing 42% of the driving workforce. Participants were recruited in person by the researcher during their breaks at the companies' canteen and depot after obtaining the managers' permission. Ethical approval was obtained from the Loughborough University Ethical Advisory Committee and all participants provided written informed consent.

4.2.2 Measurements

Refer to Chapter 3 page 99 and 100-102 for a full description of the socio-demographic assessment, anthropometric body measurements and activPAL data extraction and processing protocol.

4.2.3 Statistical analyses

Statistical analyses were conducted using SPSS version 22. activPAL-determined sitting, standing and stepping time, along with the total time and the proportion of times spent in each behaviour, on non-workdays, workdays, working hours and non-working hours on workdays 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 inter-quartile range (IQR) values were computed for all variables. Wilcoxon-signed rank tests were used to compare the proportions of time (accounting for wear time) and the actual time spent sitting, standing, stepping, total steps per day and MV stepping time per day between workdays and non-workdays and between working hours and non-working hours on workdays.

4.3 RESULTS

4.3.1 Participants and cardiovascular biomarkers

Of the 33 drivers enrolled in the study, 28 (34% of the overall workforce, 85% of those enrolled into the study) provided valid activPAL data on at least 3 workdays and 1 non-workday, and were included in the analyses. Table 4.1 displays the characteristics of the included participants, along with the recommended ranges for the markers of health measured. No significant differences were observed for age, BMI, waist circumference, blood pressure and heart rate between those who provided valid data and those who did not ($p>0.05$). This sample of drivers displayed higher than the recommended ranges for BMI (74% were clustered as overweight or obese), %body fat, waist circumference and blood pressure (67% had hypertension and 30% had pre-hypertension), putting them at high risk of cardiovascular events.

Table 4.1. Median and IQR of the body measurements and blood pressure in a sample of bus drivers from the East Midlands, UK. (N=28)

	Total sample (median ± IQR)	Healthy ranges
Age (yrs)	45 ± 17.5	
BMI (kg/m^2)*	28.1 ± 5.8	18.4 – 24.9
% Body fat**	26 ± 10	11 -17
Waist circumference (cm)***	101.5 ± 21	<94
Systolic Blood pressure (mmHg)****	137.5 ± 15	120 - 90
Diastolic blood pressure (mmHg)****	88 ± 11	80 - 60
Heart rate (beats/min)	72 ± 12	

*WHO, 1995, WHO, 2000 & WHO 2004.;** Jeukendrup & Gleeson, 2010; ***Lean, Han & Morrison, 1995; ****Blood Pressure Association, 2008

4.3.2 activPAL-determined sitting, standing and stepping time

Median activPAL-determined waking hours were 1021±106 min/day for workdays and 914±198 min/day for non-workdays ($p<0.01$). Given the significant difference in waking hours for both types of day, only proportions of time spent sitting, standing and stepping were used in the primary comparative analyses. The proportion of time spent sitting was significantly greater on workdays compared to non-workdays ($p<0.001$). A greater proportion of time was spent standing ($p<0.001$) and stepping ($p<0.01$) on non-workdays than on workdays (Table 3.2).

During workdays, the proportion of time spent sitting was significantly higher during working-hours compared to non-working hours ($p<0.001$). Significantly more time was accumulated standing ($p<0.001$) and stepping ($p<0.01$) during non-working hours in comparison to working hours on workdays (Table 4.2). Greater time was accumulated in moderate-to-vigorous stepping time (p< 0.013) and greater number of total steps (p<0.034) during working-hours compared to non-working hours.

Table 4.2. Sitting, standing and stepping time during working hours and non-working hours on work days and non-work days in sample of bus drivers from the East Midlands, UK. (N = 28)

	All days (median ± IQR)			Work days only (median ± IQR)		
	Work days	Non-work days	Differences (p value)	During working hours	Non-working hours	Differences (p value)
Waking hours (mins/day)	1021 ± 106	914 ± 198	**< 0.05**	528 ± 87	493 ± 103	0.25
% of wear time spent sitting	75 ± 9	62 ± 10	**< 0.001**	83 ± 10	68 ± 11	**< 0.001**
Time in sedentary behaviour (mins/day)	724 ± 112	528 ± 151	**< 0.001**	417 ± 88	307 ± 64	**<0.001**
% of wear time spent standing	25 ± 9	36 ± 9	**< 0.001**	17 ± 10	32 ± 12	**< 0.001**
Time standing (mins/day)	242 ± 86	312 ± 99	**< 0.01**	89 ± 47	153 ± 81	**< 0.001**
% of wear time spent in stepping	5 ± 2	8 ± 2	**< 0.001**	4 ± 3	7 ± 4	**< 0.01**
Time stepping (mins/day)	55 ± 22	74 ± 29	**< 0.01**	22 ± 14	33 ± 16	**<0.001**
MV stepping time (min/day)	9 ± 8	5 ± 11	.153	6 ± 8	2 ± 3	**.013**
Total steps per day	4792 ± 2639	4997 ± 3875	.290	2700 ± 1709	1820 ± 1257	**.034**

4.4 DISCUSSION

This study was the first of its kind to directly measure time spent sedentary and in up-right postures using the activPAL in a sample of drivers. This study demonstrated that the activPAL is a feasible tool to use in individuals with a driving occupation. 85% of the sample enrolled into the study adhered to the activPAL protocol and provided sufficient data (at least 10 hours of wear on three workdays and one non-workday) to be included in the analyses. The data revealed that the present sample accumulated extremely high volumes of sitting time on both workdays and non-workdays. On workdays drivers were sitting for over 12 hours per day, this reduced to just under 9 hours per day on non-workdays. . In addition, bus drivers accumulated less than 10 minutes of moderate-to-vigorous stepping time on both workdays and non-workdays.

High levels of sitting time in bus drivers are not surprising due to their job demands. Limited research has specifically examined sitting time in occupational drivers, and of the research available, most findings have been derived from self-report data (Morris and Crawford, 1958; French et al., 2007), limiting direct comparisons with the present study. French et al. (2007) reported that transit workers spent just over 9 hours/day sedentary when assessed using the IPAQ sitting time question, which evidence suggests underestimates sedentary time by approximately 2 hours in comparison to objective measures (Chastin et al., 2014). When using accelerometers to assess drivers' sedentary behaviour, Wong et al (2014), reported that drivers' accumulated 8 and 9 hours/day sedentary on workdays and non-workdays, respectively. The lower levels of sedentary time seen in these earlier studies when compared to the present study are likely due to differences in measurement tools. The activPAL used herein provides a direct measure of posture, whereas the accelerometer used in the study by Wong et al. (2014) estimates sedentary time through a lack of movement counts (Atkin et al., 2012). In contrast to the present study, Wong et al. (2014) observed that drivers spent a greater proportion of their time sedentary on non-workdays (64%) in comparison to workdays (52%). They also reported that the proportion of time in light activity was greater on workdays (44%) than non-workdays (33%). It could be suggested that the vibrations experienced during vehicle motion by drivers may lead to an overestimation of light intensity activity and an underestimation in sedentary time when assessed via accelerometry, although further research will be required to confirm this.

Drivers participating in this study accumulated substantially higher volumes of daily sitting on workdays than that seen in office workers, using the same device (12 hours/day versus 9-10 hours/day) (Smith et al., 2015). Participants also accumulated higher volumes of sitting time during non-workdays (62%) than that seen in other populations (Clemes et al., 2015). These findings support previous results (Clemes et al., 2014), which show that those who are highly sedentary during working hours also accumulate high levels of sitting time during their non-working hours on workdays. This study highlights that sedentary behaviours in drivers are very prominent during non-workdays (62%), which could be due to a knock on effect of the participant's established sitting behaviours during their workdays

The extremely high sitting times presented in this sample highlight these individuals as being at increased risk of chronic conditions associated with sedentary behaviours (Healy et al., 2011; Wilmot et al., 2012; Owen et al. 2012). Previous literature has reported that between 65% and 92% of drivers studied were classified as overweight or obese (French et al., 2007; Wong et al., 2014). Similar findings were observed in the present study with 74% of the sample classified as overweight or obese. In fact, research in occupational health has shown that bus drivers have a higher incidence of obesity (Morris and Crawford, 1958; Rosengreen et al., 1991; Moreno et al., 2006) and hypertension in comparison to the general population (Tse et al., 2006; Cavagioni and Geraldo, 2010; Joshi et al., 2013). Although when looking into matching age range categories across the general population, it seems that 75% of men aged 45-54 years were classified as overweight or obese (HSE, 2014). Compared with the high prevalence of hypertension found in this sample of bus drivers, 32% of men aged 45-54 years have been diagnosed with hypertension (HSE, 2014).

Previous studies have shown that sitting for longer than 10 hours per day increases the risk of myocardial infarction and coronary heart disease incidence and all-cause mortality (Petersen et al., 2014); although, recent research (Ekelund et al., 2016) has suggested that the adverse health effects could be eliminated if sufficient moderate-to-vigorous physical activity was accumulated daily (60-75 minutes). However, this sample of bus drivers only accumulated 7 minutes of moderate to vigorous stepping time on average per day. As mentioned in Chapter 2, getting bus drivers to go from 7 mins/day of MVPA to 60 mins is probably going to be unrealistic and unachievable by many. Therefore in addition to promoting increases in PA, interventions should also target sedentary behaviours during breaks from driving and out of work hours.

Drivers from this sample on average presented with a BMI, % body fat and blood pressures commensurate with an unhealthy cardiovascular profile. Coupled with their high levels of sitting and low moderate to vigorous stepping activity, these findings suggest that this group are at risk of a cardiovascular event. However, due to the cross-sectional designed of the study it is impossible to determine whether this sub-optimal cardiovascular profile is a result of the bus driving operational demands or is a common characteristic of those who become bus drivers, and only those who are already overweight or obese and physically inactive choose this occupation, resulting in a self-selection bias as previously highlighted by Morris and colleagues (1953, 1955). Therefore, further quantitative and qualitative research is needed to explore this issue. This study adds to existing evidence by quantifying the levels of sedentary and non-sedentary behaviour that accompany driving-based occupations which may contribute to these associated adverse health profiles.

4.5 STRENGTHS AND LIMITATIONS

This study provides novel information on sitting behaviour and how this is accumulated during and outside working hours in a sample of bus drivers from the UK. A strength of this study is the use of an objective measurement tool to directly assess sitting time, avoiding the limitations of bias and recall common with self-report measures. In addition the activPAL overcomes potential limitations seen with accelerometry with drivers, as mentioned above. Limitations of the study include the small sample size and the cross-sectional design that prevents us from making conclusions about causative links between sitting time and cardiovascular health. The sample was recruited from one depot in the East Midlands and is therefore unlikely to be representative of bus drivers in the UK, this highlights the need for ongoing research with larger and more diverse groups of drivers. In addition, estimates depend heavily on wear time, for which proportions were used in the primary analyses rather than absolute minute data. Moreover, as drivers did not wear the devices during water-based activities, some relevant physical activity behaviours may be missing (although we feel that this is unlikely to be a major confounding factor and water-based activities were seldom reported in the diaries. Finally, data collection took place during the autumn and winter, this colder period may have impacted leisure time physical activity and sitting behaviours. Exploring drivers' sitting and physical activity behaviours' across all seasons is therefore recommended for future research.

4.6 CONCLUSION

In conclusion, this study has highlighted the feasibility of directly measuring posture in individuals with an occupation of driving. The findings demonstrate that the present sample of bus drivers are highly sitting at work and outside work and display an unhealthy cardiovascular profile. Occupational interventions are urgently needed to reduce excessive adverse health behaviours within this high risk work force. Interventions should focus on reducing sitting and increasing movement during work breaks to improve drivers' cardiovascular health (Bailey & Locke, 2014). Interventions should also focus on reducing sitting and increasing leisure time moderate to vigorous physical activity. Pedometer-based walking interventions (Bravata et al., 2007; Lin et al., 2015) could be a feasible approach to increase physical activity during and outside working hours in drivers, although this would need confirming in appropriately designed intervention studies. Nonetheless, the present findings suggest those with driving occupations should be a priority group for future health behaviour surveillance studies and intervention.

CHAPTER FIVE

Validity of accelerometer-determined sedentary time under free-living conditions in a sample of bus drivers

The ActiGraph and the activPAL were used during data collection amongst bus drivers presented in Chapter 4. The ActiGraph was used to explore bus drivers' physical activity and the activPAL to assess bus drivers sedentary time. However, discrepancies between both devices were detected when comparing the ActiGraph-determined sedentary time (<100cpm) against the activPAL-determined sitting time. Consequently, only data obtained from the activPAL was used in Chapter 4. This chapter focuses on exploring those discrepancies further.

Therefore, this chapter specifically addresses thesis objective:

4. Explore the validity of accelerometer-determined sedentary time in comparison to activPAL measured sitting in a free-living sample of bus drivers

Chapter Overview

This chapter reports a validation study which aimed to explore the validity of accelerometer-determined sedentary time (<100 cpm) in comparison to the activPAL in a free-living sample of bus drivers. This is the first paper to test the performance of the ActiGraph compared to the actviPAL during working hours and non-working hours in a sample of bus drivers. Data were obtained from the sample of bus drivers participating in Chapter 3, who had a variety of different shift patterns. This chapter highligts that the ActiGraph accelerometer, relative to the activPAL, miss-classifies sedentary time in bus drivers using multiple cut-points, particularly during working hours.

The work outlined in this chapter has been presented at an international conference and submitted for publication to Measurement in Physical Education & Exercise Science

- **Poster presentation:** “Validity of accelerometer-determined sedentary time in bus drivers” Varela-Mato V, Yates T, Stensel D, Biddle S & Clemes SA. ICAMPAM 2015, Limerick

- **Journal article:** Varela-Mato, V., Yates, T., Stensel, D. J., Biddle, S. J. H., & Clemes, S. A. (2016). Validity of accelerometer-determined sedentary time under free-living conditions in a sample of bus drivers.

5.1 INTRODUCTION

Sedentary behaviours, described as any sitting or reclining postures with an energy expenditure ≤1.5 MET's during waking hours (SBRN, 2012), have been linked to numerous adverse health outcomes, including obesity, type 2 diabetes, metabolic syndrome, some cancers and mortality from all-causes and cardiovascular disease (Wilmot et al., 2012; Biswas et al., 2015). High levels of sedentary time have been identified in office workers (Thorp et al., 2012; Brown et al., 2013; Clemes et al., 2015) and bus drivers (Wong et al., 2014; Varela-Mato et al., 2016), which put them at greater risk of co-morbidities and mortality in comparison to other occupational groups(Tse et al., 2006; Katzmarzyk et al., 2009; Dunstan et al., 2013).

The use of accelerometry to provide an objective estimate of sedentary time, in addition to physical activity, has been widespread, with the ActiGraph being one of the most popular measurement tools within the literature. The ActiGraph is a small lightweight device that traditionally has been worn on an elastic belt on the hip. This device measures raw acceleration data by capturing the frequency and amplitude of the acceleration of the body segment to which it is attached. Once the monitoring period is finished, these data can be clustered into sedentary, light, moderate and vigorous activities during the post-processing analysis (Atkin et al., 2012). Accelerometers have been used to overcome the limitations of self-report instruments and are used to quantify both physical activity and sedentary time. In addition, studies that have used this activity monitor have shown a robust relationship between sedentary time and health outcomes (Healy et al., 2008; Kozey-Keadle et al., 2011).

However, accelerometers do not measure posture and instead sedentary time is estimated using a lack of movement counts. Although other cut-points have been proposed previously (Kozey-keadle et al., 2011; Hart et al., 2011; Ridgers et al., 2012), a cut-point of less than 100 counts per minute (cpm) has been the most widely adopted to define sedentary time (Atkin et al., 2012); although the cut-point is limited in terms of its empirical derivation (Matthews et al., 2008).

The activPAL is a lightweight device that is attached to the anterior aspect of the thigh and has the ability to distinguish between different postures based on thigh inclination (Kozey-Keadle et al., 2011). The activPAL has been shown to be a highly sensitive and valid measure of posture (Kozey-Keadle et al., 2011; Grant et al., 2006; Hart et al., 2011). Literature studying the agreement between the ActiGraph and activPAL when measuring sitting time in a free-living environment is limited (Kozey-Keadle et al., 2011; Ridgers et al., 2012; Decker et al., 2013).

Sedentary behaviours research in bus drivers is rare in the literature. Of the limited research available, studies using accelerometers to measure sedentary time in bus drivers (French et al., 2007; Wong et al., 2014), appear to give different results from those using the activPAL, as discussed in Chapter 3. For example, Wong et al (2014), reported that bus drivers' accumulated 8 hours/day of sedentary behaviour on workdays when assessed using an ActiGraph accelerometer (applying a cut-point of <150 counts/minute (cpm)), whilst Varela-Mato et al (2016) indicated that bus drivers accumulate 12 hours/day of sitting during workdays, when assessed using an activPAL.

Whilst information on bus drivers work pattern, in terms of hours spent driving, the number of breaks, and distance between stops has not been reported, large differences in sedentary time have been observed between studies applying different measurement tools to assess bus drivers' sedentary time. For example, it has been reported that bus drivers' spend between 3.7 to 4 hours sedentary during working hours when assessed using the ActiGraph (Wong et al., 2014), whilst Chapter 3 demonstrated that bus drivers spent 6.9 hours sitting during working hours when assessed using the activPAL.

Despite accelerometer-determined sedentary time being assessed in bus drivers (Wong et al., 2014), no evidence exists on the validity of this measure in this population. In fact, a preliminary data analysis conducted using the sample of bus drivers included in Chapter 4, showed significant differences between ActiGraph-determined sedentary time and activPAL-determined sitting. Due to the nature of their occupation, and their higher levels of disease risk (Wong et al., 2014) occupational drivers are an important group to study in sedentary behaviour research. This study therefore aims to explore the validity of accelerometer-determined sedentary time (<50cpm, <100 cpm, <150cpm, <200cpm, <250cpm) comparison to the activPAL in a free-living sample of bus drivers.

5.2 METHODS

5.2.1 Study design and participants

Data were collected from the sample of bus drivers who took part in Chapter 4. See page 109 for an overview of the recruitment process and health measurements.

5.2.2 Measurements

Refer to Chapter 3 page 102 to 104 for a full description of the activPAL-determined sedentary data extraction and analysis protocol.

The ActiGraph GT3X+ was worn on an elasticated belt on the waist above the mid-line of the right thigh. The device was initialised at a frequency of 100HZ and downloaded using ActiLife software v6.11.8 and firmware version 2.0.0. Continuous strings of zero counts lasting for 60 minutes or longer were considered non-wear time and excluded from the analysis. Several sedentary cut-points ranging from 0 to 500 cpm have been proposed in the literature (Atkin et al., 2012; Kozey-Keadle et al., 2011); the <100 cpm has been the most commonly used cut-point within observational research investigating the association between sedentary and non-sedentary behaviours and health (Atkin et al., 2012; Healy et al., 2008; Brocklebank et al., 2015). However, this was not empirically derived. Therefore in this study ActiGraph data were downloaded in 60-seconds epochs and sedentary time was defined as the sum of minutes where the monitor output was <50cpm, <100 cpm, <150cpm, <200cpm, <250cpm and <300cpm when applied to the vertical axis. Consequently, minutes where the monitor output was >50cpm, >100cpm, >150cpm, >200cpm, >250cpm and >300cpm were considered as non-sedentary time. Sleep time was interpreted as the consecutive string of sedentary minutes during night time that best matched the activPAL data. Sleep time was excluded from the analysis. Non wear time data (continuous strings of zero counts) that best matched the activPAL data was removed from the analysis.

Participants were advised to wear both devices continuously over a seven day period, except for water-based activities. In addition, participants were asked to complete a daily log book where they recorded their waking hours. On workdays, the times they started and finished work, along with the times of breaks during the day were recorded. Information about any non-wear time was also recorded in the daily log. At the end of the seven days the devices and diary were collected from the participants.

To be included in the analyses participants were required to have worn both devices concurrently for at least 600 minutes on at least 4 days, including three work days and one non-work day. For each participant, time matched total minutes spent sedentary and non-sedentary during working hours and outside of working hours on workdays, and total sedentary and non-sedentary time on non-workdays were extracted based on times derived from participant’s logs. Timed-matched data for waking hours during work and non-workdays and during working and non-working hours were retrieved from the activPAL and ActiGraph. These were analysed for each participant using a Microsoft Excel macro which summarised total activPAL and ActiGraph-determined sedentary time for each domain.

5.2.3 Statistical analyses

Sedentary and non-sedentary time determined by the activPAL and ActiGraph during waking hours on workdays and non-workdays, and during working-hours and non-working-hours on workdays were analysed using SPSS version 22. These variables were tested for normality using the Shapiro-Wilk Test, which confirmed that all data were normally distributed. Paired-samples t-tests were used to compare total minute data of time spent sedentary and non-sedentary between instruments on workdays and non-workdays and during working hours and non-working hours on workdays. The mean difference in time spent sedentary within the different domains, along with the 95% limits of agreement, were calculated using Bland-Altman plots (Bland and Altman, 1986). In addition, to assess the agreement of the total sitting time between the outputs of the two devices two-way mixed Intraclass Correlation Coefficients (ICC) were calculated. . ICC results were interpreted as follows: 0-0.39 indicates poor agreement: 0.4-0.59 indicates fair agreement; 0.6-0.74 indicates moderate agreement; and >0.75 indicates excellent agreement (Cicchetti, 1994). Receiver operating characteristic (ROC) curve analyses (95%CI) (Jago et al., 2007) were conducted to explore the sensitivity and specificity of each of the cut points applied to the ActiGraph data to determine sedentary time. These tests were used to examine if the ActiGraph cut-points correctly identify sedentary and non-sedentary time compared to the activPAL during workdays and non-workdays (Jago et al., 2007). Statistical significance was set at $p<0.05$. Results are presented as mean (SD) unless stated otherwise. Actigraph and activPAL outputs were plotted against each other in figure 5.5 for one person during a workday and a non-workday to illustrate the disagreement between both devices.

5.3 RESULTS

Of the 35 drivers enrolled in the study, 28 (see Chapter 3 for an overview of the driver's characteristics) provided at least 4 days of valid data for both monitors, consisting of at least 600 minutes of wear per day. The average wear times during waking hours for the activPAL and ActiGraph for workdays were 1014(57) mins/day (working-hours: 604(85) min/day) and for non-workdays were 869(295) mins/day.

The sedentary times recorded (mean minutes/day) during each of the different domains over the monitoring period, using the activPAL and different ActiGraph cut-points, are shown in Table 5.1. Relative to the activPAL, the ActiGraph significantly underestimated total daily sedentary time during workdays when using the <50 cpm, <100cpm and the <150cpm cut-point, and significantly underestimated sedentary time during working hours when applying all cut-points (Table 5.1).

Despite strong agreement between <50cpm and activPAL-determined sitting when measured using the ICC (Table 5.1, t-test:p>0.05 for both), sedentary times estimated using the <100cpm, <150cpm, <200cpm, <250cpm and <300cpm cut-points on non-workdays were significantly higher than activPAL-determined sedentary time (Table 5.1).

Table 5.1. Mean (SD) time spent sedentaryin each domain recorded by the activPAL and ActiGraph . ICCs and t-test results are based on the time spent sedentary (mins/day

Domains	ActiGraph cut-points (cpm)	ActiGraph-determined sedentary time (min/day)	activPAL-determined sedentary time (min/day)	ICC between devices	P values from the test of differences between devices (t-tests)
Total waking hours on workdays	<50	480(92)	715(123)	.261	<.001
	<100	572(96)		.334	<.001
	<150	638(95)		.400	<.01
	<200	690(91)		.450	.274
	<250	732(84)		.481	.424
	<300	768(84)		.523	.012
Total waking hours on non-workdays	<50	502(169)	536(203)	.775	.170
	<100	594(199)		.879	<.01
	<150	619(206)		.887	<.001
	<200	641(212)		.888	<.001
	<250	662(216)		.910	<.001
	<300	663(217)		.911	<.001
Working hours on workdays	<50	229(52)	478(106)	.118	<.001
	<100	298(65)		.300	<.001
	<150	348(68)		.418	<.001
	<200	388(69)		.496	<.001
	<250	420(70)		.552	<.01
	<300	445(71)		.593	.042
Non-working hours on workdays	<50	251(75)	236(65)	.727	.158
	<100	274(81)		.739	<.01
	<150	290(84)		.747	<.001
	<200	302(85)		.752	<.001
	<250	312(86)		.752	<.001
	<300	323(84)		.764	<.001

Abbreviations: ICC, intraclass correlation coefficient.

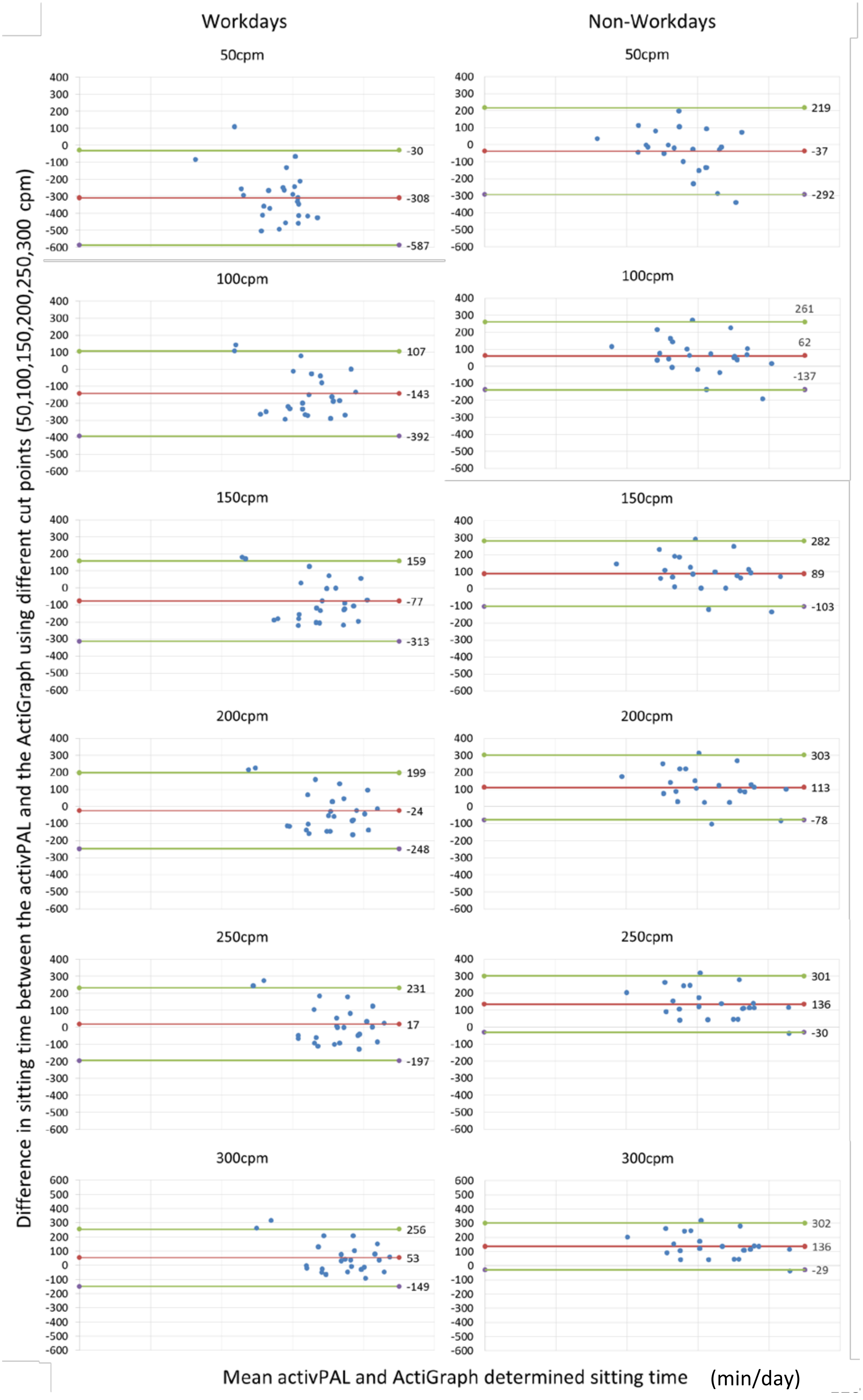
Workdays
Non-Workdays
50cpm
-30
-308
-587
50cpm
219
-37
-292
100cpm
107
-143
-392
100cpm
261
62
-137
150cpm
159
-77
-313
150cpm
282
89
-103
200cpm
199
-24
-248
200cpm
303
113
-78
250cpm
231
17
-197
250cpm
301
136
-30
300cpm
256
53
-149
300cpm
302
136
-29
400
300
200
100
0
-100
-200
-300
-400
-500
-600
Difference in sitting time between the activPAL and the ActiGraph using different cut points (50,100,150,200,250,300 cpm)
Mean activPAL and ActiGraph determined sitting time (min/day)

Figure 5.1. Bland-Altman plots showing the mean difference and the 95% limits of agreement in time spent sedentary on workdays and non-workdays, between the ActGraph GT3X+ (using different cut points) and the activPAL. The red lines represent the mean difference in minutes between the activPAL and the accelerometer and the green lines represent the 95% confidence intervals of the agreement between the measures. The *x* axis represents the mean sedentary time and the *y* axis is the difference in sitting time (in minutes) between the ActiGraph and the activPAL (accelerometer -determined sedentary time).

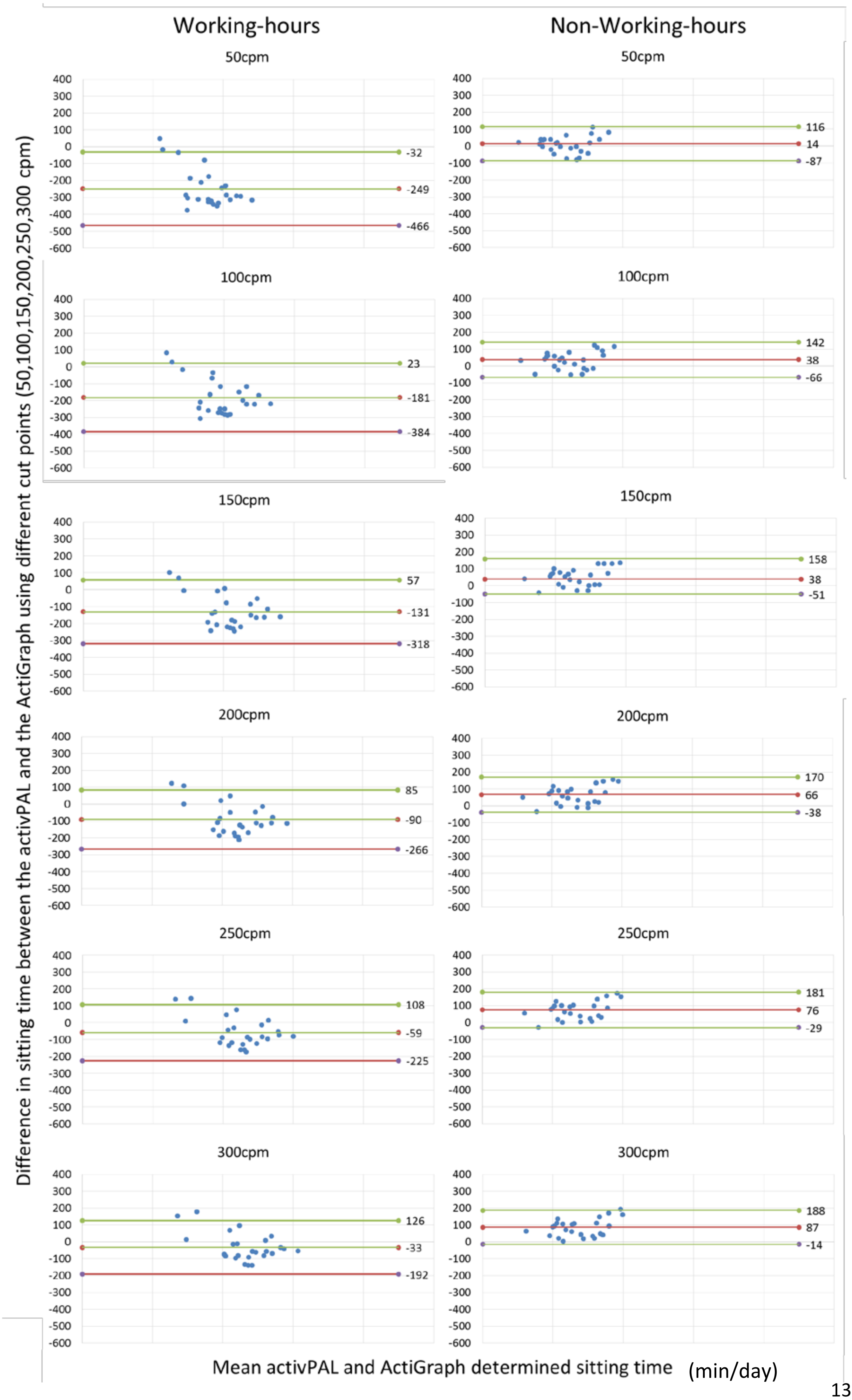
Working-hours
Non-Working-hours
50cpm
-32
-249
-466
116
14
-87
100cpm
23
-181
-384
142
38
-66
150cpm
57
-131
-318
158
38
-51
200cpm
85
-90
-266
170
66
-38
250cpm
108
-59
-225
181
76
-29
300cpm
126
-33
-192
188
87
-14
400
300
200
100
0
-100
-200
-300
-400
-500
-600
Difference in sitting time between the activPAL and the ActiGraph using different cut points (50,100,150,200,250,300 cpm)
Mean activPAL and ActiGraph determined sitting time (min/day)

Figure 5.2. Bland-Altman plots showing the mean difference and the 95% limits of agreement in time spent sedentary on working-hours and non-working-hours, between the ActGraph GT3X+ (using different cut points) and the activPAL. The red lines represent the mean difference in minutes between the activPAL and the accelerometer and the green lines represent the 95% confidence intervals of the agreement between the measures. The *x* axis represents the mean sedentary time and the *y* axis is the difference in sitting time (in minutes) between the ActiGraph and the activPAL (accelerometer -determined sedentary time).

Figure 5.3 shows the area under the ROC curve for the ActiGraph during workdays, which showed poor discrimination of sedentary time compared with the activPAL (ROC= .617). Despite cut-points showed better sensitivity than specificity, all cut points failed to correctly identify sitting time compared with the activPAL (ROC sensitivity values <.620, specificity values <.498) (Table 5.2).

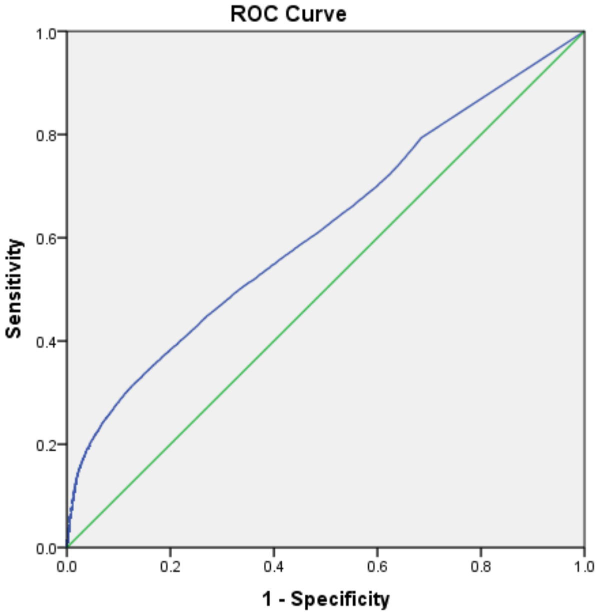

Figure 5.3. ROC curve ActiGraph-determined sedentary time during non-workdays

Table 5.2. Sensitivity and specificity values calculated across participants for each ActiGraph cut-point. The performance of each cut-point was compared to activPAL-determined total daily sitting time on workdays.

	Area under the ROC curve	
ActiGraph against activPAL	.617 (.613-.621)	
ActiGraph-determined sedentary cut points	**Sensitivity**	**Specificity**
<50cpm	.620	.498
<100cpm	.549	.400
<150cpm	.498	.331
<200cpm	.453	.277
<250cpm	.413	.234
<300cpm	.380	.197

Figure 5.4 shows the area under the ROC curve for the ActiGraph during non-workdays, which showed fair discrimination of sedentary time compared with the activPAL (ROC= .706). Despite cut-points showed better sensitivity than specificity, all cut points failed to correctly identify sitting time compared with the activPAL (ROC sensitivity values <.602, specificity values <.278) (Table 5.3).

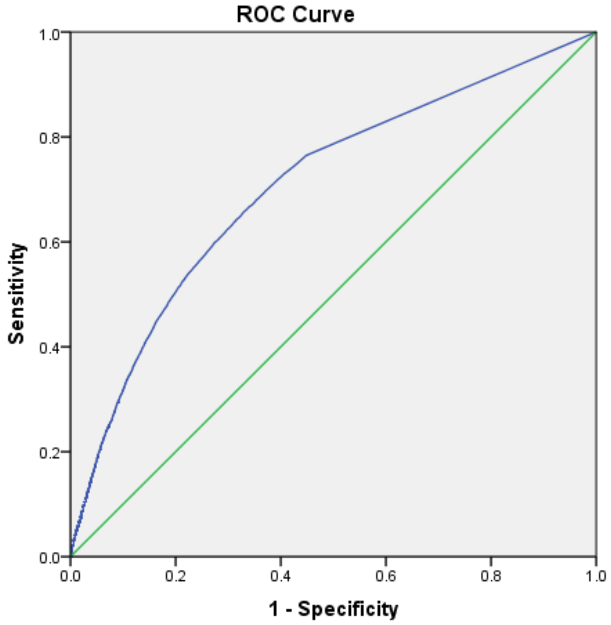

Figure 5.3. ROC curve ActiGraph-determined sedentary time during non-workdays

Table 5.3. Sensitivity and specificity values calculated across participants for each ActiGraph cut-point. The performance of each cut-point was compared to activPAL-determined total daily sitting time on non-workdays.

	Area under the ROC curve (95% CI)	
ActiGraph against activPAL	.706 (.701-.712)	
ActiGraph-determined sedentary cut points	**Sensitivity**	**Specificity**
<50cpm	.602	.278
<100cpm	.532	.219
<150cpm	.478	.182
<200cpm	.437	.158
<250cpm	.401	.139
<300cpm	.372	.124

Figure 5.5 shows the ActiGraph output illustrating activity patterns on a typical workday and non-workday for a bus driver compared with the activPAL. Sedentary time identified by the activPAL is represented by a straight line and vice-versa. ActiGraph and activPAL outputs are superposed and time-matched for waking hours during a typical workday and non-workday. Figure 5.5 highlights the inaccuracy of the ActiGraph to determine sedentary compared with the activPAL.

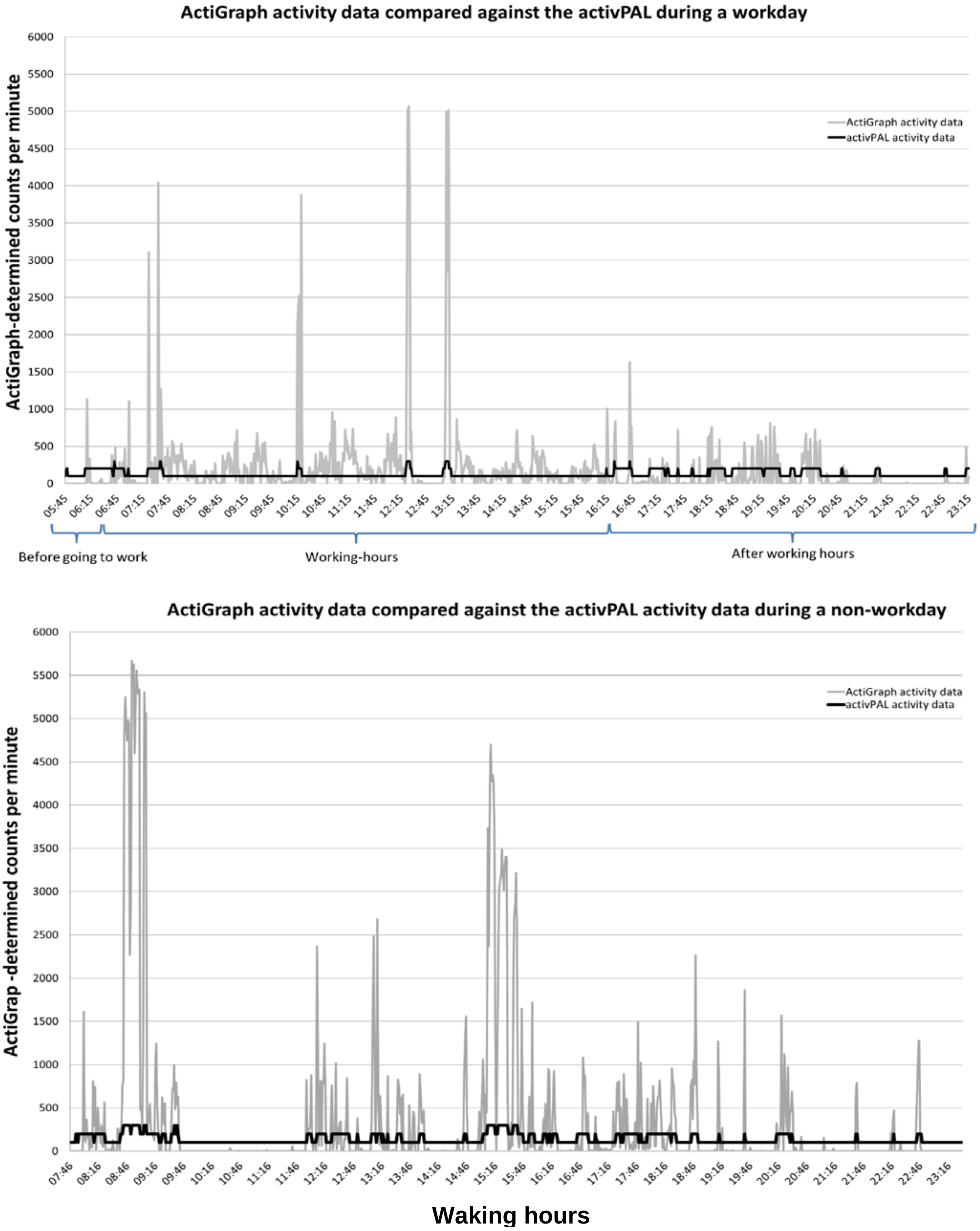

Figure 5.5. ActiGraph output illustrating activity patterns on a typical workday and non-workday for a bus driver, compared to the activPAL.

5.4 DISCUSSION

The aim of the work reported in this chapter was to explore the validity of accelerometer-determined free-living sedentary time (using <50cpm, <100cpm, <150cpm, <200cpm, <250cpm, <300cpm cut-points) during and outside working hours in comparison to the activPAL in a sample of bus drivers. The ROC curve results indicated that the ActiGraph inaccurately identifies sedentary time relative to the activPAL. These findings suggest the ActiGraph is not a valid tool to assess sedentary time in bus drivers, particularly during workdays. Despite some cut-points showing better agreement between devices during non-working hours on workdays and during non-workdays, the sensitivity and specificity analysis indicates that all cut points failed to correctly identify sitting time relative to the activPAL.

Because sedentary behaviours are ubiquitous in our day to day life, accurately measuring sedentary time is important to establish dose-response relationships with health, to determine prevalence of sedentary behaviours and identify factors to target in interventions. It is therefore important to assess the outputs from available instruments to measure sedentary time taking into account the characteristics of different occupational groups, as these might have an impact on the monitor's performance. Although it has been concluded that accelerometers are a valid tool to assess sedentary behaviour (Matthews et al., 2008), most studies have been conducted in office settings, with very few looking at other occupational groups (Thorp et al., 2012; Church et al., 2011).

To date only one study (Wong et al., 2014) has applied accelerometry to estimate sedentary time in bus drivers, which used the 150 cpm cut point. Wong et al.'s study (2014) showed that bus drivers accumulated less sedentary time during workdays in comparison to non-workdays (7.8 hours/day versus 8.9hours/day) and during working hours in comparison to non-working hours (3.7 hours/day versus 4.1 hours/day). Compared with the activPAL, accelerometer-determined sedentary time was lower during working hours compared when using all the cut-points, despite the sedentary nature of a driving occupation. Thus, the activPAL inclinometer revealed that drivers spent 478 minutes (7.9 hours/day) out of 604 minutes (10 hours/day) sedentary during working hours. It is therefore unlikely drivers accumulate high levels of non-sedentary time whilst at work as highlighted in Wong's and colleague's study (2014). Using accelerometer-applied cut-points to determined sedentary time might in tipping misclassification of sedentary time as light physical activity, as highlighted by the current paper. It is likely therefore that the high levels of light intensity activity reported during working hours by Wong et al. (2014) may also be the result of the misclassification of sedentary time as light activity. However, when exploring other thresholds as those suggested by Kozey-Keaddle et al. (2011) all cut-points described in this paper significantly underestimated sitting time during working-hours or significantly overestimated sitting time during non-working-hours and non-workdays. Kozey-Keadle et al. (2011) reported differences in sedentary time of 16 minutes/day over a 6 hour period between the <100 and <150 cpm cut-points; the <150cpm threshold resulted in sitting time being overestimated by 1.8% during compared to direct observation.

In the present study, the <250 cpm cut-point provided the closest estimate of total daily sedentary time on workdays compared to the activPAL (mean difference = +17 mins/day), however, on non-workdays, total daily sedentary time was best estimated using the <50 cpm cut-point, which underestimated sedentary time by 34 mins/day. In contrast, during working hours all cut-points tested underestimated sedentary time relative to the activPAL, with the <300 cpm cut-point providing the closest estimate (underestimating by 33 mins/day). During non-working hours on workdays, as with non-workdays the <50 cpm cut-point provided the closest estimate of sedentary time (underestimating by 15 mins/day). When assessing ActiGraph sensitivity and specificity values to determine sitting time compare with the activPAL all results ranged between poor and fair (ROC<.80); Therefore it seems that that different cut-points perform better in the different domains, suggesting the cut-point approach to determine sedentary time using the ActiGraph in bus drivers is an unreliable method, particularly during working-hours.

The ActiGraph accelerometer records the intensity of the body's movements and sedentary time is estimated through a lack of movement (Chen et al., 2005). Any motion over any of the cut-points applied to this sample of drivers will therefore be considered as non-sedentary activity and clustered as light-activity, as shown in the current chapter. Discrepancies between the activPAL and the ActiGraph could be due to the vibrations experienced during vehicle motion by the bus driver. Figure 5.5, illustrates the ActiGraph output activity patterns on a typical workday and non-workday for a bus driver, compared to the activPAL. This figure indicates that continuous accelerations during working-hours are detected by the ActiGraph and classified as non-sedentary time, whilst the time-matched activPAL output clustered this time as sitting time based on the body's posture. Therefore it is plausible that the discrepancies detected between the activPAL and the ActiGraph are a result of the vibrations experienced during vehicle motion by the bus driver, which may lead to an underestimation of sedentary time by the ActiGraph, as the vertical vibrations travel through the body. Consequently, tipping the classification over the sedentary threshold, despite the driver being seated (Patterson et al., 1993). In comparison with the activPAL, results from this study showed that the ActiGraph highly underestimated sitting time during workdays and workhours. Whilst, levels of agreement improved during non-working hours and on non-workdays, sensitivity and specificity values were considered as poor across all domains.

5.5 STRENGTHS AND LIMITATIONS

This study provides novel information on sedentary behaviour measurement and how sedentary and non-sedentary behaviours are accumulated during and outside working hours using two different tools in a sample of bus drivers. Nonetheless, this study is not without limitations. One limitation is that the bus vibrations were not objectively quantified and it is difficult therefore to assess their impact on the monitor's performance. Moreover, the sample size of this study was relatively small and included participants who were overweight or obese, which may have exacerbated the impact of the vehicle vibrations on the monitor's performance. Further research should investigate this further in other driving occupations.

5.6 CONCLUSIONS

In conclusion, the present paper highlights that the ActiGraph accelerometer, relative to the activPAL, highly miss-clasifies sedentary time in bus drivers, particularly during working hours. When the use of inclinometers is not possible in such occupational groups, further research should explore a correction formula to apply to accelerometer data for defining sedentary time in occupational drivers. Overall, sedentary behaviour measurement techniques should be improved in this understudied, highly sedentary and at risk occupational group.

CHAPTER SIX

Lorry drivers’ sedentary behaviours, physical activity and cardiovascular health

This chapter specifically addresses thesis objectives:

5. Behaviourally phenotype UK lorry driver’s sedentary and non-sedentary behaviours during workdays and non-workdays.

6. Examine markers of cardiovascular health and to profile drivers’ mental health.

7. Explore associations between time spent sitting and in non-sedentary activities (standing, light and MVPA) and cardiovascular health in lorry drivers.

Chapter Overview

This chapter reports a surveillance study where the primary aim was to phenotype UK lorry drivers’ sedentary and non-sedentary behaviours during workdays and non-workdays. Non-sedentary behaviours were clustered as standing, light and moderate-to-vigorous physical activity. A secondary aim of this chapter was to examine markers of cardiovascular health and to profile drivers’ mental health. This is the first study to measure lorry drivers’ sedentary time and the findings indicate that lorry drivers accumulate the highest sitting time reported up to date (12.5 hours per workday). In addition, lorry drivers are highly inactive and present a worrying mental and cardiovascular health profile. The work outlined in this chapter has been presented at an international conference and submitted to an open access journal.

- **Poster presentation:** “Lorry drivers’ cardiovascular health, physical activity and sedentary behaviours: The SHIFT Study phase I.” Varela-Mato V, O’Shea O, King J, Yates T, Stensel D, Biddle S, Nimmo M , & Clemes S. EUROPREVENT 2016, Istanbul.

- **Journal article:** Varela-Mato V, O’Shea O, King J, Yates T, Stensel D, Biddle S, Nimmo M , & Clemes S (2016). Lorry drivers’ sedentary behaviours, physical activity and cardiovascular health. Accepted for publication at BMJ Open

6.1 INTRODUCTION

Lorry driving has been considered as one of the most hazardous occupations worldwide (Apostolopoulos et al., 2013; Wong et al., 2007; Sieber et al., 2014). 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 (Caddick et al., 2016). Furthermore, unhealthy lifestyle behaviours such as, poor diet, lack of physical activity, smoking, high volumes of alcohol consumption and irregular sleeping patterns are highly prevalent among this occupational group (Bigert et al., 2003; Apostolopoulos et al., 2012; Passey et al., 2014). These features contribute to an increased risk of overweight and obesity, diabetes, hypertension, heart disease, cancer, fatigue, stress, sleep disturbance, musculoskeletal disorders (Wong et al., 2007; Apostolopoulos et al., 2012; Whitelegg et al., 1995; Caruso et al., 2004), and reduced life expectancy in lorry drivers in comparison to other occupational groups (Aronson et al., 1999; Hannerz and Tuchsen, 2001; Robinson and Burnett, 2005).

Sedentary behaviours defined as "any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture" (SBRN, 2012) are prevalent in most working-aged adults, particularly in those with driving occupations (Varela-Mato et al., 2016). It has been suggested that these act as an independent risk factor for increased risk of cardiovascular disease (CVD), cardiovascular mortality (CVM), all-cause mortality, diabetes (Wilmot et al., 2012; Biswas et al., 2015) and some cancers (Biswas et al., 2015). Links between poor cardio-metabolic health and occupational driving date back to the 1950s when Morris and Crawford (1958) observed higher rates of cardiovascular events and obesity in sedentary bus drivers in comparison to active conductors.

Lorry driver's lifestyle, in combination with their working environment embodies a constellation of risk factors for CVD. Whilst 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' cardiovascular health has been derived from studies undertaken in other countries; no information currently exists on lifestyle behaviours (including sitting time and physical activity) 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. A secondary aim was to examine markers of cardiovascular health and to profile drivers' mental health.

6.2 METHODS

6.2.1 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 wellbeing program. Data collection took place between May and August 2014. A volunteer sample of 159 drivers was recruited, representing 58% of the driving workforce. Drivers were recruited across all shift patterns: morning (6:00 to 14:00), afternoon (14:00 to 22:00) and night (22:00 to 6:00) on any day of the week. Participants without current self-reported 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.

6.2.2 Measurements

Refer to Chapter 3 page 99 to 102 for a full description of the socio-demographic, anthropometric, cardio-metabolic data measured in this study. Furthermore, refer to Chapter 3 page 102 to 104 for a full description of the activPAL-determined sedentary, standing and stepping data extraction and processing protocol.

6.2.3 Statistical analysis

Statistical analyses were conducted using SPSS v.22 (SPSS Inc., Chicago, IL, USA). All variables were checked for normality using the Shapiro-Wilk Test, which confirmed that the data were not normally distributed. Thus, non-parametric statistical tests were used throughout. Median and inter-quartile range (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 between workdays and non-workdays. Differences in outcomes between the three shift patterns (morning-06:00am-14:00-; afternoon -14:00 – 22:00-; and night -22:00 – 06:00) were explored using Kruskal-Wallis tests. Upon 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 minutes (this was chosen to comply with physical activity guidelines)(Department of Health, 2015). 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 physical activity and sitting behaviours (Mekary et al 2009; 2013).

The isotemporal substitution models were fitted to explore the impact of interchanging units of time spent sitting by any intensity of physical activity 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 represent the association of substituting a given unit of sitting time into each category, respectively (Mekary et al., 2009).

6.3 RESULTS

Table 1 displays participants' socio-demographic information, medical information and cardio-metabolic markers measured for the whole sample (N=159) and for the sub-sample (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 6.1). Out of 159 drivers, 84% were overweight or obese, 10% had diagnosed type II diabetes, 29% had pre-diabetes, 4% had undiagnosed diabetes, 34% had the Metabolic Syndrome, 27% were pre-hypertensive, 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.

Table 6.1. 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 sub-sample (n=87) who provided activity data.

	Total sample (Median (range)/number (%))	Sub-sample (Median (range)/number (%))	Differences (p value)
Age (yrs.)	50.0 (24.0, 67.0)	50(25.0, 65.0)	.504
Avg. working hours (h/week)	48.0 (27.0, 70.0)	48(27.0, 60.0)	.198
Ethnicity			.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			.019
GCSEs	71.0%	94.0%	
A-levels	9.0%	2.3%	
Other	11.0%	4.5%	
Medical Information			.833
CV-related medication (BP, Thrombosis, Cholesterol)	12.4%	11.4%	
Anxiety (borderline/abnormal)	31.0%	35.2%	.314
Depression(borderline/abnormal)	15.5%	17.0%	.872
Body Composition			
% Body fat	26.0(12.2, 44.5)	24.8(12.2, 43.3)	.200
Waist circumference (cm)	102.1(77.5, 146.5)	100.9(77.5, 141.0)	.412
Waist-Hip ratio (cm)	0.95(0.8, 1.1)	0.93(0.8, 1.1)	.100
BMI (kg/m^2)	28.8(19.6, 47.2)	27.7(19.6, 43.4)	.176
Blood Pressure			
Systolic blood pressure (mmHg)	129.0(108.5, 164.0)	129.0(108.5, 155.0)	.574
Diastolic blood pressure (mmHg)	81.0(63.0, 104.0)	81.0(65.0, 104.0)	.362
Heart rate (beats/min)	62.0(42.0, 89.0)	61.0(42.0, 89.0)	.292
Blood Markers (mmol/l)			
Fasting blood glucose	4.6(3.3, 11.3)	5.0(3.6, 8.1)	<.001
High density lipoprotein cholesterol	1.4(0.6, 2.6)	1.4(0.9, 1.7)	.578
Low density lipoprotein cholesterol	3.0(1.0, 5.7)	3.2(1.0, 5.4)	.151

Triglycerides	1.5(0.1, 6.9)	1.5(0.7, 4.3)	.142
Total cholesterol	4.9(2.6, 7.5)	5.1(2.6, 7.3)	.107
Lifestyle behaviours			
Avg. fruit and vegetables portions /day	5.0(0.0, 15.0)	4.3(0.0, 11.5)	.465
Alcohol units/week (n=111; sub-sample n= 88)	9.0(1.5, 60.0)	10.0(5.0, 60.0)	.129
Cigarettes/week (n=89; sub-sample n=55)	122.5(2.0, 700.0)	140.0(20.0, 700.0)	.291

Participants' accumulated a greater amount of sitting time on workdays compared to non-workdays (Table 6.2). Consequently, drivers accrued more standing time, and time in LPA on non-workdays. Nevertheless, participants acquired double the amount of time in MVPA on workdays than non-workdays.

Table 6.2. Sleeping, sitting, standing and stepping time and light and MVPA during workdays and non-workdays in a sample of lorry drivers from the East Midlands, UK (n=87)

	Workdays (Median (range))	Non-Workdays (Median (range))	Differences (p value)
Sleep time (mins/day)	399.8(158.0, 774.3)	576.8(258.6, 886.9)	**< .001**
Waking hours (mins/day)	1040.1(813.4, 1395.4)	861.2(465.6, 1181.3)	**< .001**
Time spent sitting (mins/day)	749.5(493.5, 1179.9)	463.1(258.0, 787.9)	**< .001**
Time spent standing (mins/day)	188.7(83.3, 414.2)	226.8(85.7, 501.9)	**< .001**
Time in light PA (mins/day)	85.3(48.0, 169.2)	97.6(27.2, 317.2)	**<.01**
Time in MVPA (mins/day)	12.6(1.4, 103.5)	6.0(0.0, 84.4)	**< .001**

Table 6.3 displays socio-demographic information, BMI, heart rate and activity data on workdays' for each shift pattern. Morning shift workers had greater sleeping times and lower sedentary times on workdays compared to the other shift groups. This group also exhibited significantly higher heart rates (Table 6.3). No other significant differences were observed between shift groups on workdays (Table 6.3) or non-workdays (data not shown).

Table 6.3. Median and range values for age, average working hours, BMI, heart rate 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)	Afternoon shift Median(range)	Night shift Median(range)	Differences (p value)
	n = 42	n = 21	n = 24	
Age (yrs.)	51.0 (27.0, 65.0)	48.0 (28.0, 58.0)	49.5 (25.0-60.0)	.471
Avg. working hours (h/week)	10.15(5.46, 12.5)	10.5(9.2, 14.24)	10.2(9.3, 14.33)	**<.05**
BMI (kg/m^2)	27.8(22.0, 38.7)	30.2(27.7, 43.4)	27.4 (19.6-38.6)	.507
Heart rate (beats/min)	64.5(42.0, 89.0)	61.0(47.0, 78.0)	58.5(42.0-80.0)	**<.001**
Sleep time (mins/day)	461.3(342.3, 626.6)	316.1(157.9, 774.3)	329.9(232.2-462.3)	**<.001**
Waking hours (mins/day)	995.0(813.4, 1116.7)	1063.2(942.2, 1395.4)	1095.7(977.7, 1207.8)	**<.001**
Time spent sitting (mins/day)	682.5(493.5, 853.9)	779.9(556.1, 1179.9)	785.9(680.3-884.1)	**<.001**
Time spent standing (mins/day)	177.6(91.62, 339.6)	174.6(90.0, 414.2)	194.0(133.3, 269.3)	.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)	.166
Time in MVPA (mins/day)	12.6 (1.4, 103.5)	10.0(2.0, 53.7)	15.2(3.5, 72.0)	.961

* All significant P values indicate a significant difference between the morning shift group and the other two groups.

Tables 6.4 and 6.5 show the results of the Isotemporal Substitution Models which examined the impact of interchanging units of time spent sitting with LPA, MVPA or sleep on cardio-metabolic markers on workdays, non-workdays. Substituting 30 minutes of sitting for MVPA was associated with a significant reduction in waist circumference, heart rate, triglycerides and HDL-cholesterol on workdays (Table 6.4). 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 minutes of sitting for light activity or MVPA on non-workdays. No significant associations were observed when in relation to substituting sitting time for any of the other activities on workdays and non-workdays together. Yet, a negative association was found between substituting 30 minutes of sitting with sleep on BMI and heart rate on non-workdays (Table 6.5).

Table 6.4. Association of substituting 30min of sedentary behaviour for LPA, MVPA or sleep time with measures of WC, BMI, Blood Pressure, 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 (cm)	-0.1(-1.4, 1.2)	.870	-0.6(-3.9, 2.7)	.707	-6.5(-11.0, -1.9)	**<.01**	0.1(-0.3, 0.5)	.500
BMI (kg/m^2)	0.07(-0.4, 0.6)	.775	-0.7(-1.9, 0.5)	.247	-1.5(-3.2, 0.2)	.089	-0.0(-0.2, 0.1)	.970
Systolic BP (mmHg)	0.6(-0.6, 1.9)	.338	-1.9(-5.1, 1.3)	.232	-1.1 (-5.5, 3.3)	.616	-0.3(-0.4, 0.4)	.885
Diastolic BP (mmHg)	0.6(-0.5, 1.7)	.313	-1.8(-4.7, 0.9)	.201	0.1(-3.8, 4.0)	.952	-0.2(-0.5, 0.2)	.280
Pulse (beats/min)	0.03(-1.1, 1.2)	.958	-1.9(-4.9, 1.0)	.199	-5.6(-9.6, -1.5)	**<.01**	0.1(-0.2, 0.5)	.529
Fasting Glucose (mmol/l)	0.01(-0.1, 0.1)	.905	0.1(-0.2, 0.5)	.470	-0.4(-0.8, 0.1)	.142	0.01(-0.3, 0.05)	.784
Triglycerides (mmol/l)	0.00(-0.1,0.1)	.940	0.06(-0.2, 0.3)	.687	-0.4(-0.8, 0.01)	**.051**	0.02(-0.01, 0.05)	.286
HDL Cholesterol (mmol/l)	-0.02(-0.06,0.01)	.247	-0.1(-0.2,-0.01)	.035	0.3(0.1, 0.4)	**<.01**	-0.01(-0.02, 0.01)	.314
LDL Cholesterol (mmol/l)	-0.04(-0.2,0.1)	.559	0.2(-0.1, 0.6)	.209	-0.1(-0.6, 0.5)	.748	-0.02(-0.07, 0.02)	.281
Total Cholesterol (mmol/l)	-0.6(-0.07,0.02)	.259	0.1(-0.2, 0.5)	.509	0.05(-0.4, 0.6)	.832	-0.2(-0.07, 0.02)	.259

Abbreviations: LPA, light physical activity, MVPA, moderate-to-vigorous physical activity. Coefficients represent the factor by which the cardio-vascular markers are multiplied by (95% confidence interval) for a 30min difference in the substituted physical activity behaviour.

Table 6.5. Association of substituting 30min of sedentary behaviour for LPA, MVPA or sleep time with measures of WC, BMI, Blood Pressure, 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 (cm)	-0.4(-1.2, 2.1)	.428	0.4(-1.3, 2.1)	.612	-0.8(-4.8, 3.2)	.695	-0.4 (-1.1, 0.5)	.215
BMI (kg/m^2)	0.1(-0.5, 0.2)	.369	-0.2(-0.8, 0.4)	.509	0.2(-1.2, 1.7)	.746	-0.3(-0.5, -0.05)	**.019**
Systolic BP (mmHg)	-0.3(-1.1, 0.5)	.497	0.3(-1.3, 1.9)	.683	-0.01 (-3.7,3.7)	.994	-0.6(-1.2, 0.1)	.076
Diastolic BP (mmHg)	-0.5(-1.2, 0.2)	.167	-0.5(-1.9, 0.9)	.462	0.3(-2.9, 3.6)	.839	-0.3(-0.9, 0.2)	216
Pulse (beats/min)	-0.6(-1.3, 0.2)	.151	-1.0(-2.5, 0.5)	.181	-2.6(-6.1, 0.8)	.131	-0.7(-1.3, -0.01)	**.023**
Fasting Glucose (mmol/l)	0.04(-0.05, 0.1)	.357	0.1(-0.1, 0.02)	.301	-0.3(-0.7, 0.1)	.149	0.01(-0.1, 0.1)	.828
Triglycerides (mmol/l)	-0.03(-0.1,0.04)	.417	0.07(-0.07, 0.2)	.303	-0.2(-0.5, 1.0)	.380	-0.02(-0.08, 0.04)	.500
HDL Cholesterol (mmol/l)	0.02(-0.01,0.05)	.281	-0.05(-0.1, 0.01)	.119	0.07(-1.0, 0.2)	.359	0.0 (-0.02, 0.03)	.732
LDL Cholesterol (mmol/l)	-0.08(-0.2,0.01)	.084	0.0(-0.2, 0.2)	.919	-0.01(-0.5, 0.4)	.946	-0.04(-0.2, 0.04)	.084
Total Cholesterol (mmol/l)	-0.08(-0.2,0.02)	.100	-0.03(-0.2, 0.1)	.887	0.03(-0.4, 0.5)	.887	-0.03(-0.1, 0.04)	.368

Abbreviations: LPA, light physical activity, MVPA, moderate-to-vigorous physical activity. Coefficients represent the factor by which the cardio-vascular markers are multiplied by (95% confidence interval) for a 30min difference in the substituted physical activity behaviour

To explore for potential collinearity basic correlations between all types of activity entered into the isotemporal substitution model (Table 6.4, 6.5) have been presented in Table 6.6. Weak inverse correlations were found between standing, light activity and sleeping time on non-workdays (p<.05). Fair correlations were found between standing and light stepping and moderate to vigorous stepping and sleeping (p<.05).

Table 6.6. Correlation coefficients between standing, light stepping, moderate to vigorous stepping and sleeping activities entered in the isotemporal substitution models.

	Standing	Light stepping	Moderate to vigorous stepping	Sleeping
Workdays				
Standing	1.000			
Light stepping	.498*	1.000		
Moderate to vigorous stepping	-.034	.007	1.000	
Sleeping	.103	-.179	.204*	1.000
Non-workdays				
Standing	1.000			
Light stepping	.421*	1.000		
Moderate to vigorous stepping	-.033	.050	1.000	
Sleeping	-.305*	-.241*	.106	1.000

*p<.05.

6.4 DISCUSSION

This cross-sectional study highlights the high-risk cardiovascular health profile and the high levels of objectively measured sitting time and low levels of MVPA amongst 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 to non-workdays (8 hours/day). Using an isotemporal modelling approach, this study indicates that reallocating 30 minutes of sedentary time to moderate-to-vigorous stepping, during workdays, and sleeping time, on non-workdays, was linked to favourable change of waist circumference, heart rate, triglycerides, HDL-cholesterol and BMI.

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 (Morris and Crawford, 1958; French et al., 2007; Wong et al., 2014; Varela-Mato et al., 2016), only one study used similar methods (Varela-Mato et al., 2016). Prolonged time sitting has been strongly related to higher rates of overweight and obesity, adverse cardiovascular biomarkers, premature mortality, the Metabolic Syndrome and depression (Wilmot et al., 2012; Teychenne et al., 2015; Edwardson et al., 2012). The present findings show that lorry drivers accumulate higher volumes of daily sitting on workdays in comparison to bus drivers (13hours/day versus 12hours/day), who have been found to be highly sedentary compared to the general population (Varela-Mato et al., 2016). Lorry drivers accumulated more sleeping time during non-workdays than seen in bus drivers (Varela-Mato et al., 2016), which could be understood as a compensational behaviour for the shortage of sleep during workdays. Indeed, several studies have shown that lorry drivers are a sleep deprived group, averaging 3.8 to 5.2 hours of sleep daily (Balkin et al., 2000; Dinges et al., 2005). This research also highlighted the high prevalence of physical inactivity; which has been defined as one of the major contributors to ill-health (Lee et al., 2012). Indeed, only 13% of the present sample were considered physically active, which is similar to lorry drivers from other countries (Apostolopoulos et al., 2013; Bigert et al., 2003; Robinson et al., 2005).

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. However, the protective effects of MVPA on health have previously been established (Biswas et al., 2015; Ekelund et al., 2016); 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.

Cardiovascular diseases are the largest cause of mortality in the UK accounting for 27% of all deaths (BHF, 2015). Occupational demands and unhealthy lifestyle behaviours give lorry drives a unique constellation of risk factors for CVD. Drivers from this study showed a higher prevalence of overweight and obesity compared to males aged 45-54 years in the UK (84% versus 79.4%)(PHE, 2013). Weight-related co-morbidities such as type II diabetes, pre-diabetes, hypertension and metabolic syndrome were also higher in this sample compared to the general population (PHE, 2010; PHE, 2013; Aguilar et al., 2015) or other occupational groups (Leischik et al., 2015) . 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 (Anderson et al., 2012). The present findings are in-line with research conducted on US lorry drivers (Thiese et al., 2015b) which demonstrate a high prevalence of unhealthy lifestyle behaviours, and increased risk factors for CVD. Indeed, US and UK data show that lorry drivers have a reduced life expectancy compared to other professions (Apostolopoulos et al., 2010; ONS, 2015). Despite the above evidence, lorry drivers are considered an underserved group in terms of health promotion efforts (Ng et al., 2015).

Lorry drivers endure a long working-hours culture which requires sustained attention for prolonged periods. Several internal and external factors such as strict schedules, timetables, road traffic, prolonged time sitting and shortage of sleep (as shown in this paper) induce drivers to cope with stressful situations on a daily basis. The rotating shifts and the duration of these can negatively impact family-work life-balance, resulting in a socially isolating job. These job-related constraints enhance continuous psycho-physiological arousal, resulting in serious levels of fatigue (Hamelin, 1987; Vivoli et al., 1993; van der Beek et al., 1995); hence the high incidence of mental-health conditions amongst this population (Shattell et al., 2012). In fact, 46% of the present sample were clustered as borderline or abnormal cases of anxiety and depression, which is higher than that seen in American lorry drivers (41.5%) (Shattell et al., 2012). However, most cases of mental ill-health within this occupational group reportedly go untreated (Apostolopoulos et al., 2010; Shattell et al., 2012). Sustained psycho-physiological arousal at work has been linked to cancer, ischaemic heart disease, accidents and poor mental health (Robinson and Burnett, 2005; Brunner et al., 2004; Pan et al., 2011; Grenon et al., 2012).

6.5 STRENGTHS AND LIMITATIONS

The cross-sectional design prevents us from making conclusions about causative links between sitting time and cardiovascular health. Secondly, as no Bonferroni correction was undertaken there is a chance that some of the findings from these models could be due to chance due to the multiple number of tests performed, therefore these analyses should be replicated in other populations. Thirdly, the sample was recruited from one transport depot in the East Midlands, which makes it difficult to generalise findings across the UK or abroad. Finally, data collection took place during summer time, which is the busiest time at this transport company. Exploring drivers' sedentary and physical activity 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 physical activity monitor which 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 cardiovascular health.

6.6 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. Interventions should also focus on increasing drivers' understanding of health behaviours such as diet and exercise through the implementation of education programs. Lorry drivers work within an intertwined system where the demands of economic productivity conflict with drivers' health (Caddick et al., 2016). Therefore, successful interventions also need the support of senior management to allow changes to the working environment aimed at improving lorry drivers' health. Health promotion should be prioritized and included within the company's health and safety programmes.

CHAPTER SEVEN

A Structured Health Intervention for Truckers: The SHIFT Pilot Study

This chapter specifically addresses thesis objectives:

8. Assess the effectiveness of an intervention designed to increase physical activity and reduce sitting time, on workdays and non-workdays, in a sample of lorry drivers.
9. Examine any preliminary effects of the intervention on lorry drivers' markers of cardiovascular health.

Chapter overview

This chapter reports a pilot study assessing the effectiveness of an intervention designed to increase physical activity and reduce sitting time, on workdays and non-workdays, in a sample of lorry drivers. A secondary aim of the study was to examine any preliminary effects of the intervention on lorry drivers' markers of cardiovascular health. This pilot study was designed as a single-group pre-post study which included a range of health assessments to test the preliminary effects of a multicomponent 12-week health intervention. The main outcomes were step counts and sitting time bouts assessed using the activPAL accelerometer. Body composition, blood markers and blood pressure were also assessed as secondary outcomes. Improvements were seen over the intervention period with measures of waist circumference, waist-hip ratio, fasting blood glucose, Low-density lipoprotein cholesterol, total cholesterol and reported fruit and vegetables intake per day.

The work outline in this chapter has been presented at an international conference:

- **Oral presentation:** “The Structure Health Intervention for Truckers: The SHIFT Study.” Varela-Mato V, Caddick, N, Edwardson C, King J, Yates T, Stensel D, Biddle S, Nimmo M , & Clemes S. ISPAH 2016, Bangkok.

7.1 INTRODUCTION

Long distance driving is recognised as an occupation that is detrimental to the health and well-being of employees (U.S. Bureau of Labor Statistics, 2010). Long distance drivers are exposed to a multitude of risk factors including long and variable working hours, prolonged periods of sedentary time, limited time available for physical activity, lack of healthy food choices on the road and erratic schedules which contributes to psychological stress and sleep deprivation (Caddick et al., 2016). These stressors have been linked with an increased risk of overweight and obesity, metabolic syndrome, diabetes, hypertension, heart disease, cancer, fatigue, stress, sleep disturbance, sleep deprivation and musculoskeletal disorders (Whitelegg, 1995; Bigert et al., 2003; Robinson & Burnett, 2005; Poirier et al., 2006; Frank et al., 2007; Lindstrom, 2008; Transportation Research Board, 2007; Wong et al., 2012; Apostolopoulos et al., 2013). Consequently, US data suggest that male lorry drivers have a life expectancy 12 years lower than the national average of 75.1 years (Apostolopoulos et al., 2010). Whilst no comparable data have been reported for UK lorry drivers, national statistics indicate that transport workers have among the lowest life expectancies compared to other professional groups (Office for National Statistics, 2011).

Despite the adverse health profiles seen in professional drivers (Apostolopoulos et al., 2010 Thiese et al., 2015), a recent systematic review of health promotion interventions in lorry drivers concluded that lorry drivers are an at-risk and underserved group in terms of health promotion efforts (Ng et al., 2015). To compound this, long distance drivers are also an ageing workforce, with the mean age of the UK driver population (n = 285,000) currently at

53 years (The Freight Transport Association, 2015). Whilst the small body of literature targeting lorry drivers' health behaviours has generally led to improvements in markers of health, most studies conducted to date have focused on improving health outcomes through weight loss and diet interventions (Ng et al., 2015; Thiese et al., 2015b), whilst limited research has targeted physical activity (Gilson et al., 2015) and no studies have targeted sedentary behaviour.

Sedentary behaviour is defined as "any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture" (Sedentary Behaviour Research Network, 2012). Sedentary behaviour is not the same as lack of physical activity (Sugiyama et al. 2008; Edwardson et al. 2012) as it has been established that these two behaviours exert independent effects on health. Sedentary behaviour has been associated with an increased risk of cardiovascular disease (CVD), cardiovascular mortality, all-cause mortality, diabetes and some cancers (Wilmot et al., 2012; Biswas et al. 2015). Chapter 5 highlighted that lorry drivers accumulate 13 hours of sedentary behaviour on workdays, and only small proportions of samples of lorry drivers (8%-26%) appear to be physically active (Apostolopoulos et al., 2010; Sieber et al., 2014). The high levels of sitting and the low levels of physical activity, along with poor cardio-metabolic health profiles seen in lorry drivers (Apostolopoulos et al., 2013; Ng et al., 2015), puts drivers at a greater risk of cardiovascular events and associated health conditions. A recent meta-analysis (Ekelund et al., 2016) indicated that high levels of physical activity (60-75 minutes/day of MVPA) seem to eliminate the increased mortality risks associated with high total sitting time, and even in those accumulating between 25 to 35 minutes/day of MVPA, the adverse health effects of prolonged sitting seemed to be attenuated. Despite this knowledge, as highlighted by data presented in Chapter 5, lorry drivers seem to accumulate 12 minutes/day of MVPA on workdays and 6 minutes/day during non-workdays. Achieving the recommended levels of MVPA per day (Department of Health, 2015) seems a bridge too difficult to cross amongst this very inactive and highly sedentary population (13 hours/day as shown in Chapter 5). Thus, as a , interventions should initially target reducing sedentary time and promoting light movement, as a stepping stone to lead to greater increases in PA.

The current study has been informed by knowledge gained from earlier observational research examining lifestyle behaviours of lorry drivers (including levels of physical activity and sedentary behaviour, Chapter 5), and by a series of qualitative interviews with drivers examining the facilitators and barriers to healthy lifestyle behaviours (Caddick et al., 2016, see appendix 11.5). Therefore, this pilot study aimed to assess the effectiveness of an intervention designed to increase physical activity levels towards the public health guidelines, taking into account participant's own baseline physical activity during workdays and non-workdays, in a sample of lorry drivers. A secondary aim of the study was to reduce sedentary time and to examine any preliminary effects of the intervention on lorry drivers' markers of cardiovascular health.

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7.2 METHODS

7.2.1 Study design and participants

A pre-post study design was adopted to examine the impact of a pilot multicomponent 12-week health intervention. This study design was chosen instead of a randomised control trial (RCT), as drivers were recruited from the same site and therefore contamination would be inevitable. This was implemented with a staggered design at a large UK-based transport company in the East Midlands, as part of an ongoing health and well-being programme of research undertaken in partnership with the company (Caddick et al., 2016). The health intervention, including the pre and post-health assessments took place between March and September 2015. 136 long distance HGV drivers were randomised into the study to ensure participation of drivers from all shift patterns: morning (6:00 to 14:00), afternoon (14:00 to 22:00) and night (22:00 to 6:00). Once drivers were randomised into the study they were able to opt out if desired (Figure 7.1 displays a flow chart representing drivers' uptake into the study). Drivers met with the researchers for a 2-hour health assessment at the beginning and end of the program and attended a 6-hour health education session 3 weeks after the baseline health assessment. Participants without current self-reported CVD, haemophilia, and any blood-borne viruses were included in the study. Ethical approval was obtained from the local Ethical Advisory Committee and all participants provided written informed consent.

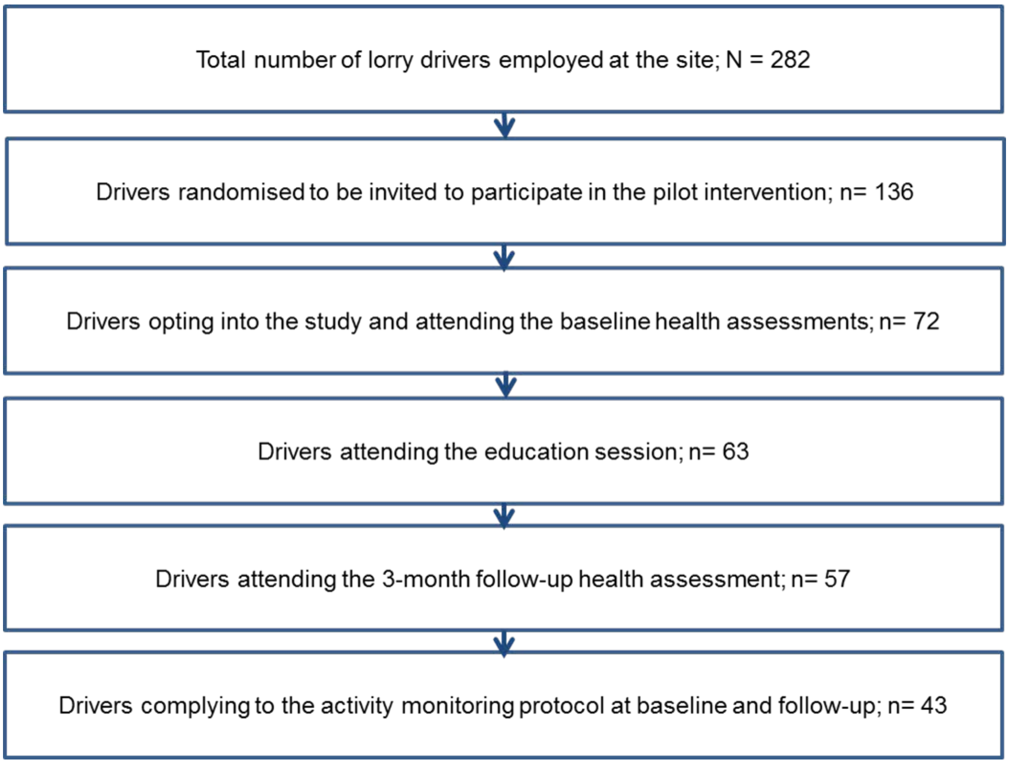
Total number of lorry drivers employed at the site; N = 282
Drivers randomised to be invited to participate in the pilot intervention; n= 136
Drivers opting into the study and attending the baseline health assessments; n= 72
Drivers attending the education session; n= 63
Drivers attending the 3-month follow-up health assessment; n= 57
Drivers complying to the activity monitoring protocol at baseline and follow-up; n= 43

Figure 7.1. Flow chart representing the lorry drivers' sample size and the uptake on the study.

7.2.2 Measurements of health biomarkers

Refer to Chapter 3 page 99 to 100 for a full description of the set of the markers of cardiovascular health assessed in this study. These measurements were taken at baseline and immediately following the 3-month intervention period.

7.2.3 The Intervention - A Structured Health Intervention for Truckers

The limited research available in health promotion amongst lorry drivers highlights the need for a multicomponent approach that facilitates lorry drivers' access to physical activity, healthy food and health information tailored specifically to their lifestyle (Ng et al., 2015). In addition, previous research has highlighted the importance of high levels of communication, social and management support to the drivers (Olson et al., 2009). Raising awareness on healthy lifestyle changes and the feasibility of applying this within drivers working patterns is of essence. As knowledge alone is insufficient to lead to health behaviour changes (Michie et al., 2014), social facilitation and access to a variety of activities throughout the intervention were the foundations of this program. Hence, this intervention comprises a complex design which aimed for the drivers to become more active, less sedentary and to improve their diet. The following strategies were introduced under the "SHIFT Study umbrella":

a) Counselling one-to-one: straight after the pre-intervention health assessments lorry drivers received their own results. Meaningful information about each biomarker (Fasting blood glucose, total cholesterol, triglycerides, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, waist circumference, BMI, systolic and diastolic blood pressure) was provided to the drivers; thus, during this session participants had the opportunity to discuss with the researcher potential health changes related to diet or exercise with the aim of improving those factors outside the healthy range.

b) The SHIFT education program: participants undertook a 6 hour structured education program, which provided them with information about diet, physical activity, sedentary behaviours, and general lifestyle involving alcohol consumption, tobacco use, sleep and stress (Table 6.1). These contents were specifically designed to cover the driver's needs, based on qualitative information gathered previously (Caddick et al., 2016). Feasible strategies to increase physical activity and improve diet during working hours were provided. Walking was promoted through the use of pedometers as a tool for self-monitoring and self-regulation. Tips to comply with the physical activity guidelines within the drivers working routine were also made available. The “small changes” philosophy using the SMART principle (Doran, 1981) was developed during this session and drivers were encouraged to establish their own action plan with Specific, Measurable, Attainable, Relevant, and Timely goals for the duration of the intervention (e.g. do not have any spread with the sandwiches; achieve 500 more steps per day…). During this session drivers were provided with 2 booklets, one containing a summary of the main messages from the session and another with tips about healthy exercising and eating as well as specific information about portions and snacking (Apendix 11.13 and 11.14). The education program was delivered by trained educators and was grounded in health behaviour change theories including Bandura’s social cognitive model (Bandura, 1986) and Leventhal’s common sense model (Leventhal et al., 1980). Informed by earlier qualitative research (Caddick et al., 2016), the education session was adapted from the DESMOND programme, which has been used successfully throughout the NHS for diabetes management (Davies et al., 2008; Yates et al., 2012).

Table 7.1. The SHIFT study timetable and summary of contents.

	Duration
Introduction/Housekeeping	15 mins
Driver Story: to learn about the drivers’ beliefs and perceptions about being at risk of health problems. To find out driver’s questions and concerns in relation to health and lifestyle to be discussed throughout the session.	30 mins
Risks and Consequences: to learn about lifestyle behaviours and their personal association with risk of health problems, taking into account their own health measures.	60 mins
Break	15 mins
Licensing, smoking, sleeping and depression: How smoking, poor sleep and depression can affect the drivers’ health and affect their licence.	25 mins
Physical Activity (+ Action Plan): to learn about the links between physical activity and health and prolonged time sitting and health; the physical activity recommendations and how to introduce physical activity within the daily routine, including trial of the cab workout; to encourage the use of pedometers to track daily activity. To discuss driver’s baseline physical activity levels (step count) and ways of increasing it. To design an action plan using SMART goals.	80 mins
Break	30 mins
Food (+ Action Plan): to learn about a healthy balanced diet (including snacks/food-on-the-go), including information about the recommended	90 mins

portion sizes and the 5 portions of fruit and vegetables a day guidelines; label reading and nutritional content; salt, sugar and fat recommendations. To design an action plan using SMART goals.	
Summary: to sum up the take home messages and to provide drivers with further advice on how to access ongoing care and support to achieve a healthier lifestyle.	15 mins

c) Cab-workout: This workout was designed to help drivers to increase their physical activity levels during their working hours. It is a combination of exercises using big muscle groups lasting for 20 minutes. Lorry drivers were provided with “cab-workout” equipment involving elastic bands, grip strength dynamometers, a peddle cycle and fitness ball, along with a booklet with examples of different exercises (appendix 11.13). The “cab-workout” was introduced during the education session and lorry drivers were advised to practice the workout during their breaks, and long waits where they were unable to leave their vehicle such as at certain stops for unloading/loading, where walking was not permitted.

d) Health coaching: as knowledge alone is insufficient to lead to health behaviour changes, opportunities for the drivers to keep with a healthier lifestyle were provided throughout the intervention by health coaches. During the intervention, researchers took on the role of health coaches, which aimed to keep motivation levels high and encourage drivers to continue with their small changes to improve health outcomes. The health coach was developed to provide drivers with easy access to health knowledge about physical activity and diet and to promote different activities through the intervention period.

e) Step challenges: as participants were provided with pedometers at the education session to facilitate self-monitoring and self-regulation, step count challenges were organised on a daily basis. During these activities drivers were grouped into teams and competed against each other or against their own baseline data.

f) Healthy pack lunches scheme: this was set up in coordination with the canteen service of the transport company. Healthy lunches were provided to drivers on a pre-order basis; this was heavily subsidised and included a full meal with drink and pudding. This was provided as an alternative to service stations' fast food.

In addition to these strategies, lorry drivers were provided with free membership at the company's gym for the duration of the intervention plus 3 months after the intervention. The company also provided those who won the step count challenges with a free 2 weeks pass for the drivers' appointed person (e.g. relative) at their local gym. Moreover, those aiming to lose weight and with a BMI >26kg/m^2 were offered a slimming world voucher for a 12 weeks course, which provided them with access to weekly meetings and general advice on diet.

7.2.4 Measurement of sitting, standing and physical activity

Sitting, standing and stepping time were measured objectively using an activPAL3 monitor (refer to Chapter 3 page 94 to 96 for a full description of the activPAL). The data activPAL-determined sitting, standing and stepping time was analysed applying a different method to that described in Chapter 3 (page 94 to 96) as a more advanced and automated method was developed prior to the start of this study. Full description of the applied methods is to follow:

Data from the activPAL were downloaded using activPAL Professional v.7.2.29 software (device firmware version 3.107) and processed using a validated automated algorithm in STATA (StataCorp. College Station, TX: StataCorp LP). This has been described in detail elsewhere (Winkler et al 2016) but in brief the algorithm uses the activPAL event files to isolate waking hours from 'sleeping' (time in bed), prolonged non-wear periods and invalid data. A valid day was defined as a day with <95% of time spent in any one behaviour (e.g., standing or sitting), >500 steps were accrued across the day and ≥10 hours of waking hours data. Participants were required to have at least four valid days of data to be included in the analysis. Following processing, data were visually checked using 'heatmaps' of activity and any data that looked like potential sleep that had not been removed by the algorithm was checked with the self-reported diary times and corrected if necessary. This happened on occasion due to waking sitting/lying bouts sometimes being longer than sitting/lying bouts during sleep in this particular population due to the nature of their employment. Output variables included average time spent sitting/lying , average time spent (hours/day) in sitting/lying bouts of 0-29minutes, 30-59 minutes, 60-119minutes and ≥120minutes, standing, stepping, number of steps per day and average waking wear time. For each participant, stepping time was further classified into MVPA (by summing the minutes in which participants accumulated >100steps/minute) (Marshall et al., 2009; Rowe et al., 2011) and light activity (LPA, stepping time minus MVPA). Those accumulating ≤30 minutes/day of MVPA were considered physically inactive (Department of health, 2015). The sitting bout length at which 50% of sitting time was accumulated was calculating using accumulation curves (proportion of total sitting time (Y-axis) plotted against each bout of sitting time in increasing duration (X-axis)) (Chastin and Granat, 2010).

The primary outcome of this intervention was physical activity levels, expressed as steps per day (objectively measured by the activPAL3). Drivers from this study were encouraged to have active breaks and accumulate more steps during non-working hours with the aim of increasing their physical activity. Secondary measures included sedentary time, weight, BMI, percent body fat, waist circumference, waist-hip ratio, blood markers (LDL, HDL, TC, FBL, TGs) and blood pressure. Using these measures another secondary outcome was to improve the 10 year CVD risk (QRISK2) factor. Other secondary measures were anxiety and depression scores, fruit and vegetables intake per day, average of alcohol consumption per week, average of tobacco use per week.

7.2.5 Statistical analysis

Statistical analyses were conducted using SPSS v.22 (SPSS Inc., Chicago, IL, USA). All variables were checked for normality using the Shapiro-Wilk Test, which confirmed that data were normally distributed. Thus, parametric statistical tests were used throughout. Mean and standard deviations (SD) values were computed for all variables. Change in biomarkers including body measurements, blood pressure, blood markers and lifestyle behaviours (fruit and vegetables intake, alcohol consumption and tobacco smoked) were assessed using paired-samples t-test. Changes in activity data including sitting, sitting bouts, standing, light stepping and MVPA during workdays and non-workdays were also assessed using paired-samples t-tests. Linear regression models were fitted to explore the relationship between changes in waist circumference, overall step counts per day, step counts on workdays, step counts on non-workdays and cardio-metabolic markers. These were adjusted to control for potential cofounding variables such as age, ethnicity, education levels, shift pattern, smoking, alcohol intake and fruit and vegetable consumption. The linear coefficient represent the association of substituting one unit of waist circumference (cm), overall step counts per day (1 unit = 1000 steps per day), step counts per workdays (1 unit = 1000 steps per day), and step counts during non-workdays (1 unit = 1000 steps per day). Changes in percentage of drivers with pre-diabetes and with >10% risk of CVD in the next 10 years (QRISK) between pre and post-intervention were assessed using a paired sample t-test. Differences between those who completed the intervention and those who did not were explored for the above mentioned variables using independent sample t-tests. Changes in the “usual” bout of sedentary time between pre and post-health intervention were calculated using a paired sample t-test.

7.3 RESULTS

Figure 6.1 presents the flow of participants through the study. Out of the 72 male drivers that agreed taking part in the intervention and attended the baseline health assessments, 15 did not attend the 3 month follow-up (mean (SD), age: 53.4(3.4) years; BMI: 29.9(2.4) kg/m^2). Therefore, 57 drivers (age: 49.5(9.1) years; BMI: 29.3(4.7) kg/m^2) completed the pre and post health assessments. Those not completing the study had a significantly higher systolic and diastolic blood pressure (SBP: 11.5(2.6) mmHg; DBP: 9.9(2.4) mmHg; $p<.001$), higher alcohol consumption and smoked less cigarettes per week than those completing the study (units of alcohol: 7.0(3.1); $p<0.05$); cigarettes; 83.1(33.0), $p<.05$). Out of the 57 drivers, 43 (age: 50.5 (8.5) years; BMI: 28.4(3.9) kg/m^2) provided additional valid activPAL data at both assessment time points. (Table 7.2 displays participants' demographic and health status information)

Table 7.2. Participants' demographic and health status information. Mean (SD) or percentage pre and post-test values are shown for average working hours and medical information.

	n	Baseline (Mean (SD)/number (%))	3 month follow-up (Mean (SD)/number (%))	P value
Age (yrs.)	57	49.5 (5)		
Marital status	57			
Single		7.0%		
Married or partnered		77.1%		
Separated or divorced		15.8%		
Avg. working hours (h/week)	57	50.0 (3.5)	50.0(3.3)	.905
Ethnicity	57			
White European		95.3%		
Asian/Asian British		4.7%		
Highest level of Education	57			
GCSEs		83.3%		
A-levels		8.3%		
Other		8.4%		
Medical Information	57			.105
CV-related medication (BP, Thrombosis, Cholesterol)		17.4%	9.5%	
Musculoskeletal issues		15.5%	19.0%	
Asthma		8.7%	7.1%	
Other health conditions		17.4%	7.1%	
Anxiety (borderline/abnormal)	57	8.9%	4.3%	**.031**
Depression (borderline/abnormal)	57	2.2%	5.7%	**.027**

Out of 57 drivers, at baseline 88% were physically inactive , 84% were overweight or obese, 78% were pre-hypertensive or hypertensive (5%), 23% had the metabolic syndrome, 29% had pre-diabetes, 12% had undiagnosed diabetes, 7.5% had diagnosed diabetes and 24% possessed >10% risk of having a cardiovascular event in the next ten years. Table 7.3 also presents the changes in health assessment measures between baseline and 3 month follow-up. Overall, positive changes between the pre and post health assessments were found for waist circumference, waist-hip ratio, heart rate, FBG, LDL-C, TC, average fruit and vegetables consumed per day ($p<0.05$, Table 7.3). These positive changes resulted in 12% reduction of drivers who possessed >10% risk of having a cardiovascular event in the next ten years, 21% reduction of drivers with pre-diabetes, 8% reduction of drivers with undiagnosed diabetes and 8% reduction of drivers with the metabolic syndrome ($p<.05$).

Table 7.3. Mean (SD) or percentage pre and post-test values are shown for the body measurements, blood pressure, blood markers and lifestyle factors for the sample of UK lorry drivers completing the study (N=43).

	n	Baseline (Mean (SD)/number (%))	3 month follow-up (Mean (SD)/number (%))	P value
Body Composition				
% Body fat	57	25.5(5.4)	25.3(5.7)	.904
Waist circumference (cm)	57	104.2(12.5)	101.9(12.7)	**<.01**
Waist-Hip ratio (cm)	57	1.0(0.1)	0.9(0.1)	**<.001**
BMI (kg/m^2)	57	29.3(4.7)	29.3(4.9)	.954
Blood Pressure				
Systolic blood pressure (mmHg)	57	129.5(11.9)	128.3(12.5)	.604
Diastolic blood pressure (mmHg)	57	82.2(8.7)	80.4(10.1)	.047
Heart rate (beats/min)	57	65.5(10.6)	63.3(9.2)	**<.001**
Blood Markers (mmol/l)				
FBG	57	5.3(1.0)	4.8(0.9)	**<.001**
HDL-C	57	1.4(0.4)	1.4(0.4)	.208
LDL-C	57	3.2(1.3)	2.4(0.7)	**<.001**
TG	57	2.1(1.2)	2.3(1.4)	**.036**
TC	57	5.1(1.4)	4.2(0.8)	**<.001**
TG-HDL ratio	57	1.7(1.2)	1.8(1.3)	.166
QRISK	57	23.8	11.9	**.047**

Diabetes status				
Pre-diabetes	57	28.6	7.7	**<.001**
Undiagnosed diabetes	57	8.2	0	**<.001**
Metabolic Syndrome	57	26.2	18.5	**.021**
Lifestyle behaviours				
Avg. fruit and vegetables /day	57	4.6(3.0)	5.4(2.5)	**.014**
Alcohol units/week	40	13.1(12.1)	15.3(15.10)	.130
Cigarettes/week	15	149.4(79.2)	148.4(87.59)	.915

Table 7.4 reports the changes in activity variables between baseline and 3 months follow up. Compared to baseline at 3 months follow-up lorry drivers spent more time in sitting bouts of 0-29 minutes (hours/day) (p<.05). No significant differences in daily step counts were observed between baseline and follow-up. However, further analysis showed that 35 out of 43 (81%) participants displayed an increase in daily step counts at follow-up (1381.1 (1794.2) steps/day during workdays and 1784.8(3767.4) steps/day on non-workdays; p<.001).

Table 7.4. Mean (SD) or percentage pre and post-test values are shown for sitting time, sitting bouts and physical activity data for the sample of UK lorry drivers completing the study (N=43).

	n	Baseline (Mean (SD)/number (%))	3 month follow-up (Mean (SD)/number (%))	P value
Overall				
Sitting time (hours/day)	43	10.4(1.4)	10.8(1.6)	.148
Sitting bouts				
0-29minutes (hours/day)	43	4.1 (1.0)	4.6(0.9)	**.015**
30-59 minutes (hours/day)	43	2.3(0.7)	2.2(0.7)	.489
60-119 minutes (hours/day)	43	2.2(1.0)	2.2(0.9)	.995
≥120 minutes (hours/day)	43	1.7(1.0)	1.7(0.9)	.838
Standing (hours/day)	43	3.8(1.1)	3.8(0.9)	1.000
Light stepping (hours/day)	43	0.9(0.3)	0.9(0.3)	.631
MV Stepping (hours/day)	43	0.1(0.1)	0.1(0.1)	.993
Total steps per day	43	8786.1(2919.0)	9541.3(3183.7)	.093
Workdays				
Sitting time (hours/day)	43	12.1(1.6)	12.4(2.2)	.490
Sitting bouts				
0-29minutes (hours/day)	43	4.0 (1.3)	4.6(1.5)	**.031**
30-59 minutes (hours/day)	43	2.5(0.9)	2.5(1.2)	. 670
60-119 minutes (hours/day)	43	2.9(1.4)	2.8 (1.1)	.527
≥120 minutes (hours/day)	43	2.6(1.8)	2.5(1.4)	.342
Standing (hours/day)	43	3.2(0.9)	3.2(1.2)	.994
Light stepping (hours/day)	43	1.2(0.2)	1.2(0.2)	.817
MV Stepping (hours/day)	43	0.1(0.1)	0.1(0.1)	.938
Total steps per day	43	8114.0(2579.5)	8748.1(2795.7)	.086
Non-Workdays				
Sitting time (hours/day)	43	8.7(2.1)	9.2(2.2)	.391
Sitting bouts				
0-29minutes (hours/day)	43	4.6 (0.9)	4.3(1.3)	.204
30-59 minutes (hours/day)	43	2.2(1.1)	2.0(0.8)	.256
60-119 minutes (hours/day)	43	1.7(1.5)	1.6(1.1)	.777
≥120 minutes (hours/day)	43	0.6(1.1)	0.9(1.3)	.177
Standing (hours/day)	43	4.3(1.5)	4.3(1.7)	.928
Light stepping (hours/day)	43	1.4(0.5)	1.3(0.4)	.524

MV Stepping (hours/day)	43	0.1(0.1)	0.1(0.1)	.972
Total steps per day	43	9291.3(3966.6)	10155.8(4454.7)	.252

Table 7.5 presents the linear regression models exploring the association between waist circumference, overall step counts per day, step counts during workdays and non-workdays and FBG, HDL-C, LDL-C, TG, TC and TG-HDL ratio. One unit increase in waist circumference was associated with changes in HDL-C (-.01, p=.034), TG (.04, p=.017) and TG-HDL-ratio (.05, p=010) (p<.05). One unit increase in step counts during workdays was positively associated with changes in HDL-C (.04, p=.034).

Table 7.5. Linear regression model exploring the association changes in waist circumference and overall step counts, step counts during workdays and non-workdays on FBG, HDL-C, LDL-C, TG, TC and TG-HDL ratio.

	FBG B(95%CI)	p value	HDL-C B(95%CI)	p value	LDL-C B(95%CI)	p value	TG B(95%CI)	P value	TC B(95%CI)	P value	TG-HDL ratio B(95%CI)	p value
Waist Circumference	.03(-.00, .06)	.083	-.01(-.02, .00)	**.034**	-.00(-.02, .02)	.705	.04(-.01, .08)	**.017**	.00(-.02, .01)	.558	.05(-.01, .08)	**.010**
Overall steps per day	-.02(-.16, .11)	.744	.02(-.01, .06)	.509	-.14(-.08, .05)	.679	-.08(-.21, .06)	.250	-.00(-.07, .06)	.879	-.10(-.25, .04)	.159
Workday steps per day	-.03(-.19, .13)	.720	.04(.00, .09)	**.034**	-.01(-.09, .08)	.822	-.11(-.28, .06)	.191	-.01(-.07, .10)	.191	-.14(-.31, .03)	.105
Non-workday steps per day	-.01(-.01, .09)	.791	-.01(-.02,.04)	.473	-.01(-.06, .04)	.742	-.04(-.15, .06)	.396	-.00(-.05, .04)	.762	-.06(-.17, .05)	.298

Abbreviations: FBG, fasting blood glucose, HDL-C, high-density lipoprotein cholesterol, LDL-C, low-density lipoprotein cholesterol, TG, triglycerides, TC, total cholesterol, TG-HDL ratio, triglycerides-high-density lipoprotein cholesterol.

Figure 7.2 shows that on average (mean (SD)) lorry drivers accumulated approximately half of their daily sitting time in bouts lasting 46.5(0.5) minutes at baseline, whilst this significantly reduced at 3 months follow-up to 42.8(0.3) minutes (p<0.001).

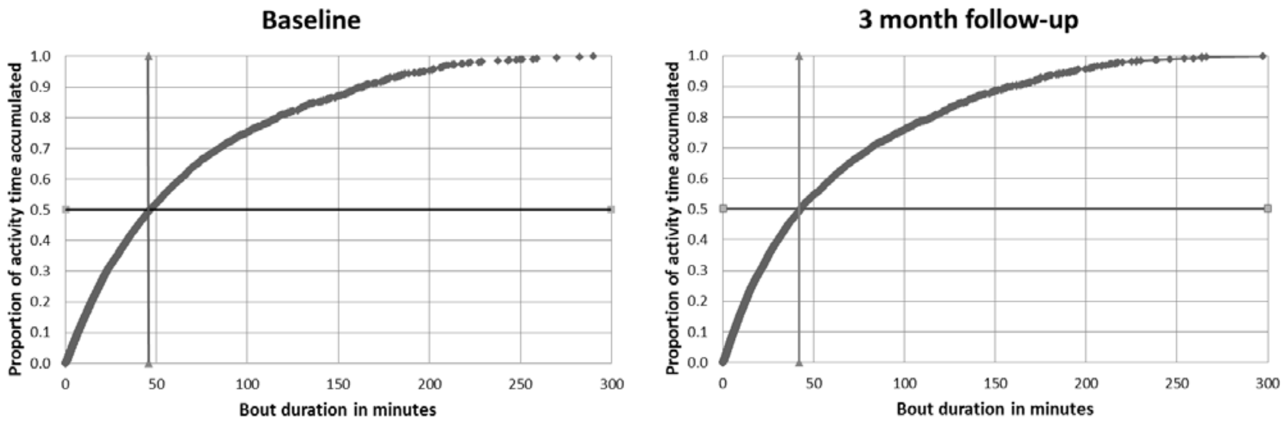

Figure 7.2. Percentage of sedentary time accrued in bouts of increasing duration across the whole sample at baseline and 3 month follow up (n=43).

7.4 DISCUSSION

This pilot study examined the effects of a multicomponent intervention on physical activity, sedentary behaviour and markers of health, measured in a sample of lorry drivers. The findings suggest that this novel intervention lead to positive changes in waist circumference, waist-hip ratio, FBG, LDL-C, TC and reported daily fruit and vegetables intakes. Further linear regression analysis indicated that changes in HDL, TG and TG-HDL ratio were associated with changes in waist circumference and step counts during workdays.

Similar to the findings in other countries (Sangaleti et al., 2014; Apostolopoulos et al., 2011; Gilson et al., 2016), these UK drivers presented a wide range of chronic disease risk factors such as high levels of sedentary time, inactivity, unhealthy cardio-metabolic profiles, overweight and obesity at baseline. Participants enrolled in this study significantly reduced their waist circumference and waist-hip ratio, which have been described as superior measures of CVD risk compared to BMI (Yusuf et al., 2005; Vazquez et al., 2004). De Koning and colleagues (2007) in their meta-analysis reported that reductions of 1 cm around the waist and 0.01 cm in WHR were associated with a 2 and 5% reduced risk of cardiovascular events, respectively. Participants from this intervention reduced their waist circumference by 2.5 cm and their waist-hip ratio by 0.1 cm, which has been defined as clinically meaningful (De Konning et al., 2007). Similar results were only observed by Olsen et al (2009), in which intervention drivers presented a 3.5cm waist circumference reduction at the end of their 6 month intervention.

Limited interventions have focused on improving lorry drivers' lipid profile (Ng et al., 2015) and of the research available, this has been mostly focused on reducing total cholesterol (Holmes et al., 1996). Positive changes in fasting blood glucose, LDL cholesterol and total cholesterol were achieved across the whole sample. These changes had further implications in validated clinical indexes such as the fasting blood glucose classification (Diabetes UK, 2016) or QRISK2 (Hippisley-Cox et al., 2008). Out of the 15% of drivers that initially were classified as pre-diabetic or diabetic, only 5% were clustered as diabetic at 3 months. The NICE guidelines (2014) recommend prioritising people for a full risk assessment if their estimated 10-year risk of CVD is 10% or more. 24% of the sample displayed ≥ 10% risk of

CVD, yet this was significantly reduced to 12% at 3 months. This is of significant importance considering the high prevalence of cardiovascular events seen in lorry drivers compared to the general population (Apostolopoulos et al., 2010; Thiese et al., 2015a).

The isolated nature of lorry driving and the limited opportunities for drivers to fulfil a healthy lifestyle means that drivers must perform most aspects of any health intervention without assistance or very limited social reinforcement. Further, strict schedules, road traffic, shortage of sleep, rotating shifts and the duration of these can negatively impact family-work life-balance, resulting in a socially isolating job. These job-related constraints enhance continuous psycho-physiological arousal (Hamblin, 1987; Vivoli et al., 1993; van der Beek et al., 1995); resulting in development of various mental-health conditions that seem prevalent amongst this occupational group (Shattell et al., 2012). Anxiety and depression were not outcomes of this study, yet significant changes were observed after the three months intervention. However, these clinical disorders were only assessed using a screening tool (Zigmond and Snaith,1983) and no further conclusions can be made. Future research investigating this issue further is strongly recommended.

Increasing drivers understanding about their own health behaviours, providing them with self-monitoring tools such a pedometers and facilitating health coaching sessions on a regular basis is of high importance. This intervention is a continuation of previous quantitative and qualitative studies (Chapter 5 and appendix 11.5) conducted in a large sample of UK lorry drivers from the same company. During these phases, lorry drivers were involved in the development and design of the intervention through public involvement events and by participating in qualitative research, which informed the intervention. This is the first study to involve the company's management team to facilitate drivers with opportunities conducive of healthier behaviours such as free membership to the gym on site, healthy pack lunches and paid time off for the drivers to attend their health assessments and the education session. In addition, this intervention is the first delivered at a transport company that has been informed by the drivers themselves (Caddick et al., 2016) using evidence-based theories to promote health behaviour change (Bandura, 1986; Leventhal et al., 1980; Yates et al., 2012). It is likely that this approach had a positive effect on the retention levels at the 3-month follow up, as 79% (n= 57 drivers) of the sample who attended the baseline health assessments completed the 3 month follow-up health assessments. This retention rate was higher than that observed in others studies, where retention rates have been below 50% (Gilson et al., 2015; Ng et al., 2015).

Most interventions in this population to date have focused on weight loss with established targets independent of the participant's baseline assessments (Olson et al., 2009; Ng et al., 2015; Thiese et al., 2015). Thiese and colleagues (2015a) reported the highest weight loss in their study (-5.1kg), in which they aimed to test the feasibility of a 12 week intervention for long-haul truck drivers (n=12). Similar to the present study, this intervention provided drivers with weekly health coaching and driver specific materials focused on healthy eating, exercise equipment and tips for a healthy lifestyle. Contrary to the present study, Thiese and colleagues set up a target of 10% weight loss for every driver, which only 4 drivers achieved. This is against the SMART goal theory (Doran, 1981) in which the present study was based, which promotes realistic and achievable goals to avoid disengagement and the feeling of failure.

To date only one intervention, apart from the present one, measured lorry drivers' activity using an objective measure (Gilson et al., 2015). Gilson et al. examined chronic disease risk in Australian truck drivers and assessed driver's use of smartphone technology during a 20-week physical activity and dietary intervention. Despite drivers rating their health as good to excellent, 68% were obese, 63% were hypertensive and 45% were on medication or had a medical condition. Due to the design of this intervention, which relied entirely on drivers logging information about their diet and physical activity levels weekly, only 19 out of 44 completed the whole program. Physical activity was assessed using a step tracker monitor; results showed no significant changes in step counts over the 20 week intervention.

Whilst the protective health effects of MVPA are well known (Warburton et al., 2006), complying with the physical activity guidelines (Department of Health, 2015) seems a bridge too difficult to cross amongst highly sedentary populations (Tucker et al., 2011). The feasibility of substituting sedentary time by equal amounts of MVPA amongst subjects with the metabolic syndrome, type 2 diabetes, overweight or obesity has been questioned previously (Duvivier et al., 2013); as it seems that these individuals seem to negatively respond to imposed-intensity bouts of acute exercise (Ekkekakis et al., 2006). Drivers from this sample were encouraged to increase their physical activity levels through increasing their step counts based on their own baseline data and their daily routine as a strategy to improve their health outcomes. Although, physical activity did not significantly change during workdays and non-workdays at 3 months follow-up, linear regression models suggest that positive changes in HDL-C were associated with increases in step counts during workdays. Previous research indicated that introducing low intensity activities such as walking at a leisurely pace and standing more often is an effective strategy to improve cardio-metabolic health parameters in sedentary subjects (Duvivier et al., 2013). Indeed, 81% of this sample increased their step counts during workdays and non-workdays at 3 months. Those who did not increase their step counts (n=8) tended to report consuming more fruit and vegetables at baseline, however this was the only difference.These findings are of interest for future interventions and have important implications for overweight and obese individuals, for which increasing their step counts might be a more feasible strategy initially rather than accruing increases in MVPA.

7.5 STRENGTHS AND LIMITATIONS

Given the pilot nature of the present study, limitations of this work include the relatively small sample, the lack of a control group and the lack of a post-intervention follow-up assessment. Our data are also restricted to lorry drivers recruited from a single workplace within the East Midlands. Despite these limitations, this study is the first of its kind to assess a multicomponent intervention targeting physical activity and sedentary behaviour in a sample of UK lorry drivers. The study piloted the effectiveness of the intervention on a variety of outcome measures. Future research should build on this pilot work by examining the effectiveness, and cost-effectiveness, of this intervention using a robust cluster randomised controlled trial, using lorry drivers from multiple sites.

7.6 CONCLUSION

Unacceptable levels of health issues and chronic conditions have been observed in lorry drivers. Due to their “hard to reach” status, limited health interventions have been implemented within this occupational group. Of the limited research available, none has involved the drivers themselves in the design of the intervention or the management team in the implementation of the intervention. This chapter highlights the feasibility of implementing a multicomponent health intervention within the transport setting and provides preliminary evidence of beneficial effects of the intervention on some markers of drivers’ health. The multicomponent design provides lorry drivers with a variety of opportunities for them to engage in health behaviours based on their own priorities and goals. Future research should test this pilot study in a larger scale and more ethnically varied population.

CHAPTER EIGHT

A Structured Health Intervention for Truckers (SHIFT): A process evaluation of a health intervention in a transport company

This chapter specifically addresses thesis objectives:

10. Assess the implications of setting up a health intervention in a transport company
11. Evaluate lorry drivers responses to the health intervention
12. Determine potential changes to the pilot study for future larger scale interventions

Chapter overview

This chapter reports a process evaluation study where the primary aim was to provide a detailed understanding of the Structured Health Intervention for Truckers (SHIFT) programme described in Chapter 7. This is a complex intervention due to the numerous components integrated into the program, the main aim of which was to improve lorry drivers' lifestyle health behaviours such as sitting behaviour and physical activity (expressed as the number of steps/day), with the longer term goal of improving drivers cardio-metabolic health. The implications of setting up such an intervention are discussed in this section, which covers aspects such as designing the intervention, how participants received the program, implications of working within a large scale company and fitting the study within their operational demands, and recommendations for future studies of similar characteristics.

8.1 INTRODUCTION

Previous research (Apostolopoulos et al., 2010, 2013, Lemke et al., 2015; Wong et al., 2012) has identified a range of health risks and conditions associated with the occupation of lorry driving including hypertension, hyperlipidaemia, diabetes, cancer, sleep apnoea and sleep deprivation, musculoskeletal and gastrointestinal disorders, and symptoms of psychological distress. Associated with many of these conditions is an increased prevalence of overweight and obesity among lorry drivers, estimated to be in the region of 57-87% of drivers worldwide (Apostolopoulos et al., 2010; Moreno et al., 2006; Puhkala et al., 2014; Thiese et al. 2015). Lorry drivers' lifestyle involves several factors which predispose them to the above health problems including long and irregular work hours, pressurised delivery schedules, traffic and stressful working conditions, lack of opportunity for physical activity, lack of availability of healthy food at service stations and the compulsorily sedentary nature of the job (Apostolopolulos et al., 2013; Passey et al., 2014).

Given the fact that lorry drivers as a professional group have among the lowest in life expectancies in the UK (Saltzman & Belzer, 2007; ONS, 2011), the high prevalence of obesity and other health problems constitutes both a major public health issue and a failing of workplace health promotion. However, there are still few published studies reporting on health promotion interventions targeted specifically at lorry drivers (Ng et al., 2015). Interventions have generally led to improvements in markers of health; yet they have mostly focused on improving health outcomes through weight loss and diet interventions (Ng et al., 2015).

Taking into account both the scale of health risks and problems facing lorry drivers, and the relative lack of health promotion efforts focusing on lorry drivers – particularly in the UK where such efforts appear absent – interventions to promote health in UK lorry drivers are sorely needed. The aim of this chapter is to provide a process evaluation of the intervention reported in Chapter six: the Structured Health Intervention for Truckers (SHIFT) programme.

As described in Chapter six, The SHIFT programme is a pilot trial of a new health intervention for lorry drivers and was delivered at a transport company based in the East Midlands (UK) with an initial sample of 72 drivers (see Table 7.1 below for driver demographics). However, only the data from those who attended the education session were included in the analysis. Further information about the design of the intervention is described in chapter 6.

In this chapter some of the challenges involved in conducting a health promotion intervention within a transport company are explored by conducting a qualitative process evaluation. Process evaluations explore the implementation, receipt, and setting of an intervention to provide contextual information regarding how and why an intervention either succeeded or failed to produce change in the participants (Oakley et al., 2006). Process evaluations may include an assessment of several factors including the views of the participants on the intervention, how the intervention was delivered and the context or environment in which the intervention was conducted. Moreover, process evaluations can help investigators determine whether an intervention was delivered as intended (fidelity), what barriers or difficulties might have been encountered in implementing the intervention, and whether or not contextual factors played a role in the success or failure of the intervention (Oakley et al. 2006). As such, process evaluations have been described as an essential component of designing and testing complex interventions whereby there are many potential ‘active ingredients’ and methodological challenges (Oakley et al., 2006; Moore et al., 2015).

The questions we attempted to answer as part of the process evaluation were as follows: a) how did the drivers respond to the intervention (e.g., in regards to interest, perceived relevance, acceptability, willingness to participate)?; b) what role did the context of the transport company play in the implementation of the intervention?; and, c) what challenges were encountered by the researchers in conducting the intervention in this setting? Answering such questions will provide valuable contextual information regarding the practicalities of conducting health interventions with lorry drivers, who are considered as a hard to reach occupational group. As noted above, there are many aspects of the lifestyle of a professional lorry driver that make it difficult to adopt regular physical activity and healthy eating practices. Furthermore, the operational environment of a large transport company is quite complex, with complicated planning arrangements and delivery schedules that need to be maintained, as well as frequent training updates and the difficulties of managing a large driving workforce. Therefore, delivering even a relatively ‘straightforward’ complex health intervention in the context of a transport company has the potential to become quite a complicated affair. In order to consider how programmes like the SHIFT pilot might be feasibly, reliably, and successfully implemented to help promote drivers’ health, it is therefore essential to consider the factors which effected the implementation of SHIFT and the processes through which it was conducted.

8.2 METHODS

Following approval by the University's research ethics committee, several sources of information were used to collect data on the processes involved in implementing SHIFT. Firstly, drivers' views on the programme were assessed mid-way through the 3 month intervention period using a brief semi-structured interview format. A sample of 16 drivers were selected to take part in these 'debrief interviews', based on availability during 3 shift patterns (Night -22:00 to 06:00-, Morning – 6:00 to 14:00, Afternoon -14:00 to 22:00) whereby the researchers spent time in the company's transport office to interview drivers. Sample questions included "What did you think of the SHIFT education session you attended?" and "Have you been able to make any lifestyle changes following the SHIFT education session?"

Second, a focus group interview with transport managers (n = 3) and an individual interview with a transport planner were conducted to assess the overall execution/implementation of SHIFT and whether the pilot programme could be implemented company-wide. In the focus group, sample questions included: "Were you able to support the drivers in their participation in the SHIFT programme? If so, how?" and "Were there any aspects of the SHIFT programme that proved operationally difficult to implement or manage?" In the individual interview with the transport planner, questions were focused on practical aspects of scheduling drivers to take part in the intervention with regard to planning and logistics. The interviews and focus groups were digitally recorded using a microphone and transcribed verbatim including all of the fillers (e.g. um, er) and non-verbal communication (sighs, laughter, claps, pauses, coughs) before being subjected to a thematic analysis (Braun & Clarke, 2006). As a first step in the analysis, the data were read and re-read as a way of immersing in the participants' stories. Segments of the text that were relevant to the research questions were then highlighted and categorised based on the following themes: drivers' responses to the programme and contextual challenges in implementing Shift. The text was then loosely coded to highlight specific words, phrases, or textual segments which were related to specific topics and refined into the sub-themes presented within the two main categories of discourse abovementioned.

Third, observations and reflections of the two lead researchers (NC and VVM) were recorded and used to evaluate the challenges involved in carrying out the SHIFT intervention within the company. These observations and reflections took the form of field notes recorded during and after the SHIFT education sessions and throughout the intervention period, and post-intervention reflections on the program's implementation (Sparkes & Smith, 2014). The observations and reflections were added to the thematic analysis and woven into the process evaluation report.

8.3 PROCESSES IN SHIFT PROGRAMME IMPLEMENTATION

The process evaluation report is divided into two main sections detailing a) drivers' responses to the SHIFT programme and b) contextual challenges involved in implementing the programme in the transport company setting.

8.3.1 Drivers' responses to the programme

A number of themes were identified which encapsulated the drivers' general response to the SHIFT program. These themes are described as "*hard-to-engage*", "*positive responses to the program*", "*raising awareness and reinforcing health messages*", and "*stimulating change*". Below, data are used from the debrief interviews, along with reflections and observations from the researchers, to discuss each of these themes as it related to the implementation of SHIFT.

Hard-to-engage

Generally speaking, drivers' attitudes towards participation in the program reflected a group that was 'hard-to-engage' (Pringle et al., 2013, 2014), which created difficulties during the initial (recruitment) stages of the project. This particular sample of lorry drivers have experienced regular and frequent health promotion campaigns run by the company's Health Action Team, yet due to the characteristics of their job, engagement remains low. Therefore, as part of the recruitment and promotion process, the researchers (NC and VVM) spent a considerable amount of time in the drivers' lobby of the company's transport office, engaging and communicating information to the drivers regarding the implications and the benefits of taking part in the SHIFT program. Participants were later randomly selected from the overall workforce and scheduled to take part in the program on an opt-out basis (Figure 7.1, Chapter 7, page 167).

Typical responses we received during this phase of the study reflected a degree of scepticism about the work we were doing and about our capacity to make changes within the company which would increase opportunities for healthy living, as several drivers commented: “You’re working with your hands tied behind your back” or “You might as well pack up and go home now.” Indeed, the drivers commonly asserted that the constraints of their working lives – particularly in regards to working hours – were the primary reasons for unhealthy lifestyle practices, and that these constraints were not amenable to change through our intervention (Caddick et al., 2016).

There was also a perception amongst the driving workforce that drivers in general were “stuck in their ways” and would always be resistant to attempts to effect change in their lifestyles; as the following quote from one of the program participants highlights:

> *A lot of them are stuck in their ways and I said to them [SHIFT educators] “You’ll be wasting your time with a lot of the drivers here.” I mean, I don’t know how many drivers signed up for it [SHIFT program] but I bet a lot of them were like “Ohhhh, I ain’t doing that!” (LDP52)*

Even amongst some of the drivers who agreed to participate in the program, our well-intentioned, non-directive and participant-focused interactions could still be construed as unwelcome “preaching” of health messages by drivers resistant to change:

> *I’m the sort of person that the more people preach to me, the more I dig my heels in. (LDP10)*

Such responses might be considered as typical of men who seek to resist the repeated 'imposition' of over-zealous health promotion messages, for example by the media (Gough & Conner, 2006).

Positive responses to the program

Despite drivers in general resembling a 'hard-to-engage' population, there was ample evidence that participation in the SHIFT program helped to transform drivers' attitudes towards health and that the program was enjoyed and valued by participants.

> *[It was] really good. I didn't expect it – I was apprehensive about it, thinking it would be a waste of time, this and that. But once I was on it and the information you immediately gave me – it was . . . even though you're think you're fit, it's still quite shocking some of the stuff you can improve on. (LDP69)*

> *I enjoyed it all. I didn't go into it looking to enjoy it sort of thing. I was just gonna see what I could do to not enjoy it really – I've done lots of things like that. But no – they [educators] were very good, very entertaining and good with putting the information out there. (LDP11)*

> *I thought it was very good and informative. We all hear these things on the televisions and to varying degrees take notice. But it's actually when you're in the [SHIFT education] session that you can be a bit more focused on it. And I did find it astounding that when we are delayed or at these premises [deliveries/warehouses]*

> *for a long time, just simply standing is better than sitting, which is good because we do have plenty of time to stand rather than sit. (LDP21)*

These positive responses provide some indication that the program was considered appropriate by the drivers, that the education they received was pitched at the right level and was informative, and that drivers were encouraged to reflect on their lifestyles and consider incorporating changes. However, due to the design of the study there is also the possibility that drivers who responded positively were already predisposed to promoting their own health; a possibility we explore further below.

Raising awareness and reinforcing health messages

One of the key themes we derived from the debrief interviews with the drivers was that the SHIFT program helped to raise awareness of various dietary hazards and of the importance of increasing one's levels of physical activity, in particular walking (Yates et al., 2012). In addition, the program helped to reinforce key health messages (e.g., 5-a-day, reducing fat and sugar intake, increasing daily 'step-count', physical activity guidelines) with which the drivers were familiar but upon which they had been slow to act. This theme of 'raising awareness' is evident in the following data extracts from the debrief interviews:

> *It puts it at the front of your mind rather than at the back . . . just being more aware of my health and what I'm putting into my body (LDP11)*

> *Just more self-aware of what I'm eating and what I'm doing really. I wanna live a bit longer than 65 or whatever so you've got to do something haven't you. (LDP46)*

> *Some of the stuff I thought I knew I didn't know, I didn't know nothing about that. So that was quite an eye opener as well. (LDP69)*

As these extracts illustrate, participating in the SHIFT programme helped improve the drivers' awareness of the health risks associated with poor diet and inactivity, challenged some misconceptions they held previously, and helped to reinforce the importance of persevering with efforts to implement lifestyle change.

Stimulating change

One of the key themes we identified was termed 'stimulating change' and captured the extent to which participating in SHIFT helped drivers to change their lifestyle habits. Two sub-themes are incorporated within this theme (acceptability of intervention components, and the question of sample bias), and these will also be discussed below.

> *It kind of gives you that little push because you actually know what's going on, instead of thinking "Ahhh, I'm fit as a fiddle" you think – don't you, but until you actually see the results you don't really physically know, do you? So yeah, it gives you that slight little push. (LDP46)*

As this quote demonstrates, participating in SHIFT and receiving the results of a full health assessment during the SHIFT education session stimulated drivers' intentions to change their lifestyle behaviours and to try to improve their scores on the various health outcome measures. Therefore, during this session, drivers had the opportunity to discuss their own results (if desired) with their peers and the educators and seek advice on how to integrate lifestyle changes within their daily routine. In addition, drivers also frequently described being successful in making specific "small changes" to their daily routines such as walking more both outside of work and during in-work delays, cutting down portion sizes and making healthier food choices.

> *Generally now – I get out more and I do a bit of walking about. I think – instead of sitting here for an hour, I go for a walk for an hour and I come back – wherever I am. (LDP46)*

> *I've changed my margarine to Flora low cholesterol stuff. And my food intake now, I know when I've had enough – I don't eat a lot, I'd only have like – today when I go out, I've got one sandwich and I'll eat two bananas a day. And all I drink is juice with water, non-sugar stuff – so yeah, I'm doing alright. (LDP35)*

> *I do try and do as much sort of activity as I can. I'm wearing the pedometer and I keep checking that every day . . . It's a way of checking really – you just don't realise. (LDP48)*

> *It spurred me on and I watched everything I ate for – till yesterday and then I just seemed to crash – don't ask me why [laughs]. But I've already got it in my mind that that's not gonna stop me, I'm gonna get back on with it. (LDP59)*

Participants frequently expressed surprise that they could potentially improve their health by making small changes to their lifestyles such as standing and walking more during the day, and by making healthy food ‘swaps’ such as brown bread instead of white, and water instead of fizzy drinks. They mainly spoke of changing their lifestyles “slowly but surely” in order to improve their health behaviours. Some drivers even described making substantial efforts at lifestyle change in order to bring their weight under control and achieve better health:

> *I’ve cut down on portion sizes and I’ve joined the local gym as well. So I’m just going all out now. And now my partner is talking about the traffic lights stuff on food – so keep avoiding the red stuff and keep going for the green stuff. I bring smoothies into work as well now. And since the session I’ve stopped eating chocolate, I’ve not had any coke. I used to have a chocolate bar every day and about two or three cans of coke. I’ve not had any of that. (LDP66)*

Accordingly, feedback from the drivers indicates that the SHIFT program was successful in prompting lifestyle changes among the drivers.

Sub-theme: Sample bias?

To avoid the sample bias, participants were randomly selected from the overall driver workforce, although they were given the opportunity to opt-out of the program. It is possible therefore that those who decided to participate were already interested in lifestyle change and were contemplating efforts to improve their health when the program began (as shown in the quote below – LDP52); with the rest of this “hard-to-engage” group remaining unengaged.

> *I'd already put everything in place beforehand and I'd just been sticking to it since. (LDP52)*

> *NC: Did you come away from the session with a plan of any changes that you wanted to put into practice?*
> *LDP68: Not necessarily because I'm already doing that anyway but it's just reinforced them – to keep it up . . . It's kept me on the right track.*

As indicated previously, the SHIFT program appeared to successfully change some drivers' attitudes toward health, improving their awareness of health risks, and encouraging them to do more to promote their own health. Moreover, it even helped to transform the behaviours of some drivers who might previously have been described as "hard-to-engage". However, the possibility of some elements of a self-selecting sample bias cannot be discounted.

***Sub-theme: Acceptability of intervention components*.**

The drivers commented during the debrief interviews on various components of the intervention, with these comments providing useful evaluative statements that helped us understand the acceptability of SHIFT to driver participants.

Firstly, the SHIFT education session was evaluated positively by the majority of drivers interviewed. One driver commented, for example:

> *I genuinely actually quite liked it. Quite informative, we all learnt a lot, plus it was a bit of a giggle – it wasn't too serious was it? Yeah, I thought it was very useful. (LDP46)*

Similarly, drivers were on the whole receptive to the opportunity for a health assessment and receiving feedback on a range of health outcomes:

> *It brings health to the forefront of your mind and especially with some of the measurements, which is quite nice. Free health check? Carry on! Because at my age – 48, 49 in June, I have to start thinking of these things. (LDP4)*

Feedback regarding the cab workout enabled us to determine what worked and what didn't in regards to the equipment provided and exercises recommended. For instance, drivers generally responded well to the resistance bands and reported using them when delayed or on a break, but the resistance balls were viewed as awkward and cumbersome to carry around:

> *I'm only using the Therabands because it's the easiest thing to carry. The ball, I know you have to keep blowing up the bloody thing. I know you can collapse it and re-inflate it but the theraband's easy – just fold it up and put it in your bag. (LDP4)*

> *I've not actually used the ball yet because I don't really get a great deal of time on a [loading] bay because most of the time I'm unloading myself. But when I have my breaks I'm using the therabands. But I'm using the grip strengths every day. (LDP66)*

The peddle cycle devices were also quite poorly taken up by the drivers, again for practical reasons (see comment below); although some drivers indicated that the uptake would improve if peddle cycles were part of the cabin's furniture:

> *The peddle thing, they're just too flimsy, they're just all over the shop. I haven't used them very much. (LDP11)*

Amongst some of the drivers, use of the cab workout kit was viewed as unacceptable because it was perceived to interfere with rest-time during the working day:

> *When you have your break at work, you just need a rest really. (LDP55)*

> *On my break I have me kip – I go to sleep or read the newspaper. (LDP10)*

In order to optimise the cab workout for future interventions, it should be noted that the grip strength tools and resistance bands were viewed as lightweight, accessible and practical but the resistance balls and peddle cycle machines were viewed as cumbersome and impractical. Drivers may also benefit from further encouragement to utilise opportunities for being active in ways that do not compromise rest-time (e.g., during delays on arrival at a customer).

With regards to acceptability, it is also notable that there was a very low take-up of drivers on the "healthy lunches" scheme, and this was eventually discontinued by the catering staff who helped set it up. Feedback from drivers who declined to participate in this scheme (whereby drivers paid a subsidised £1.50 for a sandwich or salad, a piece of fruit, and a bottle of water), was that the lunches would not provide enough sustenance for a 12 or 13 hour shift in the lorry and that there was a limited range of food choice options on the healthy lunches menu. In addition, the “healthy lunches” scheme was set up during the busiest time of the company, which conflicted with the drivers’ schedules and many didn’t know when to order the packed lunch for because they were required to order it the week before; with drivers generally preferring to bring their own. Accordingly, future schemes might consider how healthier choice food options can be made more varied, appealing, appetising, and satiating for lorry drivers.

8.4 CONTEXTUAL CHALLENGES IN IMPLEMENTING SHIFT

Several themes describe the challenges we faced in implementing the SHIFT programme within the contextual setting of the transport company. These themes were “operational demands”, “communication”, “participant burden”, and “cost-benefit”. Below, we use our own observations and reflections – along with data from the interviews and focus group – to describe the nature of these challenges and steps we took to overcome them and/or limit their influence on our pilot study.

Operational demands

One of the most significant challenges we encountered was accommodating our data collection (i.e., the health assessments) in the midst of the company’s complex operational demands. To complete a full health assessment took 2 hours per driver, and planning the drivers to attend these health assessments when the company had tight delivery schedules that needed to be maintained proved to be difficult. Indeed, due to a chronic shortage of drivers within the wider transport industry (Road Haulage Association, 2015), problems with short-staffing meant that the company had little opportunity to release the drivers for the time required to attend the health assessments. As such, there was a situation of competing priorities whereby the transport managers wanted to support the pilot study and facilitate the health assessments, yet on occasions this was incompatible with the company's operational activity. As a result, data collection had to be extended for an extra month and half because, in the case of some drivers, health assessment appointments had to be cancelled last minute because they were required to start their shift immediately. As such, we frequently had to re-schedule drivers for the health assessments. In the focus group session, the transport managers acknowledged that planning 60 drivers to attend a 2-hour health assessment would always be challenging operationally. One way to mitigate this challenge in the future may be to work with transport staff in charge of planning operations from the first stages of conceptualising a health intervention, and to ensure that intensive periods of data collection do not clash with periods of increased operational demand (e.g., summer months, during the Christmas and holiday season).

Communication with drivers

Finding the most effective means of communication with the drivers proved to be challenging throughout the intervention. We first encountered this challenge during the recruitment phase of the pilot study. One of the main problems with communication was the transient nature of the workforce. Drivers in the company start their shifts at all different times of the day and night (each driver has a two hour "start-window" when they can be called in), only passing briefly through the transport office at the start of their shift to pick up their keys and paperwork, and then again at the end of their shift to clock-out.

Communicating face-to-face with the drivers (which was generally perceived by the company and the researchers (NC and VVM) as one of the more effective modes of communication) thus proved challenging, and required the researchers to spend several days camped out in the drivers' lobby – over several shift patterns to cover the 24-hour working period – in order to maximise the number of drivers with whom we could communicate. This approach was utilised in the first instance in order to provide drivers with the necessary information about the study (i.e., what we were doing and why, how to get involved, when the intervention would begin). However, despite its effectiveness, we were unable to utilise it on an ongoing basis as our primary means of communication due to the frequency with which drivers needed to be provided with information about the study, and the time-intensive nature of this strategy. This should be taken into consideration for future interventions if resources are available, because this would imply having a researcher on site permanently.

We also provided the drivers with written briefs regarding the project by placing information leaflets and project updates in the drivers' pigeon holes. We found this strategy to be relatively ineffective because the drivers were typically 'information-saturated' with training updates and management operations, and tended to dismiss information not pertinent to their core duties without much consideration, although this improved slightly by placing the information in recognisable envelopes with the SHIFT logo on it. Mid-way through the intervention, we also erected a dedicated "SHIFT study notice board" in the transport office, and filled it in with information about the project and an eye-catching display intended to draw the drivers' attention. We placed project updates on the notice board, and when combined with pigeon-hole information, this became a more effective strategy as the study went on and more of the drivers' workforce became aware of what we were doing. Finally, for all drivers who took part in the study, we obtained telephone and email contact details so that we could arrange the health assessments directly and send project updates. The combination of these last two strategies proved the most effective and feasible means of communicating with the driving workforce.

Participant burden

Another barrier/challenge we encountered was the perceived burden on participants of taking part in the study. This burden mainly related to the health assessments whereby participants were required to undertake an 8-hour fast (for a finger prick test measuring blood glucose), and to wear two activity monitoring devices for a 7-day period. The fasting caused problems especially for the night-time drivers (22:00 to 06:00), who would wake-up in the early afternoon and start their shift in the evening, having not been allowed to consume anything except water before coming into work. Whilst all drivers were allowed time to consume a meal prior to heading out in the lorry, the canteen was not open during the night shift and at certain hours during the day, and fasting proved uncomfortable or too much of a nuisance for some drivers. In addition, the activity-monitoring devices (an accelerometer attached to an elasticated belt fitted around the waist, and an inclinometer taped to the middle of the thigh) were generally viewed as uncomfortable or irritating, and thus some drivers were reluctant to take part when they realised what the data collection entailed. Ultimately, and linking back to the above point about possible sample bias, it may have been that drivers who were motivated to take part were willing to put up with the mild inconveniences of fasting and wearing the devices in order to reap the anticipated benefits of taking part in the intervention. However, the participant burden related only to the data collection, and not to the intervention itself. As such, the implementation of the SHIFT programme by a company by itself (i.e., without the evaluation measures involving activity monitoring and blood sampling) would be unlikely to encounter these barriers.

Cost/benefit

Less of a “challenge” per se, but of clear importance to the managers as described in the focus group session, was a cost/benefit analysis that favoured implementation of the SHIFT program. The final cost/benefit will clearly be dependent on the study results – including the feedback from participants as outlined in this process evaluation. The key costs which the company needed to balance were the costs of releasing staff from regular duties to attend the 6-hour education session (and the additional time costs of the health assessments), and the expense of funding the SHIFT program itself. Central to justifying these costs will be whether the SHIFT program was able to make significant differences on our core outcome measures, and long-term, whether participation is associated with a reduction in sickness absence and an improvement in employee well-being.

8.5 DISCUSSION

This chapter reported a process evaluation of a new health intervention for lorry drivers. The results illustrate support for the SHIFT program from the perspective of the participants, and provide the context and background against which the intervention outcomes must be interpreted (Oakley et al., 2006). In particular, this process evaluation demonstrated that SHIFT was considered acceptable by participants, and that participating in SHIFT helped to raise drivers’ awareness of key health issues and helped to stimulate changes in their lifestyles. For example, drivers reported becoming more aware of how their day-to-day activities regarding food choice and physical activity impacted on their health, and expressed a desire to improve their lifestyles. They also reported making concrete changes to their working routines such as walking/standing more on breaks and when delayed at a customer, and using exercise equipment provided to them as part of a novel ‘cab workout’.

The findings provide important evidence that tailored health promotion interventions can be effective in engaging drivers and in stimulating changes in their lifestyle behaviours. This is significant given that drivers are often considered to lack the necessary tools for making positive changes because of their restrictive working environments (Passey et al., 2014). Moreover, the observation that drivers responded positively to the SHIFT pilot program and found it acceptable and relevant is especially promising given the lack of currently available health promotion efforts with drivers in the UK. Drivers are, as Apostolopoulos et al. (2013) put it, “vulnerable to a plethora of health risks and are also a medically underserved population” (pg. 121-122), and therefore the SHIFT pilot study constitutes a positive step in the direction of improved driver health and well-being.

Our findings are also relevant to work in the area of workplace health promotion (Harden, Peersman, Mauthner & Oakley, 1999; Malik, Blake, & Suggs, 2014; Rongen, Robroek, Lenthe, & Burdorf, 2013). Health interventions for lorry drivers differ from those in other work environments due to the “off-site” nature of the job and that “workplace-bound” interventions are not applicable (Puhkala et al., 2014). Workplace health promotion with lorry drivers therefore entails that researchers find ways of overcoming practical barriers (e.g., a lack of safe spaces for physical activity, lack of available healthy food options) that drivers face out on the road. In addition, due to the nature of their job, it is important researchers build up a relationship with the drivers, which offers genuine support and applicable advice on how to carry on small changes towards a healthier lifestyle. The various components of the SHIFT program were intended to address these barriers, for example by providing drivers with exercises they could do within their lorry cabs and by providing a healthy lunch scheme. Our findings demonstrate that certain components of the 'cab workout' kit were considered suitable by drivers (i.e., Therabands/resistance bands and grip strength tools) but that other components were not considered suitable including pedal cycle machines and resistance balls. We also learned that – consistent with previous research (Gill & Wijk, 2004; Jack, Piacentini & Schroder, 1998) – drivers require healthy food options that are considered appealing and satisfying enough to "keep them going" for a 12 or 13 hour shift. Further consideration of how to overcome this particular barrier would be important for future health interventions with drivers.

Strengths of the SHIFT program that may have helped to successfully reach out to drivers include that health information was tailored to the specific health needs and challenges faced by lorry drivers, thereby making it relevant and acceptable to a large number of our target population (Harden et al., 1999). In addition, this health intervention provided drivers with long-lasting tools and techniques that will enable them to pursue a healthy lifestyle during their daily routine. Correspondingly, a weakness of the pilot study was a failure to engage a proportion of the drivers in our efforts at health promotion. Indeed, we were not able to demonstrate that SHIFT was able to reach out to our entire target audience due to the number of drivers that declined to participate and remained "hard-to-engage". Further work needs to be done in order to find ways of engaging with this group of drivers who likely remained highly sedentary and constitute an "at-risk" population in terms of lifestyle-related diseases. One strategy to engage this population may be to use popular and more acceptable activities (e.g., football) as a 'hook' to engage men in health promotion in ways that appeal to them. Pringle et al. (2013, 2014), for example, demonstrated much success in engaging men in health promotion activities when programs were delivered through the guise of English Premier League football clubs (e.g. the Football Fans in Training campaign - FFIT - http://www.ffit.org.uk/index.php). Having health programs associated with the 'club badge' and delivered at club grounds helped to stimulate interest in health promotion among men who otherwise would not have participated and would be considered as "hard-to-engage" (Pringle et al., 2013). Taking such strategies into transport companies – places that employ a large number of potentially "hard-to-engage" men – and promoting them on-site may be one way to improve the uptake of drivers in health interventions.

Another potential way of reaching out to more drivers may be to train and employ driver 'health coaches' as proxy conveyors of health promotion efforts. This has been discussed among the study authors as a way of increasing employee ownership (Harden et al. 1999) over health promotion efforts, and as a way of continuing to capitalise on the momentum for health promotion generated through SHIFT. One rationale for having drivers themselves as conveyors of health information and encouragement is that – for some drivers – they may constitute more appropriate/impactful health promotion *messengers* (Smith, Tomasone, Latimer-Cheung, & Martin-Ginis, 2015). That is, drivers possess a familiar credibility based on the fact that they share the same barriers and challenges to healthy living as other drivers, and they are more likely to share trust and camaraderie with other drivers that may be missing in interactions with managers and/or health professionals (Caddick et al., *2016;*). Under the guidance and training of expert health professionals, drivers acting as ‘driver health coaches’ might therefore be able to engage with other drivers who would otherwise decline to take part in health promotion initiatives.

8.6 CONCLUSION

Taking account of both the strengths and weaknesses of the SHIFT program, results of this study provide important learning that may usefully inform the future development of health interventions for drivers (Pringle et al., 2014). We have demonstrated that the SHIFT program is relevant and acceptable to drivers, and that it can be effective in raising awareness and stimulating lifestyle change among participants. The SHIFT program should now be evaluated on a larger scale, including at other transport companies, and tested through fully randomised controlled trials.

CHAPTER NINE

Overall discussion

Chapter overview

This final chapter closes the thesis by discussing the findings of the overall thesis in the context with the literature, it acknowledges strengths and limitations of the thesis, and includes suggestions for future research.

9.1 CONSOLIDATED FINDINGS OF THIS THESIS

This thesis was designed to investigate sitting time and physical activity patterns in samples of bus and lorry drivers in the UK. In addition this thesis aimed to profile lorry drivers' cardiovascular health and to explore any links between this and drivers' sitting time and physical activity behaviours. In addition this thesis includes pilot testing of the intervention and a process evaluation of the intervention. Therefore this thesis comprises 5 distinct but interlinked studies, which objectives and related findings are highlighted in table 9.1.

Table 9.1 Objectives and related findings of the thesis

Number	Objectives	Chapter	Key findings
1.	To ascertain the feasibility of measuring bus drivers sedentary behaviours using an activPAL inclinometer to directly measure drivers' sitting and non-sedentary behaviours over the course of a week.	4	• 85% of the sample adhered to the activPAL protocol and provided sufficient data (≥10 hours of wear on 4 days) to be included in the analyses.
2.	To quantify the prevalence of bus drivers sitting and non-sedentary behaviours during and outside working hours.	4	• Bus drivers spent 75% (12 hours) of their waking time on workdays sitting and 62% (9 hours) of their waking time sitting on non-workdays. • 83% of the time at work was spent sitting compared to 68% of non-working hours during workdays ($p<0.001$) • 5% of the time on workdays was spent stepping versus 8% on non-workdays ($p<0.01$).
3.	To profile bus drivers basic markers of cardiometabolic health.	4	• Bus drivers displayed higher than the recommended ranges for BMI (28.1±5.8 kg/m^2), % body fat (26±9), waist circumference (101.5 ± 21) and Systolic (137±14) and diastolic blood pressure (88±11). • Bus drivers unhealthy cardiovascular markers

			coupled with the high levels of sitting time and low levels of physical activity puts them at an increased risk of a cardiovascular event.
4.	To explore the validity of accelerometer-determined sedentary time using different cut-points (<50cpm, <100cpm, <150cpm, <200cpm, <250cpm, <300cpm) in comparison to activPAL measured sitting in a free-living sample of bus drivers.	5	• Relative to the activPAL, the ActiGraph significantly underestimated sedentary time during workdays when using the <50 cpm, <100cpm and the <150cpm cut-point, and significantly underestimated sedentary time during working hours when applying any of the cut-points • During non-workdays and non-working hours the ActiGraph significantly overestimated sedentary time when applying all the cut-points, except for when using the <50cpm threshold • The area under the ROC curve for the ActiGraph during workdays showed poor discrimination of sedentary time compared with the activPAL (ROC= .617). Despite all cut-points showing better sensitivity than specificity, sensitivity values did not reach a sufficient level (ROC sensitivity values <.620, specificity values <.498) • The area under the ROC curve for the ActiGraph during non-workdaysshowed fair discrimination of sedentary time compared with the activPAL (ROC= .706). Despite all cut-points showing better sensitivity than specificity, all cut points failed to correctly identify sitting time compared with the activPAL (ROC

			sensitivity values <.602, specificity values <.278)
5.	To behaviourally phenotype UK lorry drivers sitting time and non-sedentary behaviours during workdays and non-workdays	6	• Lorry drivers accumulate 13 hours sitting on workdays and 8 hours on non-workdays (p< 0.001). This is higher than that reported in bus drivers. • Drivers spent a greater time standing and in light activity on non-workdays compared to workdays (Standing: 226.8 min versus 188.7 min, p< 0.001; Light: 97.6 min versus 85.3, p<0.01). • Higher MVPA was accrued during workdays compared to non-workdays (12.6 min versus 6 min; p< 0.001) • Morning workers (06:00 to 14:00pm) accumulated greater sleeping time than workers from the other shifts (p< 0.001). They also accumulated the lowest amount of time sedentary compared to others (p< 0.001).
6.	To examine markers of cardiovascular health and to profile drivers' mental health.	6	• 84% were overweight or obese, 10% had diagnosed type II diabetes, 29% had pre-diabetes, 4% had undiagnosed diabetes, 34% had the Metabolic Syndrome, 27% were pre-hypertensive, 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. • Furthermore, 15% and 31% were considered to have borderline or abnormal scores

			for depression and anxiety, respectively. - The average age was 50 years and 12% were taking CV-related medication.
7.	To explore associations between time spent in sedentary and non-sedentary behaviours (standing, light and MVPA) and cardiovascular health in lorry drivers	6	- The isotemporal substitution model indicated that interchanging 30 minutes of sitting by an equal amount of MVPA on workdays would reduce lorry drivers' waist circumference (-6.5 cm), heart rate (-5.6 beats/min) and triglycerides (-0.4mmol/L) and would rise HDL-cholesterol by 0.3mmol/l.
8.	Assessing the effectiveness of an intervention designed to increase physical activity and reduce sitting time, on workdays and non-workdays, in a sample of lorry drivers.	7	- The length of the "usual" sitting time bouts reduced significantly at 3 months. (50% of the time: -3.7minutes; 25% of the time: -6.3 minutes; 25% of the time: -5 minutes)
9.	A secondary aim of the study was to examine any preliminary effects of the intervention on lorry drivers' markers of cardiovascular health	7	- At 3 months significant reductions were found for waist circumference (-2.5cm), waist-hip ratio (-0.1cm), heart rate (2beats/min), FBG (-0.6 mmol/L), LDL-C (-0.7 mmol/L), TC(-0.7 mmol/L).
10.	To assess the implications of setting up a health intervention in a transport company	8	Several challenges were identify when designing and setting up the intervention: - Operational demands: due to shortage of drivers, releasing them for 2 hours for the 2 health assessments proved difficult, and on a regular basis appointments had to be cancelled and re-schedule last minute. - Staggered design of the study to fit the company's schedule (with frequent re-adjustments). Overall, the 3 months intervention lasted for 6 months.

			• The lack of understanding and scepticism about the study by members of the transport team, made recruitment and data collection difficult. • Communication with drivers: due to their “passer-by” activity at the transport office, recruitment and promotion proved challenging. Contacting drivers implied combining different strategies for an efficient transmission of the message. • Participant burden: fasting for 8 hours pre-health assessments, wearing 2 monitors to assess their activity for 7 days afterwards and lack of time to have a proper meal after the assessment. • Cost/benefit: realising the drivers for the health assessment and the education session would imply extra costs to the company, yet it might be seen as a worthwhile investment for healthier workforce.
11.	To evaluate lorry drivers responses to the health intervention	8	A number of themes were identified which encapsulated the drivers’ general response to the SHIFT program: • Hard to engage: high levels of scepticism, which had to be overcome by a great amount of promotion and interaction with the drivers. • Positive responses to the program: this indicates drivers considered it appropriate, informative, and which encouraged them to reflect on their lifestyles and consider incorporating changes. • Raising awareness and

			reinforcing health messages: drivers indicated that participating in the intervention helped them to raise their awareness of the health risks associated with a poor diet and inactivity, challenged some misconceptions they held previously and helped to reinforce the importance of persevering with efforts to implement lifestyle change. • Stimulating change: participating in SHIFT and receiving the results of a full health assessment during the SHIFT education session stimulated drivers' intentions to change their lifestyle behaviours through "small changes".
12.	To determine potential changes to the pilot study for future larger scale interventions	8	• Cab workout: no fitness balls or peddle cycles (unless the peddle cycles are already in the cab) • Healthy packed lunch's scheme: wider variety in food choices, bigger portions and flexibility to order with short notice. • Working together with the transport team from very early stages of the intervention. Regular PPI with the transport office workers and the drivers. Promotion and engagement of the drivers on regular basis. • Planning and booking appointments in advance to allow time for the company to cover the drivers' shift and the driver to prepare him/herself. Allowing time for cancellations if necessary. • Communicating with the

			drivers through organised "lobby" time, text message and news board. - To develop the health coach roll, as a reference person where to find support to pursue a healthier lifestyle.

9.2 KEY FINDINGS AND IMPLICATIONS FOR FUTURE RESEARCH

9.2.1 Chapter 4. Time spent sitting during and outside working hours in bus drivers: a pilot study

To our knowledge this was the first study of its kind to directly measure time spent sedentary and non-sedentary using the activPAL in a sample of drivers. One of the key findings of this study was that the activPAL is a feasible tool to measure sedentary behaviour in bus drivers, as 85% of the sample complied with the activPAL wear protocol (>600 minutes on 4 days). Another main finding was that bus drivers spent over 12 hours sedentary during workdays and just under 9 hours sedentary during non-workdays. In addition bus drivers were found to be highly sedentary during non-working hours on workdays. This seems to support the findings presented by Clemes and colleagues (2014ab; 2016), which indicate that those who are highly sedentary during working hours also accumulate great amounts of time sedentary outside working hours. Based on these findings bus drivers can be best describe as a highly sedentary occupational group, which is mainly driven by the compulsory sedentary nature of their job, yet sedentary behaviour research in this occupational group is scarce.

When analysing, basic cardio-metabolic factors such as BMI, % body fat and blood pressure, the results indicate the sample on average display an unhealthy cardiovascular profile, similar to limited previous research within this occupational group (Tse et al., 2006; Joshi et al., 2013). This knowledge is not new however, as in the 1950´s, Morris and colleagues (1953; 1958) highlighted the poor cardiovascular health profile seen in inactive London bus drivers, compared to bus conductors. Despite their revealing observations (Morris et al., 1953; Morris and Crawford, 1958), since the 1950’s only two studies have assessed bus drivers’ sedentary behaviours and physical activity (French et al., 2007; Wong et al., 2014), and neither study used tools which directly measured bus driver’s posture. Given the current knowledge about the links between sedentary behaviour and health (Wilmot et al., 2012; Biswas et al., 2015), it is reasonable to think that bus drivers’ cardiovascular profile is strongly related to the amount of hours they spend sitting. However, the lack of longitudinal research amongst this occupational group prevents us from making firm conclusions regarding the causative nature of the poor health profile seen in the present sample of bus drivers. In addition, due to the feasibility design of this study, with its small sample size; a larger scale surveillance study is needed to understand in more detail the activity and sedentary patterns in bus drivers, and the impact of these behaviours on their CV health. This will likely be needed before interventions can be developed.

Although bus drivers accumulated 4 hours standing during workdays and 5.2 hours during non-workdays, only 55 minutes and 74 minutes of this standing time was spent stepping. These results are worse than those presented by Wong et al. (2014), whose results pointed out bus drivers spend 44% (6.6 hours) and 33% (4.6 hours) of their waking time in light activity during workdays and non-workdays, respectively. However, these results led to the question of how was it possible for drivers to be more active during workdays than non-workdays considering they have a compulsory sedentary job? This could be down to the use of an ActiGraph-accelerometer to assess bus drivers' activity patterns, instead of a postural monitor as used in the present thesis. This question led to the research conducted in Chapter 5 which examined the agreement between the activPAL and ActiGraph in this same sample of bus drivers. Chapter 4 demonstrated the feasibility of directly measuring sitting time in professional drivers and this study informed the work undertaken in Chapters 6 and 7. This chapter also highlights the need for occupational interventions to reduce bus drivers' sedentary time and increase their physical activity levels to improve their cardiovascular health. Overall, further research amongst this occupational group to increase our understanding about their working patterns and how this impacts their health is needed.

9.2.2 Chapter 5. Validity of accelerometer-determined sedentary time under free-living conditions in a sample of bus drivers

The use of accelerometry to provide an objective estimate of sedentary time, in addition to physical activity, is widespread, with the ActiGraph being one of the most popular measurement tools across the literature. However, accelerometers do not measure posture and instead sedentary time is estimated using a lack of movement counts (e.g. <100 counts per minute (cpm) as an indication of sedentary time) (Kozey-Keadle et al., 2010). On the other hand, the activPAL inclinometer has been designed to detect postural changes, and it has been shown to be a highly sensitive and valid measure of posture (Grant et al., 2006; Kozey-Keadle et al., 2011; Hart et al., 2011). In light of this knowledge and taking into account the findings from Chapter 4, Chapter 5 assessed the validity of the ActiGraph accelerometer determined free-living sedentary time (using <50cpm, <100cpm, <150cpm, <200cpm, <250cpm, <300cpm cut-points) during and outside working hours in comparison to the activPAL in a sample of bus drivers.

To our knowledge this is the first study to assess the output of two activity monitors to measure sedentary time in this occupational group. Because sedentary behaviours are ubiquitous in our day to day life, accurately measuring sedentary time is important to establish dose-response relationships with health, to determine prevalence of sedentary behaviours and identify factors to target in interventions. The free-living conditions in which this experiment was conducted (workdays, working hours, non-working hours, and non-workdays) highlighted better agreement between devices during non-working hours on workdays and during non-workdays, yet the sensitivity and specificity analyses indicated that any of the cut-points reach sufficient specificity and sensitivity levels to accurately identify sedentary time relative to the activPAL.

However, during working hours the ActiGraph accelerometer highly underestimated sedentary time when using all the cut-points, despite the sedentary nature of a driving occupation. Whilst the activPAL detects posture, the ActiGraph measures sedentary behaviours through a lack of movement (eg. Acceleration), hence the most plausible explanation for this disagreement is that the ActiGraph picks up the accelerations produced during the vehicle's movement. In fact when plotting activPAL data against the ActiGraph in

Figure 5.5 continuous accelerations during working-hours are identified by the ActiGraph and miss-classified as non-sedentary time, whilst the time-matched output from the activPAL clustered the participant as sitting during the majority of working hours based on their posture. These analyses highlighted that there is no standard cut-point that can be used to extract ActiGraph-determined sedentary time accurately compared with the actviPAL during bus drivers working and non-working hours. In Chapter 5, the <250 cpm cut-point provided the closest estimate of total daily sedentary time on workdays compared to the activPAL (mean difference = +17 mins/day), however, on non-workdays, total daily sedentary time was best estimated using the <50 cpm cut-point, which underestimated sedentary time by 34 mins/day. In contrast, during working hours all cut-points tested underestimated sedentary time relative to the activPAL, with the <300 cpm cut-point providing the closest estimate (underestimating by 33 mins/day). During non-working hours on workdays, as with non-workdays the <50 cpm cut-point provided the closest estimate of sedentary time (underestimating by 15 mins/day). When assessing ActiGraph sensitivity and specificity values to determine sitting time compare with the activPAL all results ranged between poor and fair (ROC<.80); Therefore it seems that that different cut-points perform better in the different domains, suggesting the cut-point approach to determine sedentary time using the ActiGraph in bus drivers is an unreliable method, particularly during working-hours.

Findings from Chapter 5 indicate that the validity of the ActiGraph at detecting sedentary postures is low compared to the activPAL. The high underestimation of sedentary time during working hours indicated the activPAL should be the preferred objective monitor when assessing sitting behaviours during working hours in this occupational group. For this reason it was decided that in the surveillance and intervention studies reported in Chapters 6 and 7, sitting behaviours would only be measured using the activPAL.

9.2.3 Chapter 6. Lorry drivers' sedentary behaviours, physical activity and cardiovascular health

Despite lorry drivers being classified as 'compulsory sedentary workers', no research has focused on their sedentary time, and limited research from international studies has investigated levels of physical activity in lorry drivers. Therefore, the study reported in Chapter 5 was, to our knowledge, the first to assess lorry driver's sedentary patterns. This study indicated that lorry drivers spent on average 13 hours sedentary on workdays and 8 hours sedentary on non-workdays. This is the highest sitting time reported up to date in the literature, when compared to other occupational groups, which suggests lorry drivers should be a primary target for sedentary behaviour research and occupational interventions.

Along with the high levels of sedentary time, this thesis highlights the low levels of physical activity seen in this sample of lorry drivers, as only 13% of the sample assessed were classified as physically active (≥30 minutes a day in MVPA). However, these findings refer to overall MVPA per day and it is likely that it is not a true representation of those who comply with the PA guidelines (Department of Health, 2015). Due to the manual approach applied to analyse activity data, information is limited to the total time spent sitting and in up-right postures. Future research should develop new techniques and explore lorry drivers' activity patterns further and provide information about sitting, light physical activity and MVPA bouts to further our understanding on lorry drivers' activity behaviours.

Another important finding of this research is the unhealthy cardiovascular profile presented by this sample of drivers. For the first time, this study profiled body composition, blood biomarkers, blood pressure, heart rate, lifestyle behaviours and mental health outcomes in a sample of UK lorry drivers. Evidence from this thesis suggests that lorry drivers exhibit higher than nationally representative rates of obesity, and obesity-related co-morbidities (PHE, 2010,2013), which could explain the reduced life expectancy seen in lorry drivers in comparison to other occupational groups (Ng et al., 2015; Office for National Statistics, 2015). This study is also the first to explore the impact of interchanging 30 minutes a day of sedentary behaviour with the same amount of MVPA on cardiovascular markers among this occupational group. Promising results indicate that substituting 30 minutes of sitting for MVPA during workdays was associated with a significant reduction in waist circumference, heart rate, triglycerides and HDL cholesterol. This could be due to the protective health effects of MVPA (Biswas et al., 2015). This evidence highlights the need for further research and occupational interventions to increase lorry drivers MVPA and reduce their sitting time to improve their deteriorated cardiovascular profile.

Epidemiological studies have highlighted that individuals working in strenuous mental conditions compensate with unhealthy behaviours (Apostolopoulos et al., 2011). Lorry drivers fall under this category, yet limited research about their working patterns and health behaviours is available (Apostolopoulos et al., 2012;2013; 2014), and of the limited research available none is based in the UK. Therefore, researchers should firstly increase their understanding about UK lorry drivers working conditions and the barriers to a healthy lifestyle faced by this group to facilitate the design of a feasible and effective intervention. Qualitative research for an in depth insight of the intertwined relationships between the transport sector's demands and lorry drivers' lifestyle is of essence. This should answer questions such as: is the health of lorry drivers being influenced by their working environment or by their lifestyle choices or both? And, are lifestyle choices a response to their working conditions? As part of an ongoing programme of research with a local transport company during the time of the research conducted within this thesis, a qualitative study was conducted by our research team which aimed to address these questions. This paper can be found in appendix 11.5, the findings of both Chapter 5 and this qualitative work informed the development of the pilot SHIFT intervention described in Chapter 7.

9.2.4 Chapter 7. A Structured Health Intervention for Truckers (SHIFT): a pilot study

The research reported in this chapter was, to our knowledge, the first to implement a health intervention aiming at reducing sitting time and increasing PA and exploring the impact of these changes on cardio-metabolic health in lorry drivers. There are many difficulties associated with developing a complex intervention in an occupational setting where participants are not based within a specific working environment. However, results from this study highlight the feasibility and the success of developing and implementing such interventions within these working conditions.

It has been highlighted that the UK Logistics sector is experiencing a short-fall in HGV drivers, estimated to be of the order of ~60,000, with barriers to recruitment including the lack of roadside facilities, medical concerns and long hours of work (The Freight Transport Association, 2015). Recommendations on how to address this shortfall and attract younger employees to the sector made by the All Party Parliamentary Group for Freight Transport include increasing awareness within the industry of the need to address driver health risks (The All Party Parliamentary Group for Freight Transport, 2015). Results from this study show that overall participants improved their cardio-metabolic health and reduced the duration of their "usual" siting time bouts. Although non-significant changes in step counts were observed between baseline and 3 months follow up, 81% of the sample increased their step counts on both workdays and non-workdays. When exploring any differences between those who increase their step counts and those who did not, it was observed that participants who did not increase their step counts reported a significantly higher fruit and vegetable consumption at baseline and at 3 months follow up than those who increased their step counts. Therefore, it could be plausible that these drivers perceived themselves as healthy enough due to their high fruit and vegetable intake. The multicomponent nature of this intervention offered lorry drivers opportunities to engage in different behaviours associated with a healthy lifestyle. As a result of the short duration of this feasibility intervention drivers were encourage to focus on small behaviour changes for a more prolonged effect. Hence, it is possible that some participants preferred to focus on their physical activity levels, whilst others concentrated on their diet. This is an interesting discussion point as it will have implications in future health interventions in lorry drivers, and it seems important to offer different opportunities to engage in a healthier lifestyle to suit the driver's needs.

Despite only 43 out of 63 drivers that attended the education session completing the activity monitoring protocol (wore the activPAL for 7 days) at baseline and 3 months, a total of 57 drivers completed the intervention as shown in Chapter 6. This highlights that the design of this intervention reached the drivers interests and fulfilled their needs, which kept them engaged with the intervention. The education component was a highlight of this intervention, as indicated by the drivers. This increased their awareness on different health aspects and encouraged them to set up action plans to improve their general health. Special emphasis was put on increasing their step counts but also on breaking up their sitting time more often when possible. Results presented in Chapter 7 support this statement.

Whilst the activPAL was the primary outcome measure applied in Chapter 6, several issues were highlighted by those who didn’t wear it at the 3 month post-health assessment. These involved rashes on the skin due to the sticky pads; the uncomfortable nature of the sticky pad due to hair on legs; and the device falling off regularly resulting in missing devices. However, those who wore the device completed the full 7 day period and the daily log. Therefore this highlights that future interventions will have to design a more successful way of attaching this device to the front line of the thigh to overcome these issues and avoid any missing data.

9.2.5 Chapter 8. A Structured Health Intervention for Truckers (SHIFT): A process evaluation of a pilot health intervention in a transport company

Complex health interventions have been defined by Moore and colleages (2015) as "interventions that comprise multiple interacting components, although additional dimensions of complexity include the difficulty of their implementation and the number of organisational levels they target". The process evaluation conducted in Chapter 8 points out the main challenges we faced when developing the SHIFT Intervention, which were mainly related to drivers scepticism to participate in the study and the scheduling of the drivers for the health assessments and education session.

The SHIFT Study comprises three different phases involving a surveillance study (Chapter 6) qualitative research (appendix 11.5) and the SHIFT pilot intervention (Chapter 7). The first two phases of the study lasted one year and out of 282 drivers employed at the depot used for this research, 165 participated in either the first or second phase of the project. In addition, before implementing the intervention, regular promotion of the 3rd phase of the study took place at the lorry drivers' lobby. Those who were randomly selected to be invited to participate in the intervention also received a letter with information about the study one month in advance. This would allow them enough time to enquire and decide about their participation in the program. Overall, there was a good general awareness of the study within the driver population. Yet the research in Chapter 8 highlights the high resistance and the difficulties found among the drivers and the company's operational system to implement the SHIFT intervention.

This is the first study of its kind and it sheds light into the structural and logistical obstacles of implementing an intervention in the “real world”; where challenging processes might have had a negative impact on the success of the intervention, e.g. dropout rates. In addition, it has been suggested that recruitment and retention of participants can be negatively affected if the participants are severely ill or hard to reach (Datta & Petticre, 2013), which fits with the lorry drivers health and working characteristics. The dropout rates in this study could also be related to contextual factors that hindered the implementation of the intervention which included: working within the company’s busiest time of the year and the endemic shortage of drivers experience by the transport sector (FTA, 2014). This resulted in constant re-scheduling of the drivers and the delay on the implementation of the intervention, which might have entailed drivers losing interest and dropping out, particularly prior to the education session. This indicates that future interventions should design a more structured communication system with the drivers, following the recommendations described in Chapter 8. In addition, future interventions should be designed whilst working in collaboration with the planning team and adjusted to fit realistic timelines based on the company’s capacity.

This research also highlights that despite the support from the transport managers, there was a lack of engagement by those in charge of planning and sending drivers out due to the organisational pressures. Previous research (Datta & Petticre, 2013) suggested that limited knowledge of the program and the lack of incentives for engaging with it can be a barrier to the smooth implementation of a health program. Front line managers and those in charge of planning, were only provided with the basic information about the study, that combined with the extra responsibilities added to their daily tasks, might have resulted in a lack of interest and ultimately the relegation of the study to a secondary level. This suggests that future research should consider the involvement of all parties including the management and operational team in the development and implementation of a health intervention. This could imply the office personnel to undergo the same health assessments and a similar intervention tailored to their working environment as the drivers, with the addition of regular update meetings for an in depth understanding of the health intervention.

Overall the process evaluation presented in Chapter 8 highlights that regardless the health marker outcomes presented in Chapter 7, the SHIFT pilot intervention had a positive impact on the participants’ mentality in regards to health behaviours. It is interesting to point out that the key to the success of this complex intervention (Chapter 7) was the use of qualitative research to explore lorry drivers’ perceptions of the barriers to a healthy lifestyle, along with their attitudes towards the different strategies provided within this health intervention to overcome these barriers. These ongoing interactions with the participants helped to foster the intervention towards their own needs, resulting in a positive experience for those that underwent the whole process. Indeed, this positive attitude could have only been captured by this qualitative piece of work.

9.3 OVERALL DISCUSSION

The implications of the detrimental effects on health of prolonged time sitting are well documented (Wilmot et al., 2012; Biswas et al., 2015). Thus interventional research is urgently needed to reverse the current trend towards lower physical activity levels and increased time spent sedentary (Brownson et al., 2005; Sallis et al., 2006; Knuth and Hallal, 2009; Owen et al., 2010b; Thorp et al., 2011; Kohl et al., 2012). Findings from this thesis describe bus and lorry drivers as a highly sedentary occupational group, accumulating the highest sedentary times reported to date. Yet, the lack of research and their working conditions show they are a highly underserved population.

This thesis comprises a collection of studies that explore bus and lorry drivers' activity behaviours and cardiovascular health and cluster them as an at-risk population. Bus drivers underwent basic cardio-metabolic tests (Chapter 4); where the findings indicated that this small sample on average exhibited a high prevalence of overweight and obesity and displayed trends for being pre-hypertensive. These findings, coupled with the relatively high average age of the sample (44 years), and their low levels of physical activity and high levels of daily sitting, puts them at a high-risk of a cardiovascular event. This study highlighted potential discrepancies between sitting time measured using the activPAL (in the present thesis) and sedentary time measured using the ActiGraph in an Australian study of bus drivers (Wong et al., 2014), which led to the comparison study of the two devices reported in Chapter 5. This study indicated that the ActiGraph highly underestimated sedentary time in comparison with the activPAL, particularly during working hours; which suggests the ActiGraph is not a valid tool to assess sedentary time in bus drivers. Further work should be conducted to find a correction formula of the algorithm to be able to improve the accuracy of the ActiGraph to determine sedentary time.

A larger scale study with a greater range of health measures was conducted in a sample of UK lorry drivers. The SHIFT Study was designed to a) profile lorry drivers' sedentary time, physical activity and cardiovascular health; b) understand the barriers to a healthy lifestyle and c) design an intervention to reduce their sedentary time, increase physical activity, and improve health. The first phase of this study (Chapter 6) showed that out of this sample of lorry drivers 84% were overweight or obese, 10% had diagnosed type II diabetes, 29% had pre-diabetes, 4% had undiagnosed diabetes, 34% had the Metabolic Syndrome, 27% were pre-hypertensive, 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. In addition, 31% were borderline or had anxiety and 15.5% were borderline or had depression. Along with this lorry drivers spent on average 13 hours per working day sitting. These results underline lorry drivers as a high-risk occupational group and support research from the US also indicating the poor health profiles seen in long distance drivers (Apostolopoulos et al., 2011;2012;2014). In fact, obese lorry drivers are 55% more likely to have an accident than normal weight drivers, which directly impacts the health of other road users (Anderson et al., 2012). To compound this, long distance drivers are also an ageing workforce. A recent report prepared by an All Party Parliamentary Group for Freight Transport has highlighted the "demographic time bomb" the logistics industry is currently facing and the health impact of an ageing, at-risk, workforce “driving a vehicle often referred to as ‘a 40-tonne missile’”(The All Party Parliamentary Group for Freight Transport, 2015).

The qualitative research conducted in this sample of lorry drivers (appendix 11.5) furthers our limited knowledge on the intertwined system of working demands and lack of opportunities lorry drivers face for a healthy lifestyle. This result in a number of barriers drivers have to overcome before engaging in healthier lifestyles (e.g. time, long hours working culture, stress, shortage of sleep, food on the road and the sedentary nature of the job). The combination of this neoliberal economic discourse with the men’s health mentality and their own perception of an “average man” (Caddick et al., 2016), leads them to avoid healthy lifestyle choices. The data gathered from this phase of the study informed the SHIFT pilot intervention (Chapter 7).

Chapters 7 and 8 indicates that a successful health intervention amongst lorry drivers should be nurtured to cover their specific needs, accounting for their challenging working environment and their own perceptions about health behaviours. This intervention highlights that facilitating opportunities for drivers to engage with more physical activity and healthier diet are key in this occupational group. This should be accompanied by increased awareness of how to adapt healthy lifestyles to their particular daily routine. The promising results of this intervention suggest that health promotion should be a priority within the companies’ agenda and introduced as part of the health and safety programs. Healthier working environments and health promotion are recommended strategies to attract new drivers to the industry, and to promote health of the current drivers. These findings have relevance to interventions aiming at increasing physical activity and reducing sitting among lorry drivers. Further testing of this intervention is warranted using a robust RCT design in a larger sample, before the efficacy of this intervention can be confirmed however.

9.4 OVERALL STRENGTHS AND LIMITATIONS OF THIS THESIS

One of the strengths of this thesis was the use of the activPAL throughout to assess sitting and upright postures, thus overcoming the limitations of self-report measures or other types of accelerometers that do not measure postures directly. Secondly, the novelty of the topic itself should be considered a strength of this thesis, as the research comprising each of these individual studies is, to our knowledge, the first to assess bus and lorry drivers' sedentary behaviours. As a result, this research provides novel information on sitting behaviour and how it is accumulated during workdays and non-workdays in a sample of bus drivers and lorry drivers. In addition, drivers participating in the SHIFT Study were recruited from all shift patterns (morning, afternoon and night), hence accounting for any potential differences associated with shift workers. Lastly, the major strength of this thesis is its mixed-methods approach and that its overall design follows the MRC guidance for the development of complex interventions (Craig & Petticrew, 2013), including 5 stages: 1) a pilot study to test the feasibility of the instruments; 2) a surveillance study to phenotype drivers' health, physical activity and sedentary behaviours; 3) a qualitative research study to understand the barriers to a healthier lifestyle (included as an appendix, 11.5); 4) a pilot intervention to promote changes in lorry drivers health behaviours, and 5) a process evaluation to assess the success of the intervention implementation. This compounds an in depth source of knowledge that furthers our understanding about drivers' lifestyle from a holistic perspective, taking into account their own behaviours, health perceptions and working environment.

Limitations of this thesis include the relatively small and homogeneous sample of drivers participating in these studies. Most participants were white British and middle income class and recruited from the East Midlands, which can limit the generalisability of these results. For instance it has been shown that South Asians living in the UK have substantially lower levels of physical activity than White Europeans (Fischbacher et al, 2004, William et al 2011a). In addition, data collection for all studies took place during very specific times of the year coinciding with the busiest time of the year for the lorry drivers and winter months for the bus drivers, which might have had a negative impact on their behaviours. Therefore, exploring drivers sedentary and physical activity behaviour's across all seasons is recommended. Another limitation is that this thesis examined bus and lorry drivers only, and there are many others employed in compulsory sedentary occupations such as taxi and train drivers. Lastly, lorry drivers participating in all studies of this thesis were self-selected, as for ethical issues the study design was based on an opt-out basis, hence it is likely that these studies are not representative of those within the opposite ends of the spectrum (very healthy and extremely unhealthy). The pilot intervention was a pre-post design with no control group. A randomised controlled trial is therefore needed to explore the efficacy of this intervention.

9.5 RECOMMENDATIONS FOR FUTURE RESEARCH

Based on the findings from the thesis, priorities for future research are evident. Research into the lifestyle behaviours of bus and lorry drivers is in its early stages, particularly intervention research. There is a need for further surveillance work to explore physical activity and sedentary behaviour and other lifestyle behaviours, such as diet, smoking and alcohol intake, in larger and more diverse samples of bus and lorry drivers. This research should also be expanded to include other workers with compulsory sedentary occupations such as taxi, train and tram drivers, and airline pilots. Following an increase in our understanding of the lifestyle behaviours in workers in compulsory sedentary occupations, along with the barriers and facilitators to heathy lifestyles, tailored interventions should be developed, pilot tested, and then examined in definitive RCTs. If successful, these interventions should ultimately inform policy changes. In addition, the Chartered Institute of Logistics and Transport (CILT) foresee the SHIFT programme being embedded within drivers' compulsory continued professional development, as a way to tackle health inequalities within the transport sector. However, before this can be achieved the intervention needs formal evaluation. Future research suggestions which arise directly from the work undertaken in this thesis include:

a) Large scale surveillance studies that measure driver's sedentary behaviours and physical activity using objective measurements across different regions, age ranges and shift patterns. This would help to create a data set with comparable data and to inform feasible interventions and policy changes.

b) A large scale RCT, which assesses the impact of an intervention on chronic health conditions, physical activity and sedentary behaviours at baseline, 6-and 12-months.

This information will help to inform the development of good practice health guidelines to be disseminated within the transport sector. The design of the RCT should involve the lorry drivers and the management team, to take into account structural barriers that might impact on the good development of the study, as well as to fit within the company's working routine.

c) An economic evaluation to explore the impact of changes in the health outcome measures after an RCT on longer term Health Related Quality of Life via changes in the likelihood of developing certain conditions (e.g. diabetes, cardiovascular disease).

d) Development of a health program to be embedded within drivers' compulsory continued professional development (CPD) training. To prioritise driver's health and well-being within the transport sector' health and safety agenda.

9.6 THE TRANSPORT SECTOR AND RECOMMENDATIONS FOR A HEALTHIER WORKFORCE

In 1995, Whitelegg and colleagues suggested that bus and lorry driving makes the driver ill and stated "The environment in which drivers spend the majority of their time is polluted, noisy and dangerous. It is an environment over which they have no control whatsoever and it is an environment that wrecks their schedules, disrupts their home life, makes social activities and regular breaks very hard to plan and supplies constant hassle. To make matters worse drivers frequently bear the brunt of criticism for problems that crop up whilst driving" (page 2). Despite this statement bus and lorry drivers have received very little scientific and government attention. More recently the Freight Transport Association and the Chartered Institute of Logistics and Transport have shown concern about the current shortage of HGV drivers (estimated to be in the region of 45,000) combined with the impact of an aging workforce (average age of 53 years). In January 2016, The Deputy Chief Executive from the FTA stated (FTA, 2016) "The past 12 months have seen a slight improvement in the number of unfilled driver vacancies across the sector, and the Government's recognition of the need to professionalise the industry through its new HGV Driver Trailblazer Apprenticeships (Apprenticeship Standards set by groups of employers from the transport industry) is a huge step forward. However, there is still a great deal to be done to make the industry more attractive and to help employers recruit and retain staff. We need to improve the public perception of logistics and make it a desirable place to work..." (11.01.2016). Despite the intentions of improving drivers' working conditions, lorry drivers' health was not included in the FTA's agenda, and it is only referenced at the driving licence renewal section within the Health and Safety law (medical test every 5 years if 45 years or older; every year if 65 or older). Although a comment on driver health is mentioned in the All Party Parliamentary report (The All Party Parliamentary Group for Freight Transport, 2015).

Although this research is at its very early stages we can already envisage some potential necessary changes within the transport industry to improve the driver workforce health and to increase the sector's appeal to new staff. This section compiles a number of recommendations for the transport sector to improve lorry drivers' working conditions and ultimately their health. These have been inspired by Whitelegg et al.'s (1995) recommendations, informed by the research conducted within this thesis and based on personal reflections gathered through the informal and formal conversations with the lorry drivers throughout the program:

1. Promoting healthy behaviours and lifestyle should be introduced as a priority within the transport health and safety agenda. This should be focused on promoting and developing prevention strategies to improve drivers' health and reduce the risk of accidents on the road and minimise sick leave.
2. Introduction of realistic work schedules that fully reflect the realities of traffic congestion, keeping in mind speed limits, and the need for breaks and rest periods. This should be kept under constant review to ensure drivers do not become the principal victims in absorbing the failures of the transport system and so workers do not bear the brunt of cost cutting (Whitelegg et al., 1995)
3. To limit the weekly working hours (including driving, waiting and resting times) to standards comparable to other workforces (48 hours a week, EU´s Working Time Directive), this will facilitate the conciliation between work and family life and will allow drivers to engage in other activities. A pattern of activity whereby drivers wake up, go to work, and return straight home to sleep is to be avoided as a primary cause of driver ill-health.
4. To compensate longer routes with shorter routes to avoid overtime at work and to guarantee drivers sleeping and recovering time. This will also help drivers to maximise the time that can be spent at home and /or the time which can be spent with co-workers and friends.

5. To have longer daily rest periods in between shifts, currently set at 11 hours, to guarantee drivers spare time to cover basic needs such as family life and eating time, in addition to 8 hours sleep.

6. Drivers should become more involved with the management decisions about their schedules, routes, timings and implementation of shift patterns and working practices. Drivers have considerable experience on these matters which are of value to the overall commercial success of the organisation. In addition, this has been shown to help reduce stress and improve health, as they have greater levels of involvement in the management process (Taylor and Dorn, 2006).

7. Lorry drivers are under continuous psycho-physiological arousal, which combined with the isolation drivers experience during their working hours, increases the risk of stress, anxiety and depression. Therefore, working weeks should be limited to 5 days to allow drivers to mentally and physically recover from their working week and to allow them time to engage in social activities with their peers.

8. Based on drivers daily working hours (9 to 10 hours/day), the compulsory break of 45 minutes should be increased to 1 hour to comply with the Highway Code that recommends drivers to take a 15 minutes break every two hours.

9. One of the most prevalent health issues amongst lorry drivers is musculoskeletal disorders (e.g. joints, lower back…). Flexibility to distribute the compulsory breaks based on their health needs, rather than timings fixed by driving regulations would allow them to prevent or improve musculoskeletal issues.

10. Lorry drivers' lack of awareness and opportunities to pursue healthy behaviours indicate a CPD training course on healthy living should be compulsory to all drivers. This would be designed as a prevention toolkit and would provide drivers with techniques and strategies to pursue a healthy lifestyle.
11. Considering the risk of unhealthy drivers on the road, to other road users, free regular health checks should be facilitated to all drivers.
12. Stress, fatigue, anxiety and depression are prevalent amongst this occupational group, which might be exacerbated by the predominant isolation of lorry drivers' working lifestyles. Primary detection, counselling and mindfulness techniques (Grossman et al., 2004) should be facilitated to all drivers.
13. In collaboration with the government, stakeholders and different parties within the transport sector drivers should be provided with safe facilities on site and on the road. These facilities should be well lit, well located, adequately supervised, easily accessible and be fully equipped environments where drivers can be physically active and have access to healthy food.

9.7 OVERALL THESIS CONCLUSION

Based on the findings from this thesis it can be concluded that bus and lorry drivers are a highly under-researched population. This thesis highlights they are an at-risk occupational group. The amount of sedentary time they accumulate has been found to be the highest reported up to date, in comparison to other occupational groups, which combined with the lack of physical activity seen in this sample, puts them at high risk of associated co-morbidities and health conditions. In addition, bus and lorry drivers' cardiovascular profile on average falls within the unhealthy ranges for the majority of health markers. Improvements in cardiovascular outcomes were seen in lorry drivers when increasing their daily steps per day by 1381 steps on workdays and 1784 steps on non-workdays. This information has provided a foundation for future research, which should explore the links between different levels of compulsory sedentary time (driving) and cardiovascular health to develop health guidelines for the transport sector (potentially to reduce the current allowance for driving hours per day). In addition, health promotion campaigns and interventions should be implemented amongst these occupational groups to improve their health prospects and life expectancy. Targeting bus and lorry drivers' health behaviours is a public health priority.

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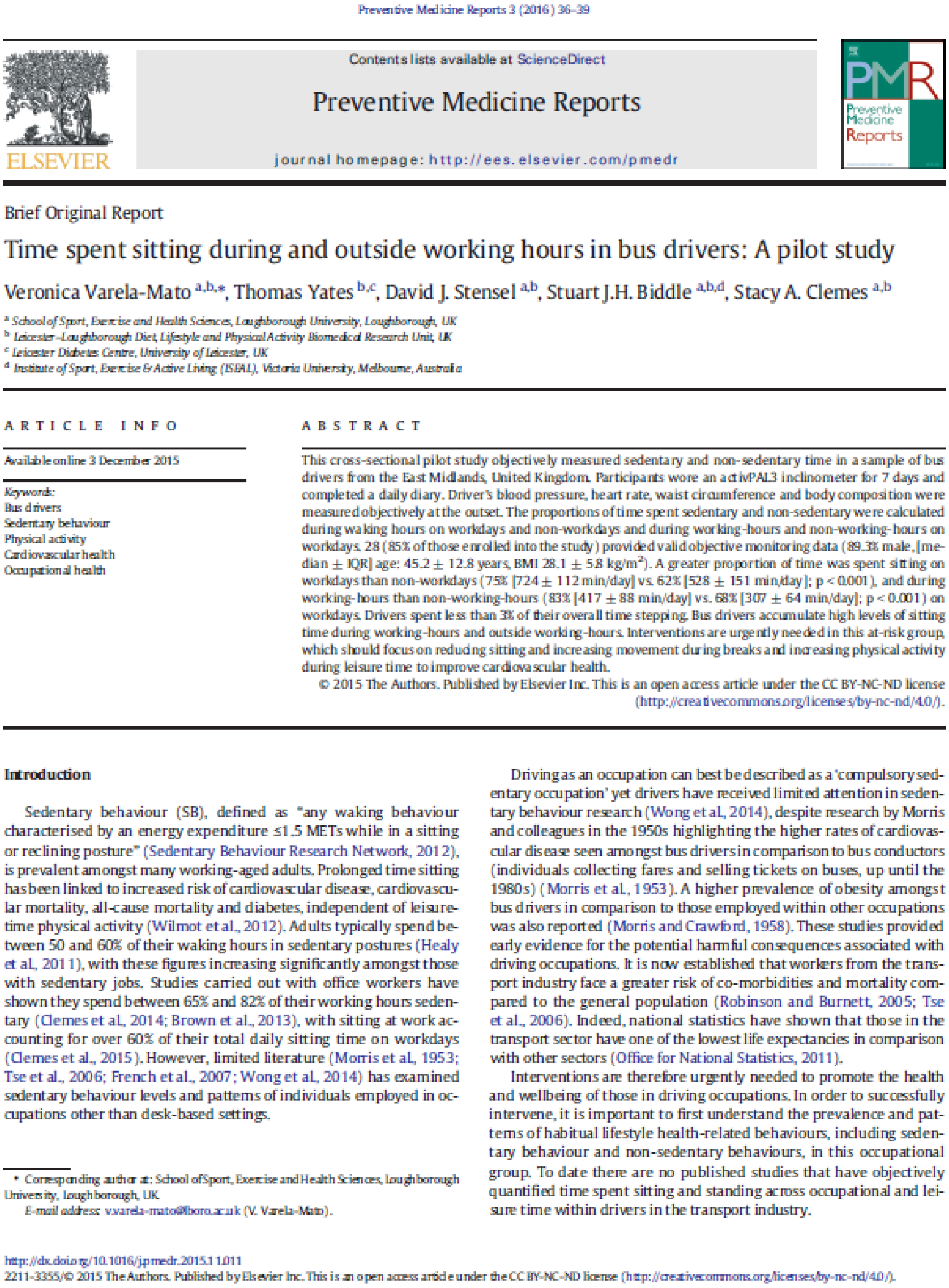
APPENDICES

11.1 First page of bus drivers' pilot study



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Brief Original Report

Time spent sitting during and outside working hours in bus drivers: A pilot study

Veronica Varela-Mato [a,b,*], Thomas Yates [b,c], David J. Stensel [a,b], Stuart J.H. Biddle [a,b,d], Stacy A. Clemes [a,b]

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[b] *Leicester–Loughborough Diet, Lifestyle and Physical Activity Biomedical Research Unit, UK*
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ARTICLE INFO

Available online 3 December 2015

Keywords:
Bus drivers
Sedentary behaviour
Physical activity
Cardiovascular health
Occupational health

ABSTRACT

This cross-sectional pilot study objectively measured sedentary and non-sedentary time in a sample of bus drivers from the East Midlands, United Kingdom. Participants wore an activPAL3 inclinometer for 7 days and completed a daily diary. Driver's blood pressure, heart rate, waist circumference and body composition were measured objectively at the outset. The proportions of time spent sedentary and non-sedentary were calculated during waking hours on workdays and non-workdays and during working-hours and non-working-hours on workdays. 28 (85% of those enrolled into the study) provided valid objective monitoring data (89.3% male, [median ± IQR] age: 45.2 ± 12.8 years, BMI 28.1 ± 5.8 kg/m^2). A greater proportion of time was spent sitting on workdays than non-workdays (75% [724 ± 112 min/day] vs. 62% [528 ± 151 min/day]; $p < 0.001$), and during working-hours than non-working-hours (83% [417 ± 88 min/day] vs. 68% [307 ± 64 min/day]; $p < 0.001$) on workdays. Drivers spent less than 3% of their overall time stepping. Bus drivers accumulate high levels of sitting time during working-hours and outside working-hours. Interventions are urgently needed in this at-risk group, which should focus on reducing sitting and increasing movement during breaks and increasing physical activity during leisure time to improve cardiovascular health.

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Introduction

Sedentary behaviour (SB), defined as "any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture" (Sedentary Behaviour Research Network, 2012), is prevalent amongst many working-aged adults. Prolonged time sitting has been linked to increased risk of cardiovascular disease, cardiovascular mortality, all-cause mortality and diabetes, independent of leisure-time physical activity (Wilmot et al., 2012). Adults typically spend between 50 and 60% of their waking hours in sedentary postures (Healy et al., 2011), with these figures increasing significantly amongst those with sedentary jobs. Studies carried out with office workers have shown they spend between 65% and 82% of their working hours sedentary (Clemes et al., 2014; Brown et al., 2013), with sitting at work accounting for over 60% of their total daily sitting time on workdays (Clemes et al., 2015). However, limited literature (Morris et al., 1953; Tse et al., 2006; French et al., 2007; Wong et al., 2014) has examined sedentary behaviour levels and patterns of individuals employed in occupations other than desk-based settings.

Driving as an occupation can best be described as a 'compulsory sedentary occupation' yet drivers have received limited attention in sedentary behaviour research (Wong et al., 2014), despite research by Morris and colleagues in the 1950s highlighting the higher rates of cardiovascular disease seen amongst bus drivers in comparison to bus conductors (individuals collecting fares and selling tickets on buses, up until the 1980s) (Morris et al., 1953). A higher prevalence of obesity amongst bus drivers in comparison to those employed within other occupations was also reported (Morris and Crawford, 1958). These studies provided early evidence for the potential harmful consequences associated with driving occupations. It is now established that workers from the transport industry face a greater risk of co-morbidities and mortality compared to the general population (Robinson and Burnett, 2005; Tse et al., 2006). Indeed, national statistics have shown that those in the transport sector have one of the lowest life expectancies in comparison with other sectors (Office for National Statistics, 2011).

Interventions are therefore urgently needed to promote the health and wellbeing of those in driving occupations. In order to successfully intervene, it is important to first understand the prevalence and patterns of habitual lifestyle health-related behaviours, including sedentary behaviour and non-sedentary behaviours, in this occupational group. To date there are no published studies that have objectively quantified time spent sitting and standing across occupational and leisure time within drivers in the transport industry.

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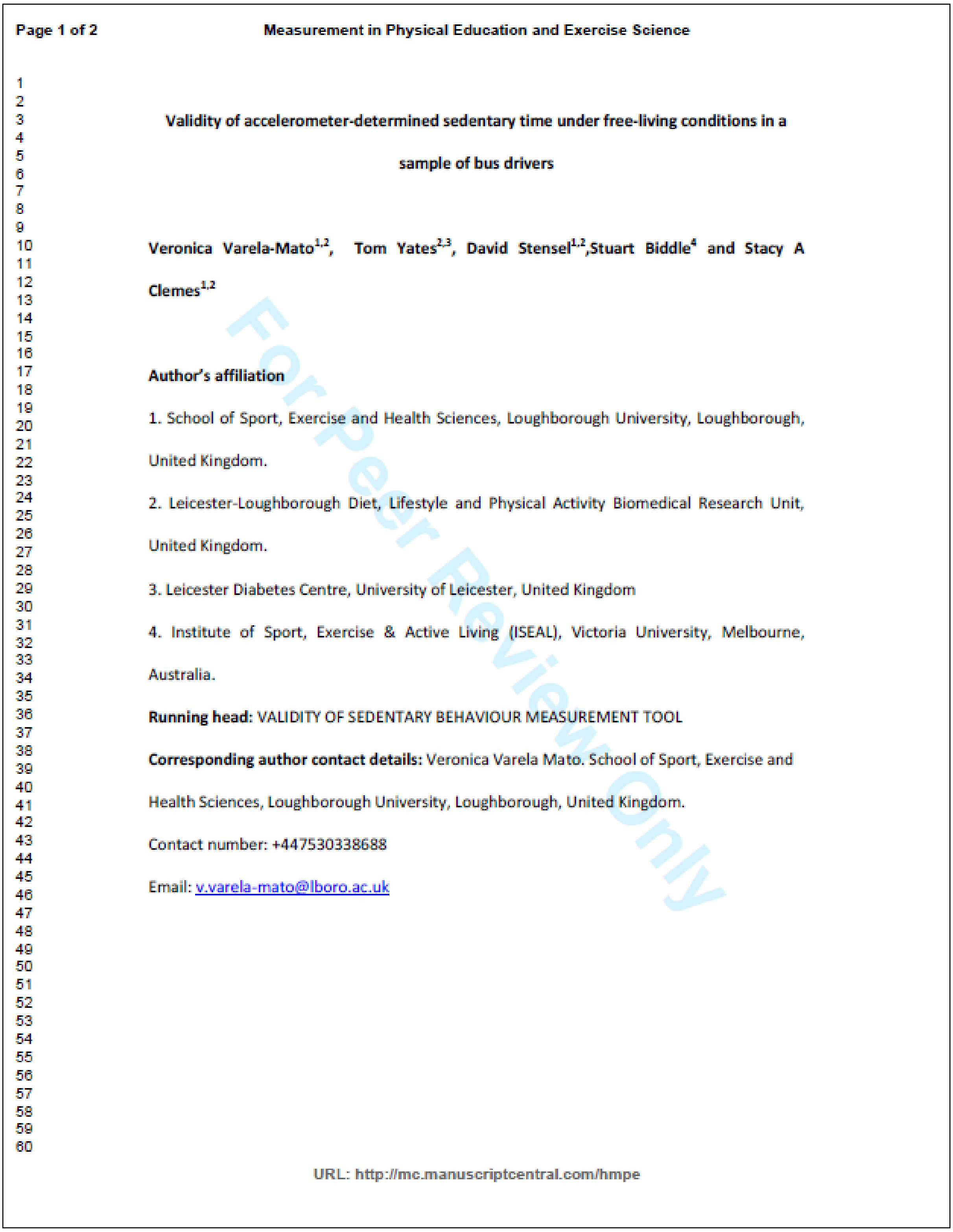
11.2First page of submitted validation study



Page 1 of 2 **Measurement in Physical Education and Exercise Science**

Validity of accelerometer-determined sedentary time under free-living conditions in a sample of bus drivers

Veronica Varela-Mato[1,2], Tom Yates[2,3], David Stensel[1,2], Stuart Biddle[4] and Stacy A Clemes[1,2]

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Running head: VALIDITY OF SEDENTARY BEHAVIOUR MEASUREMENT TOOL

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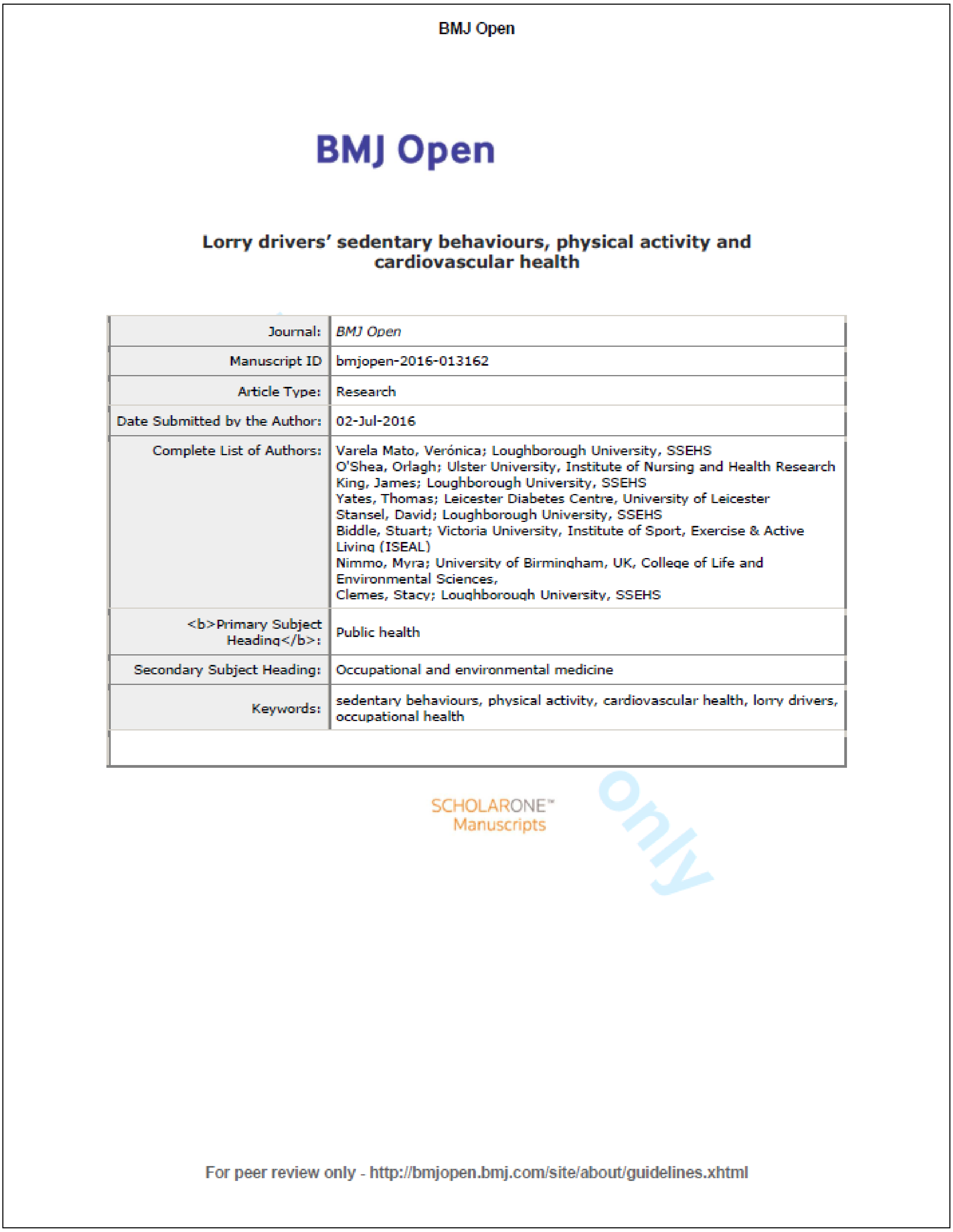
11.3 First page of submitted surveillance study



BMJ Open

Lorry drivers' sedentary behaviours, physical activity and cardiovascular health

Journal:	*BMJ Open*
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Article Type:	Research
Date Submitted by the Author:	02-Jul-2016
Complete List of Authors:	Varela Mato, Verónica; Loughborough University, SSEHS O'Shea, Orlagh; Ulster University, Institute of Nursing and Health Research King, James; Loughborough University, SSEHS Yates, Thomas; Leicester Diabetes Centre, University of Leicester Stansel, David; Loughborough University, SSEHS Biddle, Stuart; Victoria University, Institute of Sport, Exercise & Active Living (ISEAL) Nimmo, Myra; University of Birmingham, UK, College of Life and Environmental Sciences, Clemes, Stacy; Loughborough University, SSEHS
Primary Subject Heading:	Public health
Secondary Subject Heading:	Occupational and environmental medicine
Keywords:	sedentary behaviours, physical activity, cardiovascular health, lorry drivers, occupational health

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11.4Focus Magazine article

SHIFT-ing into better health

SHIFT

Above: Lorry driving has been associated with a range of health problems

Above: The main goal of SHIFT is to promote healthier lifestyles among drivers

AUTHOR
Veronica Varela-Mato
Dr James King

SECTOR HIGHLIGHTS

- Supply Chain
- Transport Planning
- Active Travel & Travel Planning
- Bus & Coach
- Ports Maritime Waterways
- Freight Forwarding

Maintaining a healthy and balanced lifestyle can be a significant challenge for anyone whose occupation involves prolonged periods of inactivity and sitting time.

It goes without saying, of course, that lorry drivers fall into this category. Researchers at the Leicester-Loughborough Diet, Lifestyle & Physical Activity Biomedical Research Unit and Loughborough University have developed a new intervention aimed at promoting healthier lifestyles among lorry drivers.

The SHIFT programme – a Structured Health Intervention For Truckers – is a pilot study that aims to help drivers overcome a range of barriers to healthy living that have been identified in our own and previous research. These barriers include long and irregular work hours, traffic and stressful working conditions, lack of opportunity for physical activity, lack of availability of healthy food at services stations, and the chronic and compulsory sedentary nature of lorry driving. Linked to these barriers are a number of worrying trends in lorry drivers' health, with 85% of drivers worldwide reportedly overweight or obese and 44% with high blood pressure. Moreover, lorry driving has been associated with a range of health problems, including diabetes, cancer, sleep apnoea and sleep deprivation, musculoskeletal and gastrointestinal disorders, and symptoms of psychological distress.

The main goals of SHIFT were to promote healthier lifestyles among drivers by reducing sitting time during breaks and non-working hours, increasing physical activity and improving diet and hydration. Based on feedback from the drivers and different health measures, the programme proved to be successful in improving the drive's health. However, this was run as a pilot programme.

Where do we go from here? Further research to evaluate the pilot programme on a larger scale is needed. Researchers need to conduct ongoing process evaluations to look at what works best out of the various programme components in order to refine the SHIFT programme and optimise its potential for success.

Our hope is that the SHIFT programme will develop into a successful health intervention that may be adopted throughout the transport sector as a way of tackling the major health challenges facing workers in this industry. With support and investment from government and transport companies, we are optimistic that health programs like SHIFT will help to reduce the health problems associated with driving, and improve the well-being and quality of life of transport workers in the UK.

About the authors

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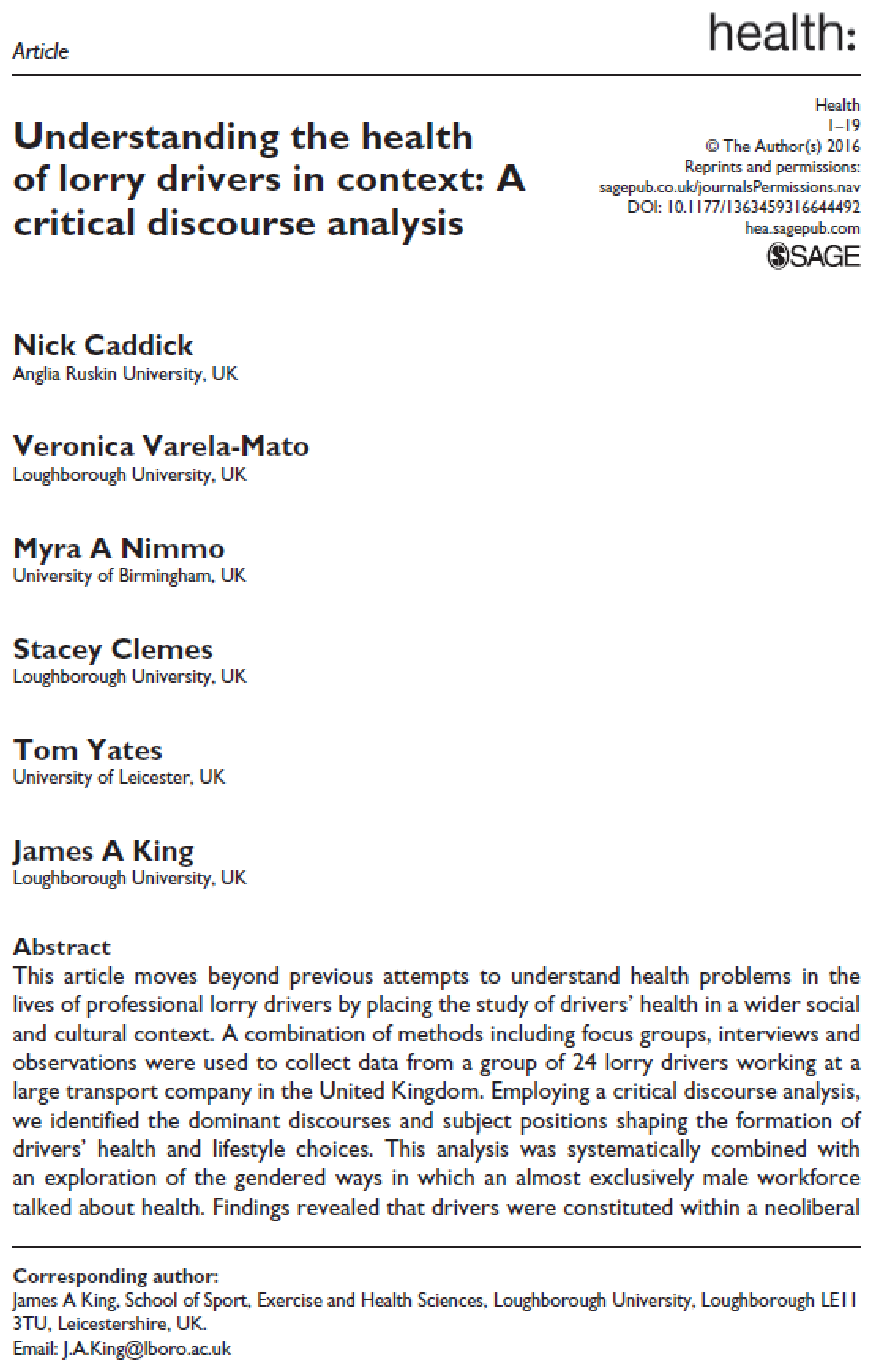
11.5First page of qualitative research paper published by Caddick et al., 2016.



Article

health:

Health
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Understanding the health of lorry drivers in context: A critical discourse analysis

Nick Caddick
Anglia Ruskin University, UK

Veronica Varela-Mato
Loughborough University, UK

Myra A Nimmo
University of Birmingham, UK

Stacey Clemes
Loughborough University, UK

Tom Yates
University of Leicester, UK

James A King
Loughborough University, UK

Abstract

This article moves beyond previous attempts to understand health problems in the lives of professional lorry drivers by placing the study of drivers' health in a wider social and cultural context. A combination of methods including focus groups, interviews and observations were used to collect data from a group of 24 lorry drivers working at a large transport company in the United Kingdom. Employing a critical discourse analysis, we identified the dominant discourses and subject positions shaping the formation of drivers' health and lifestyle choices. This analysis was systematically combined with an exploration of the gendered ways in which an almost exclusively male workforce talked about health. Findings revealed that drivers were constituted within a neoliberal

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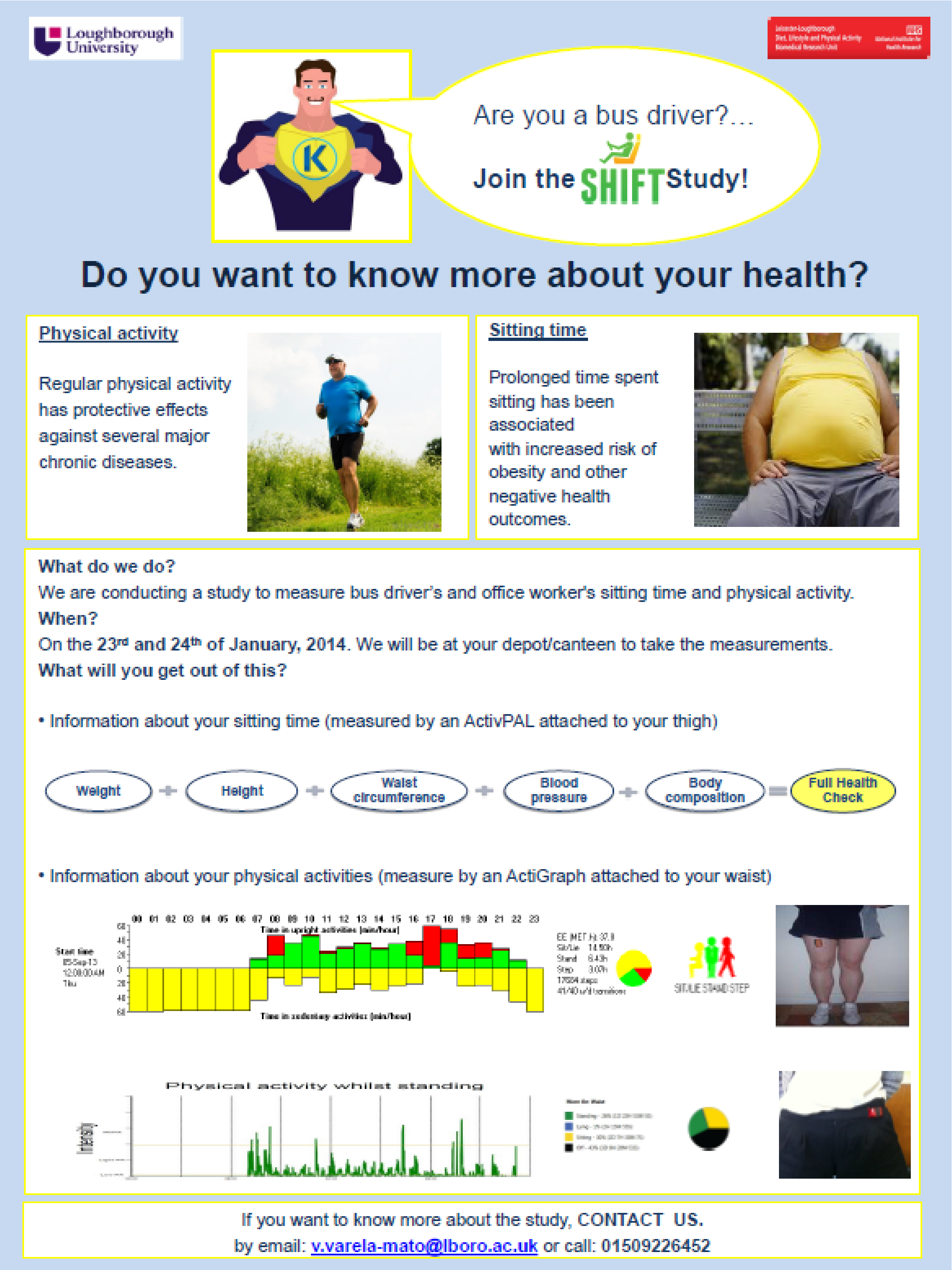
11.6Participant’s leaflet pilot study



Are you a bus driver?…

Join the SHIFT Study!

Do you want to know more about your health?

Physical activity

Regular physical activity has protective effects against several major chronic diseases.

Sitting time

Prolonged time spent sitting has been associated with increased risk of obesity and other negative health outcomes.

What do we do?

We are conducting a study to measure bus driver’s and office worker's sitting time and physical activity.

When?

On the 23rd and 24th of January, 2014. We will be at your depot/canteen to take the measurements.

What will you get out of this?

- Information about your sitting time (measured by an ActivPAL attached to your thigh)

Weight + Height + Waist circumference + Blood pressure + Body composition = Full Health Check

- Information about your physical activities (measure by an ActiGraph attached to your waist)

If you want to know more about the study, CONTACT US.

by email: v.varela-mato@lboro.ac.uk or call: 01509226452

Loughborough University
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time in upright activities [min/hour]
Time in sedentary activities [min/hour]
60
40
20
0
20
40
60
Start time
05-Sep-13
12:00:00AM
Thu
EE [MET.h]: 37.8
Sit/Lie 14.50h
Stand 6.43h
Step 3.07h
17004 steps
41/40 u/d transitions
SIT/LIE STAND STEP
Physical activity whilst standing
Intensity

HOW TO GET INVOLVED!

☐ The SHIFT Study is due to start at the beginning of June. If you want to know more about the study or you wish to take part please contact your occupational health team.

☐ A group of researchers from Loughborough University will be also based at your depot for two months from the beginning of June. You can also contact them directly.

Veronica Varela Mato, v.varela-mato@lboro.ac.uk
telephone: 01509 226452.
James King, J.A.King@lboro.ac.uk
telephone: 01509226324.
Orlagh O'Shea, o.oshea-13@student.lboro.ac.uk
telephone: 07516858377

☐**What will happen once you get involved?**
You will be asked to come for a session with the researches which will last for 1 hour approximately. In this session you will have to fill in some questionnaires and then you will undertake the measurements before mentioned. As these are fasting measurements a meal will be provided to you at the end of the session.

☐**What happens afterwards?**
When the data collection is finished, you will be contacted to take part in a discussion group about how to create a healthier working environment.

WILL THERE BE ANY INTERVENTION?

☐Yes, once the discussion groups are over researchers will use that information to create an intervention suitable to your needs.
☐You will then be contacted to offer you the opportunity to take part.

Healthy Life
NEXT EXIT

☐**What happens if I'm not happy with how the research is conducted?**

○If you have any problems during the assessment period is convenient for you to talk directly with the researcher.
○You can also chat to your occupational health team
○However, if you are not happy with how the research was conducted, please contact the Mrs Zoe Stockdale, the Secretary for the University's Ethics Approvals (Human Participants) Sub-Committee:
Miss Z Stockdale, Research Office, Rutland Building, Loughborough University, Epinal Way, Loughborough, LE11 3TU. Tel: 01509 222423. Email: Z.C.Stockdale@lboro.ac.uk

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

PEPSICO

The SHIFT Study

Sitting time and physical activity in relation to cardiovascular health

-Information sheet-

Loughborough University

BACKGROUND AND PURPOSE

☐Cardiovascular disease (CVD) is a major health concern in many developed countries. Sitting time is prevalent amongst most working age adults. Some studies have shown that prolonged time sitting increases the risk of CVD, diabetes, obesity and some cancers.

☐The purpose of this study is to examine the levels of sitting time and physical activity in and outside working hours in relation to risk factors for cardiovascular health amongst bus and lorry drivers and office workers within the East Midlands.

☐This study is based on a similar project amongst bus drivers, from which preliminary data shows they spent on average above 75% of their waking time sitting. In addition they presented unhealthy ranges for most cardiovascular indicators.

DID YOU KNOW?

Loughborough University and PepsiCo have recently established a partnership to support research aiming to promote healthier working environments.

☐This study involves researchers from the School of Sport, Exercise & Health Sciences at Loughborough University and The NIHR Leicester-Loughborough Diet, Lifestyle and Physical Activity Biomedical Research Unit working in collaboration with the occupational health team from PepsiCo .

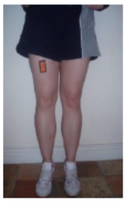
MEASUREMENTS AND REQUIREMENTS

Participants will be asked to complete a health screening questionnaire and to fast for at least 8h before the session.

Measurements at the depot involving:

☐ Blood pressure
☐ Body composition
☐ Waist and hip circumference
☐ Height
☐ Lung capacity
☐ Finger prick to analyse:
  ○ Glucose (sugar in blood)
  ○ HDL Cholesterol
  ○ LDL Cholesterol
  ○ Total Cholesterol
  ○ Triglycerides (fat in blood)

Free living measurements involving:
1. Sitting time monitor on your thigh.
2. Physical activity monitor on your waist.



You will be asked to wear them for 7 days and to keep a log book of your wear time. You are asked to follow your normal routine over this assessing period.

WHAT WILL HAPPEN TO MY DATA?

☐The information obtained from the measurements will be available to you straight away. This might help you for further health-related decisions and be of personal interest.

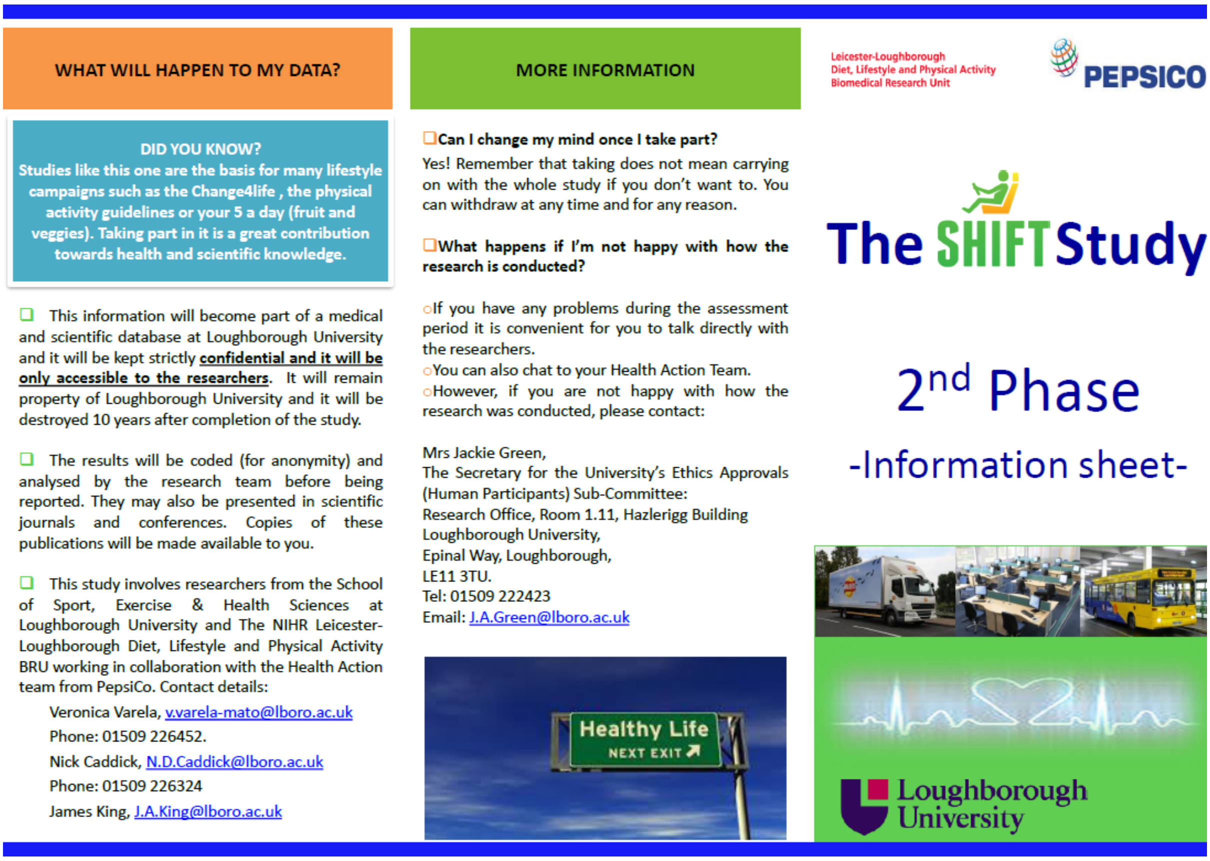
☐This information will become part of a medical and scientific database at Loughborough University and it will be kept strictly confidential and it will be only accessible to the researchers. It will remain property of Loughborough University and it will be destroyed 10 years after completion of the study.

☐The results will be coded (for anonymity) and analysed by the research team before being reported. The results may also be presented in scientific journals and conferences. Copies of these publications will be made available to your by the research team.

DID YOU KNOW?
Studies like this one are the basis for many lifestyle campaigns such as the Change4life , the physical activity guidelines or your 5 a day (fruit and veggies). Taking part in it is a great contribution towards health and scientific knowledge.

☐**Once I take part, can I change my mind?**
Yes! if at any time, before, during or after the study you wish to withdraw please just contact the main investigator. You can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing.

11.8 Participant's information sheet qualitative study



WHAT WILL HAPPEN TO MY DATA?

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☐ The results will be coded (for anonymity) and analysed by the research team before being reported. They may also be presented in scientific journals and conferences. Copies of these publications will be made available to you.

☐ This study involves researchers from the School of Sport, Exercise & Health Sciences at Loughborough University and The NIHR Leicester-Loughborough Diet, Lifestyle and Physical Activity BRU working in collaboration with the Health Action team from PepsiCo. Contact details:

Veronica Varela, v.varela-mato@lboro.ac.uk
Phone: 01509 226452.
Nick Caddick, N.D.Caddick@lboro.ac.uk
Phone: 01509 226324
James King, J.A.King@lboro.ac.uk

MORE INFORMATION

☐**Can I change my mind once I take part?**
Yes! Remember that taking does not mean carrying on with the whole study if you don't want to. You can withdraw at any time and for any reason.

☐**What happens if I'm not happy with how the research is conducted?**

○If you have any problems during the assessment period it is convenient for you to talk directly with the researchers.
○You can also chat to your Health Action Team.
○However, if you are not happy with how the research was conducted, please contact:

Mrs Jackie Green,
The Secretary for the University's Ethics Approvals (Human Participants) Sub-Committee:
Research Office, Room 1.11, Hazlerigg Building
Loughborough University,
Epinal Way, Loughborough,
LE11 3TU.
Tel: 01509 222423
Email: J.A.Green@lboro.ac.uk

Healthy Life
NEXT EXIT ↗

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

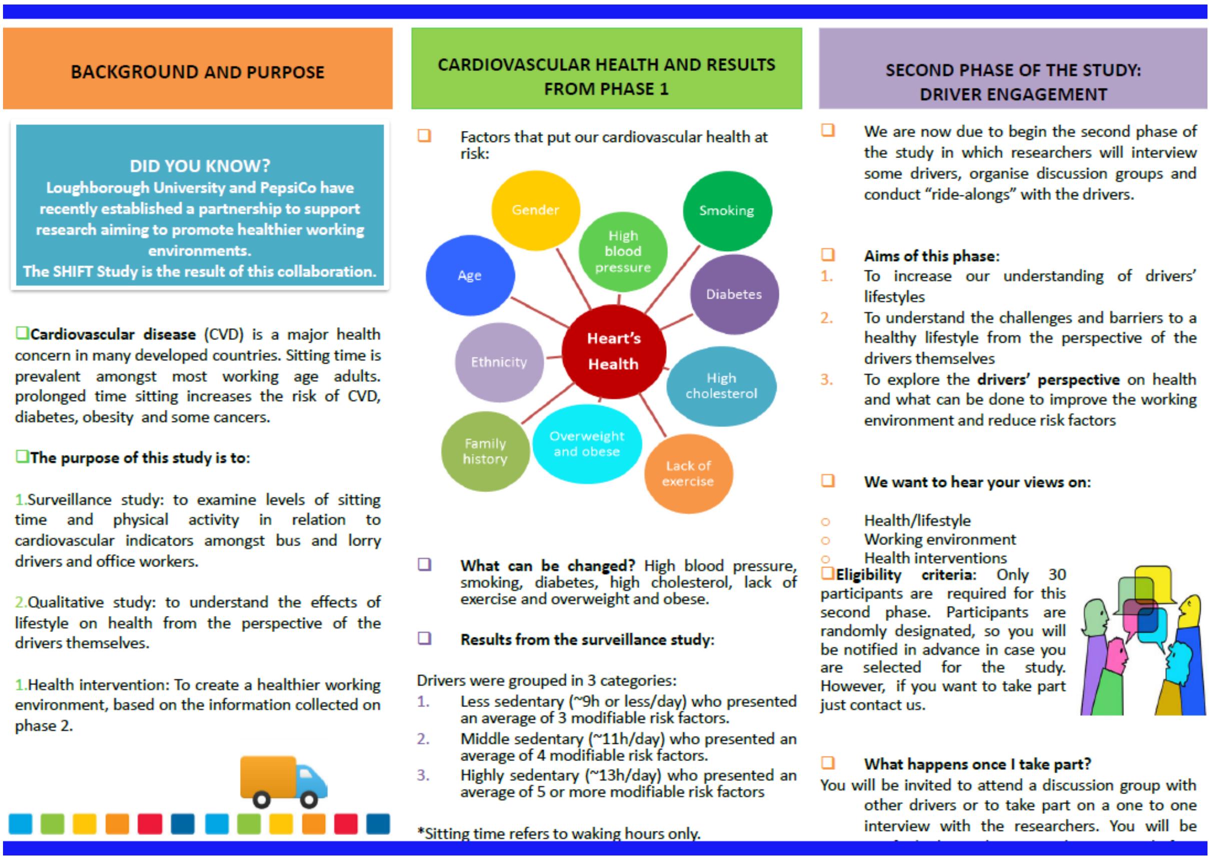
PEPSICO

The SHIFT Study

2nd Phase

-Information sheet-

Loughborough University



BACKGROUND AND PURPOSE

DID YOU KNOW?
Loughborough University and PepsiCo have recently established a partnership to support research aiming to promote healthier working environments.
The SHIFT Study is the result of this collaboration.

☐**Cardiovascular disease** (CVD) is a major health concern in many developed countries. Sitting time is prevalent amongst most working age adults. prolonged time sitting increases the risk of CVD, diabetes, obesity and some cancers.

☐**The purpose of this study is to:**

1.Surveillance study: to examine levels of sitting time and physical activity in relation to cardiovascular indicators amongst bus and lorry drivers and office workers.

2.Qualitative study: to understand the effects of lifestyle on health from the perspective of the drivers themselves.

1.Health intervention: To create a healthier working environment, based on the information collected on phase 2.

CARDIOVASCULAR HEALTH AND RESULTS FROM PHASE 1

☐ Factors that put our cardiovascular health at risk:

Heart's Health
Gender
High blood pressure
Smoking
Age
Diabetes
Ethnicity
High cholesterol
Family history
Overweight and obese
Lack of exercise

☐ **What can be changed?** High blood pressure, smoking, diabetes, high cholesterol, lack of exercise and overweight and obese.

☐ **Results from the surveillance study:**

Drivers were grouped in 3 categories:
1. Less sedentary (~9h or less/day) who presented an average of 3 modifiable risk factors.
2. Middle sedentary (~11h/day) who presented an average of 4 modifiable risk factors.
3. Highly sedentary (~13h/day) who presented an average of 5 or more modifiable risk factors

*Sitting time refers to waking hours only.

SECOND PHASE OF THE STUDY: DRIVER ENGAGEMENT

☐ We are now due to begin the second phase of the study in which researchers will interview some drivers, organise discussion groups and conduct "ride-alongs" with the drivers.

☐ **Aims of this phase:**
1. To increase our understanding of drivers' lifestyles
2. To understand the challenges and barriers to a healthy lifestyle from the perspective of the drivers themselves
3. To explore the **drivers' perspective** on health and what can be done to improve the working environment and reduce risk factors

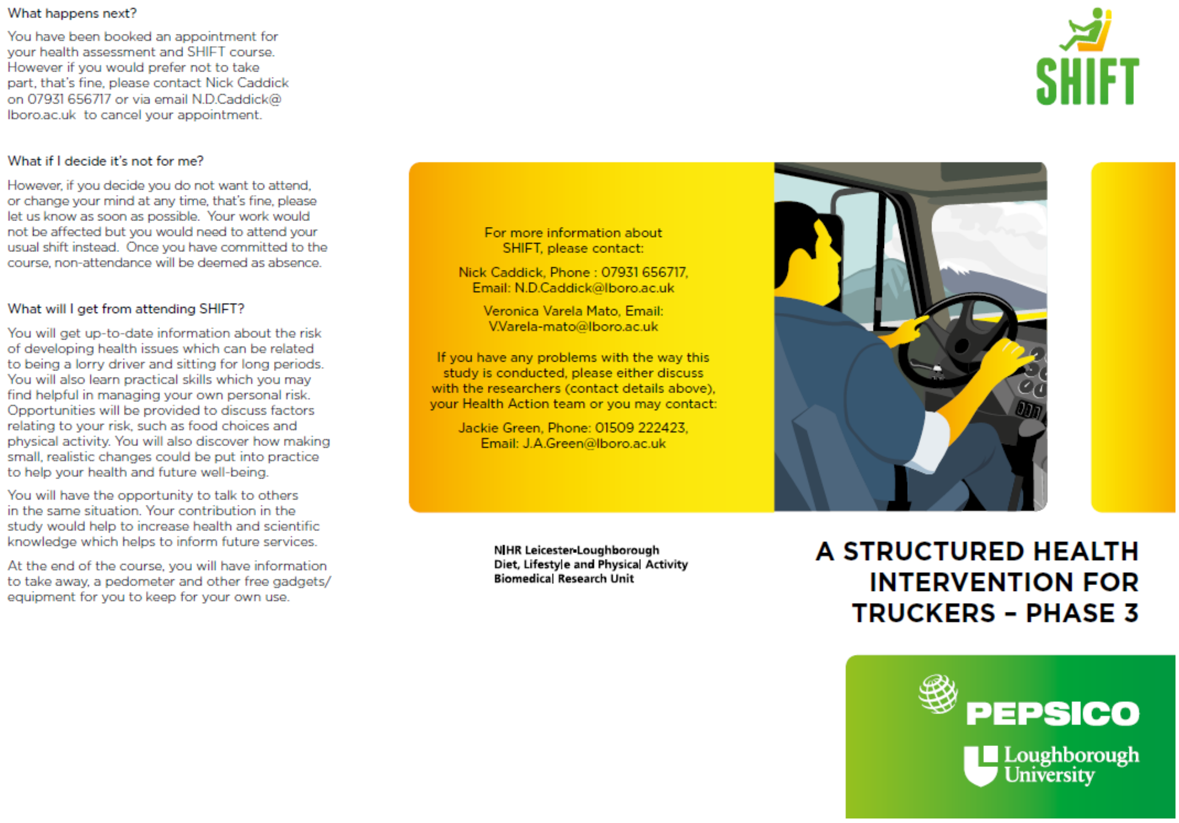
☐ **We want to hear your views on:**

○ Health/lifestyle
○ Working environment
○ Health interventions

☐**Eligibility criteria:** Only 30 participants are required for this second phase. Participants are randomly designated, so you will be notified in advance in case you are selected for the study. However, if you want to take part just contact us.

☐ **What happens once I take part?**
You will be invited to attend a discussion group with other drivers or to take part on a one to one interview with the researchers. You will be

11.9 Participant’s information sheet intervention



What happens next?

You have been booked an appointment for your health assessment and SHIFT course. However if you would prefer not to take part, that’s fine, please contact Nick Caddick on 07931 656717 or via email N.D.Caddick@lboro.ac.uk to cancel your appointment.

What if I decide it’s not for me?

However, if you decide you do not want to attend, or change your mind at any time, that’s fine, please let us know as soon as possible. Your work would not be affected but you would need to attend your usual shift instead. Once you have committed to the course, non-attendance will be deemed as absence.

What will I get from attending SHIFT?

You will get up-to-date information about the risk of developing health issues which can be related to being a lorry driver and sitting for long periods. You will also learn practical skills which you may find helpful in managing your own personal risk. Opportunities will be provided to discuss factors relating to your risk, such as food choices and physical activity. You will also discover how making small, realistic changes could be put into practice to help your health and future well-being.

You will have the opportunity to talk to others in the same situation. Your contribution in the study would help to increase health and scientific knowledge which helps to inform future services.

At the end of the course, you will have information to take away, a pedometer and other free gadgets/equipment for you to keep for your own use.

For more information about
SHIFT, please contact:

Nick Caddick, Phone : 07931 656717,
Email: N.D.Caddick@lboro.ac.uk

Veronica Varela Mato, Email:
V.Varela-mato@lboro.ac.uk

If you have any problems with the way this study is conducted, please either discuss with the researchers (contact details above), your Health Action team or you may contact:

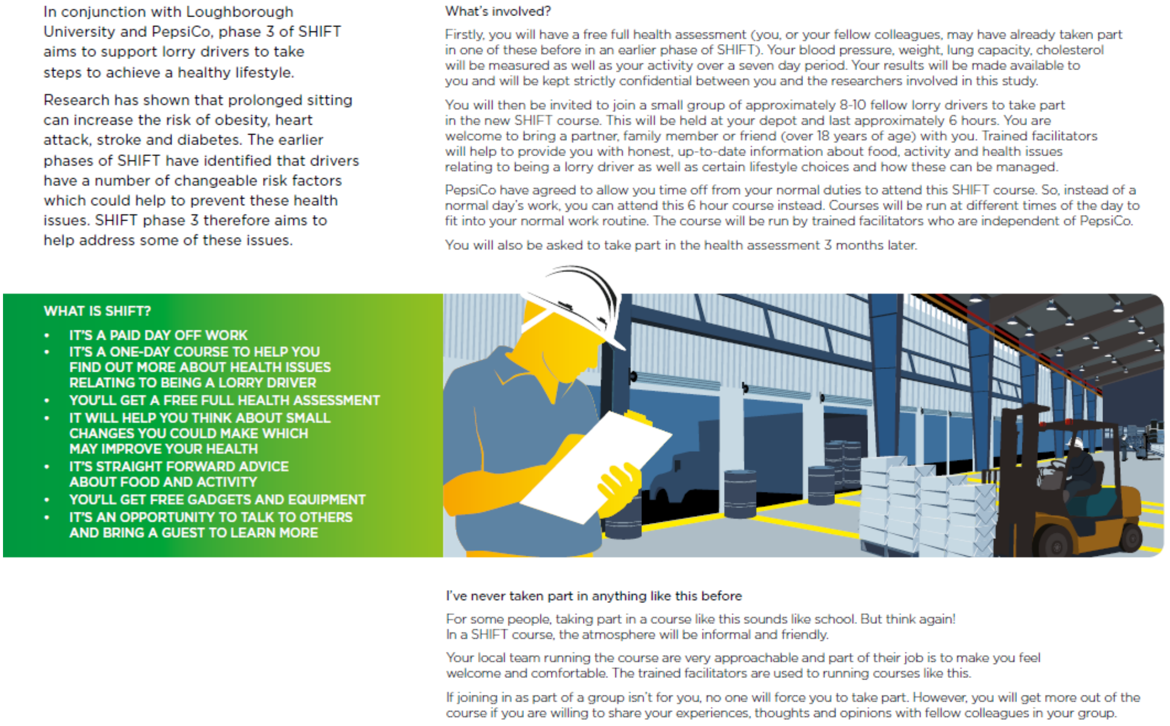
Jackie Green, Phone: 01509 222423,
Email: J.A.Green@lboro.ac.uk

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

SHIFT

A STRUCTURED HEALTH INTERVENTION FOR TRUCKERS – PHASE 3

PEPSICO
Loughborough University



In conjunction with Loughborough University and PepsiCo, phase 3 of SHIFT aims to support lorry drivers to take steps to achieve a healthy lifestyle.

Research has shown that prolonged sitting can increase the risk of obesity, heart attack, stroke and diabetes. The earlier phases of SHIFT have identified that drivers have a number of changeable risk factors which could help to prevent these health issues. SHIFT phase 3 therefore aims to help address some of these issues.

WHAT IS SHIFT?

- IT’S A PAID DAY OFF WORK
- IT’S A ONE-DAY COURSE TO HELP YOU FIND OUT MORE ABOUT HEALTH ISSUES RELATING TO BEING A LORRY DRIVER
- YOU’LL GET A FREE FULL HEALTH ASSESSMENT
- IT WILL HELP YOU THINK ABOUT SMALL CHANGES YOU COULD MAKE WHICH MAY IMPROVE YOUR HEALTH
- IT’S STRAIGHT FORWARD ADVICE ABOUT FOOD AND ACTIVITY
- YOU’LL GET FREE GADGETS AND EQUIPMENT
- IT’S AN OPPORTUNITY TO TALK TO OTHERS AND BRING A GUEST TO LEARN MORE

What’s involved?

Firstly, you will have a free full health assessment (you, or your fellow colleagues, may have already taken part in one of these before in an earlier phase of SHIFT). Your blood pressure, weight, lung capacity, cholesterol will be measured as well as your activity over a seven day period. Your results will be made available to you and will be kept strictly confidential between you and the researchers involved in this study.

You will then be invited to join a small group of approximately 8-10 fellow lorry drivers to take part in the new SHIFT course. This will be held at your depot and last approximately 6 hours. You are welcome to bring a partner, family member or friend (over 18 years of age) with you. Trained facilitators will help to provide you with honest, up-to-date information about food, activity and health issues relating to being a lorry driver as well as certain lifestyle choices and how these can be managed.

PepsiCo have agreed to allow you time off from your normal duties to attend this SHIFT course. So, instead of a normal day’s work, you can attend this 6 hour course instead. Courses will be run at different times of the day to fit into your normal work routine. The course will be run by trained facilitators who are independent of PepsiCo.

You will also be asked to take part in the health assessment 3 months later.

I’ve never taken part in anything like this before

For some people, taking part in a course like this sounds like school. But think again! In a SHIFT course, the atmosphere will be informal and friendly.

Your local team running the course are very approachable and part of their job is to make you feel welcome and comfortable. The trained facilitators are used to running courses like this.

If joining in as part of a group isn’t for you, no one will force you to take part. However, you will get more out of the course if you are willing to share your experiences, thoughts and opinions with fellow colleagues in your group.

11.10 Participant's consent form, questionnaire and daily log.

SHIFT

-The SHIFT Study-

SITTING TIME AND PHYSICAL ACTIVITY AND OTHER HEALTH OUTCOMES STUDY

INFORMED CONSENT FORM

The purpose and details of this study have been explained to me. I understand that this study is purely for research purposes. The data obtained from the study will be used to enhance academic and health knowledge.

I have understood that all the steps involved in the study will not cause harm to me and that all the procedures have been approved by the Loughborough University Ethical Advisory Committee.

I have sufficiently understood the Information Sheet and this Consent Form.

I understand that I have the right to withdraw from this study at any stage for any reason, and that I will not be required to explain my reasons for withdrawing.

I understand that all the information I provide will be treated in strict confidence and will be kept anonymous and confidential to the researchers unless, it is judged that confidentiality will have to be breached for the safety of the participant or others.

I agree to participate in the study.

Yes _____   No_____

Kindly sign this form if you agree to participate.

Surname ________________________________   First Name _______________________

Signature ________________________   Date _______________________

Email____ Contact number_______________________

Signature of investigator: ________________________________

Date ________________________________

Leicester-Loughborough
Diet, Lifestyle and Physical Activity
Biomedical Research Unit
NHS
National Institute for Health Research

ID: ____________

Loughborough University

Accelerometer #: ____________________

activPAL #: __________________________

Sedentary Behaviours and physical activity Study

Activity Monitor Instructions & Daily Log

Please keep this booklet in a safe place so you can return it to us at the end of the 8 days

If you have any questions or concerns, please contact: Veronica Varela (v.varela-mato@lboro.ac.uk) Nick Caddick (N.D.Caddick@lboro.ac.uk)

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

NHS
National Institute for
Health Research

Loughborough
University

1. General information

Please read the next questions and fill in as accurate as possible. In those questions that you need to select between 2 options **put a circle** on the right answer.

Age: ________ **Gender:** Female / Male

Occupation: lorry Driver / Office worker **Shift:** morning / afternoon / night

Years working at the company: __________ **Average hours worked/week:** _________

Marital Status:

Single / Co-habiting / Married* / Re-married / Separated / Divorced / Widowed

* including those in civil partnerships – 1st marriage

Post code: ___________________________________

Type of housing:

- ☐ Buying it-mortgage/loan
- ☐ Owned
- ☐ Rented
- ☐ Live there rent free
- ☐ Part rent - part mortgage
- ☐ Don't know
- ☐ Squatting

Number of bedrooms in the house _________

Number of people living in the house Adults ☐ Kids ☐

Housing benefit: yes / no

Do you have a car? yes / no **if yes, how many?** ☐

Level of education:

- ☐ Some secondary school education
- ☐ GCSEs
- ☐ A-levels
- ☐ University graduate (e.g. Bachelor's degree)
- ☐ Post-graduate certificate (e.g. PGCE)
- ☐ Master's degree
- ☐ Professional or Doctorate degree (e.g. Ph.D)
- ☐ Other:________________________________

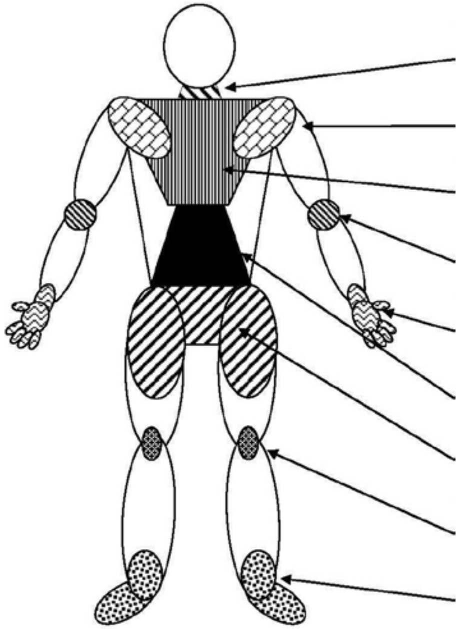
Diabetes Status: yes / no

Are you contemplating on becoming more active? yes / no

What is your ethnic origin? (Please tick one)

White	White		Black / Black British	African	
	White British			Caribbean	
	White European		Other ethnic group	Arab	
Asia/Asian British	Indian			White & Black	
	Pakistani			White & Asian	
	Bangladeshi		Other (please state)		
	Chinese				

2. Musculoskeletal Problems: The following questions refer to trouble experienced in muscles and joints which have progressively come about. Please answer every question even if you have never had trouble in any parts of your body. This picture shows how the body has been divided. You should decide for yourself which part (if any) is or has been affected.



	Have you at any time during the last 12 months had trouble (such as ache, pain, discomfort, numbness) in:	On a scale of 0 to 10, how much pain did you experience? (0 is no pain, 10 is the most pain you can imagine)	During the last 12 months have you been prevented from carrying out normal activities (e.g. job, housework, hobbies) because of this trouble in:	During the last 12 months have you seen a physician for this condition:	During the last 7 days have you had trouble in:
NECK	YES NO		YES NO	YES NO	YES NO
SHOULDER	YES NO		YES NO	YES NO	YES NO
UPPER BACK	YES NO		YES NO	YES NO	YES NO
ELBOW	YES NO		YES NO	YES NO	YES NO
WRIST/HAND	YES NO		YES NO	YES NO	YES NO
LOWER BACK	YES NO		YES NO	YES NO	YES NO
HIP/THIGH	YES NO		YES NO	YES NO	YES NO
KNEE	YES NO		YES NO	YES NO	YES NO
ANKLE/FEET	YES NO		YES NO	YES NO	YES NO

3. Well-Being and Feelings

Remember that personal data such as names will not be linked to the questionnaire and your questionnaire will only be seen by the main researchers of the study

Hospital Anxiety and Depression Scale (HADS)

Instructions - Read every sentence. Place an X on the answer that best describes how you have been feeling during the **LAST WEEK**. For these questions, spontaneous answers are the most important.

1. I feel tense or wound up
Most of the time
☐ A lot of the time
☐ From time to time
☐ Not at all

3. I get a sort of frightened feeling as if something awful is about to happen

☐ Very definitely and quite badly
☐ Yes, but not too badly
☐ A little but it doesn't worry me
☐ Not at all

5. Worrying thoughts go through my mind

☐ A great deal of the time
☐ A lot of the time
☐ From time to time but not often
☐ Only occasionaly

7. I can sit at ease and feel relaxed

☐ Definitely
☐ Usually
☐ Not often
☐ Not at all

9. I get a sort of frightened feeling like butterflies in the stomach

☐ Not at all
☐ Occasionally
☐ Quite often
☐ Very often

2. I still enjoy the things I used to enjoy

☐ Hardly at all
☐ Only a little
☐ Not quite as much
☐ Definitely as much

4. I can laugh and see the funny side of things

☐ Not at all
☐ Definitely not so much now
☐ Not quite as much now
☐ As much as I always could

6. I feel cheerful

☐ Not at all
☐ Not often
☐ Sometimes
☐ Most of the time

8. I feel as if I am slowed down

☐ Nearly all of the time
☐ Very often
☐ Sometimes
☐ Not at all

10. I have lost interest in my appearance

☐ Definitely
☐ I don't take as much care as I should
☐ I may not take quite as much care
☐ I take just as much care as ever

11. I feel restless, as if I have to be on the move

☐ Very much indeed
☐ Quite a lot
☐ Not very much
☐ Not at all

13. I get a sudden feeling of panic

☐ Very often indeed
☐ Quite often
☐ Not very often
☐ Not at all

12. I look forward with enjoyment to things

☐ As much as I ever did
☐ Rather less than I used to
☐ Definitely less than I used to
☐ Hardly at all

14. I can enjoy a good TV or radio programme or book

☐ Often
☐ Sometimes
☐ Not often
☐ Very seldom

This set of questions is about walking.

*On the following questions, please circle the percentage that best corresponds to your views for **each** question*

1. How confident are you that you could walk for 10 minutes every day										
0%	10%	20%	30%	40%	50%	60 %	70%	80%	90%	100%
2. How confident are you that you could walk for 20 minutes every day										
0%	10%	20%	30%	40%	50%	60 %	70%	80%	90%	100%
3. How confident are you that you could walk for 30 minutes every day										
0%	10%	20%	30%	40%	50%	60 %	70%	80%	90%	100%
4. How confident are you that you could walk for 40 minutes every day										
0%	10%	20%	30%	40%	50%	60 %	70%	80%	90%	100%
5. How confident are you that you could walk for 50 minutes every day										
0%	10%	20%	30%	40%	50%	60 %	70%	80%	90%	100%
6. How confident are you that you could walk for 60 minutes every day										
0%	10%	20%	30%	40%	50%	60 %	70%	80%	90%	100%

This set of questions is about sitting.

*On the following questions, please circle the percentage that best corresponds to your views for **each** question*

1. How confident are you that would be able to reduce the amount of time you spend sitting by 30 min per day?										
0%	10%	20%	30%	40%	50%	60 %	70%	80%	90%	100%
2. How confident are you that would be able to reduce the amount of time you spend sitting by 60 min per day?										
0%	10%	20%	30%	40%	50%	60 %	70%	80%	90%	100%
3. How confident are you that would be able to reduce the amount of time you spend sitting by 90 min per day?										
0%	10%	20%	30%	40%	50%	60 %	70%	80%	90%	100%
4. How confident are you that would be able to reduce the amount of time you spend sitting by 120 min per day?										
0%	10%	20%	30%	40%	50%	60 %	70%	80%	90%	100%
5. How confident are you that would be able to reduce the amount of time you spend sitting by 150 min per day?										
0%	10%	20%	30%	40%	50%	60 %	70%	80%	90%	100%

Work engagement

The following 9 statements are about how you feel at work**.** Please read each statement carefully and decide if you ever feel this way about your job. If you have never had this feeling, circle the “0” (zero) in the space after the statement. If you have had this feeling, indicate how often you feel it by crossing the number (from 1 to 6) that best describes how frequently you feel that way.

0=never
1=Almost never (a few times a year or less)
2=rarely (once a month or less)
3=sometimes (a few times a month)
4=often (once a week)
5= very often (a few times a week)
6= Always (every day)

At my work I feel bursting with energy						
0	1	2	3	4	5	6
At my job, I feel strong and vigorous						
0	1	2	3	4	5	6
I am enthusiastic about my job						
0	1	2	3	4	5	6
My job inspires me						
0	1	2	3	4	5	6
When I get up in the morning, I feel like going to work						
0	1	2	3	4	5	6
I feel happy when I am working intensely						
0	1	2	3	4	5	6
I am proud of the work that I do						
0	1	2	3	4	5	6
I am immersed in my work						
0	1	2	3	4	5	6
I get carried away when I am working						
0	1	2	3	4	5	6

Work Ability

On a scale from 0 to 10 where 0 is the worst job performance anyone could have at your job and 10 is the performance of a top worker, how would you rate (please circle):

	Worst performance										Top performance
a) The usual performance of most workers in a job similar to yours?	0	1	2	3	4	5	6	7	8	9	10
b) Your usual job performance over the past year or two?	0	1	2	3	4	5	6	7	8	9	10
c) Your overall job performance on the days you worked during the past 4 weeks (28 days)?	0	1	2	3	4	5	6	7	8	9	10

In the past year (12 months), how many whole days have you been off work because of a health problem (Disease or health care or for health examination)?

_______________days

In the past 4 weeks (28 days), how many whole days have you been off work because of a health problem (Disease or health care or for health examination)?

_______________days

In the past year (12 months), how many whole days have you gone to work despite feeling that you should have taken sick leave due to your state of health?

_______________days

In the past 4 weeks (28 days), how many days did you come in early, go home late, or work on your day off? (Please enter a whole number only)

_____________ days

4. Sleep Quality

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month.

Please answer all questions:

1 During the past month, what time have you usually gone to bed at night? __________

2 During the past month, how long (in minutes) has it usually taken you to fall asleep each night? (number of minutes) _________

3 During the past month, what time have you usually gotten up in the morning? ______

4 During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)_____________________

For each of the remaining questions, check the one best response. Please answer all questions.

5 During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes:

Not during the past month ☐ Less than once a week ☐ Once or twice a week ☐ Three or more times a week ☐

b) Wake up in the middle of the night or early morning

Not during the past month ☐ Less than once a week ☐ Once or twice a week ☐ Three or more times a week ☐

c) Have to get up to use the bathroom

Not during the past month ☐ Less than once a week ☐ Once or twice a week ☐ Three or more times a week ☐

d) Cannot breathe comfortably

Not during the past month ☐ Less than once a week ☐ Once or twice a week ☐ Three or more times a week ☐

e) Cough or snore loudly

Not during the ☐ Less than once ☐ Once or twice ☐ Three or more ☐

past month ☐ a week ☐ a week ☐ times a week ☐

f) Feel too cold

Not during the past month ☐ Less than once a week ☐ Once or twice a week ☐ Three or more times a week ☐

g) Feel too hot

Not during the past month ☐ Less than once a week ☐ Once or twice a week ☐ Three or more times a week ☐

h) Had bad dreams

Not during the past month ☐ Less than once a week ☐ Once or twice a week ☐ Three or more times a week ☐

i) Have pain

Not during the past month ☐ Less than once a week ☐ Once or twice a week ☐ Three or more times a week ☐

j) Other reason(s), please describe

____

____

How often during the past month have you had trouble sleeping because of this?

Not during the past month ☐ Less than once a week ☐ Once or twice a week ☐ Three or more times a week ☐

6 During the past month, how would you rate your sleep quality overall?

Very good ☐ Fairly good ☐ Fairly bad ☐ Very bad ☐

7 During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the past month ☐ Less than once a week ☐ Once or twice a week ☐ Three or more times a week ☐

8 During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month ☐	Less than once a week ☐	Once or twice a week ☐	Three or more times a week ☐

9 During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all ☐	Only very slight problem ☐	Somewhat of a problem ☐	A very big problem ☐

10 Do you have a bed partner or roommate?

No bed partner or room mate ☐	Partner/roommate in other room ☐	Partner in same room, but not same bed ☐	Partner in same bed ☐

If you have a room mate or bed partner, ask him/her how often in the past month you have had . . .

a) Loud snoring

Not during the past month ☐	Less than once a week ☐	Once or twice a week ☐	Three or more times a week ☐

b) Long pauses between breaths while asleep

Not during the past month ☐	Less than once a week ☐	Once or twice a week ☐	Three or more times a week ☐

c) Legs twitching or jerking while you sleep

Not during the past month ☐	Less than once a week ☐	Once or twice a week ☐	Three or more times a week ☐

d) Episodes of disorientation or confusion during sleep

Not during the past month ☐	Less than once a week ☐	Once or twice a week ☐	Three or more times a week ☐

e) Other restlessness while you sleep; please describe

Not during the past month ☐ Less than once a week ☐ Once or twice a week ☐ Three or more times a week ☐

ID: ______________

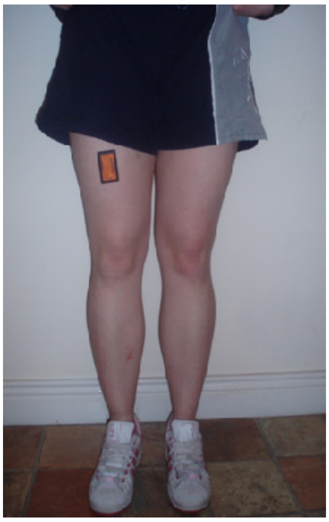
Accelerometer #: __________________

activPAL #: _______________________

The daily log

Instructions

How to wear the thigh monitor

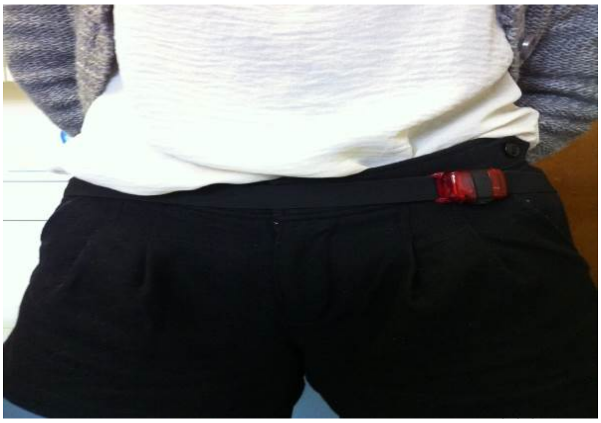


- The thigh monitor or activPAL measures your posture – specifically your sitting, standing and sleeping time
- Wear it **continuously for 7 days.**
- Put it on your upper mid-thigh and that the **'man' on the device is standing upright** – head facing upwards (see picture below).
- The thigh monitor is **waterproof** so you can continue wearing it whilst bathing, showering etc…

Note: the monitor will be flashing every 6 seconds. This is an indication that it is working. If it stops flashing, contact us immediately and we will provide you with a new one.

How to wear the hip monitor

- The hip monitor or Actigraph measures the intensity of your physical activity (light, moderate or vigorous activity).
- It is to be worn **for 7 days**. However, it should be removed when bathing, showering and/or swimming. If you find it uncomfortable to sleep with, you can take it off but it is very important that you **put it on as soon as you wake up in the morning.**
- The monitor should be placed on, or as close to, your waistband as possible and rest on your hip bone, either side is OK.
- The monitor can be worn either underneath or on top of your clothing, just as long as it fits snugly around your waistband.
- The monitor will be **flashing** whilst recording data, if it stops flashing please contact Veronica Varela-Mato as it has stopped working and we will need to change it.



How to fill in the daily log

- The log is divided into 7 days. Please complete each day's questions as accurately as possible – record the exact times or to the nearest 5 minutes.

   1. Indicate the date.
   2. Record the time that you **woke up** and when you put the waist device on.
   3. Indicate if you have worn the waist device or not on that night by ticking the correspondent box.
   4. State if it a **work or non-work day**.
   5. If it was a work day, please record the time you **started and finish working** and if you had **breaks**.
   6. Record any times you **removed** any of both devices for more than 15 minutes during the day.
   7. Finally, if you take off the waist monitor to sleep, please **record the time that you removed** it and tick the corresponding box the following morning.

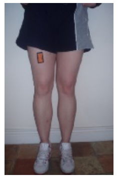
NOTES:

- Midnight = 12am; midday = 12pm
- **Sleep and awaking times are very important.**

Daily log (Remember to fill it in daily). Write your comments at the Thigh device

Waist device (ActiGraph)

Thigh device (ActivPAL)



Date: ___/___/___ Waking up time?	What time did you put the waist device on?	Is today a work or non-work day?	What time did you start working?	Did you have a lunch break?	What time did you finish working?	Did you go to sleep with the waist device on?	At what time did you go to bed?	Did you remove the thigh device?	Did you remove the waist device?
01/04/14 7:30 [✓ am]/pm	7:35 [✓ am]/pm	[✓ Work] Non-work	8:30 [✓ am]/pm	12:30am/[✓ pm] 1:30 am/[✓ pm]	5:00 am/[✓ pm]	[✓ Yes] / no	23:30 [✓ am] / pm	_____ am/pm ____ am/pm	20:20am/[✓ pm] 20:50am/[✓ pm]
Day 1 ___/___/___ _____ am/pm	_____ am/pm	Work Non-work	_____ am/pm	_____ am/pm _____ am/pm	_____ am/pm	Yes / no	_____ am/pm	_____ am/pm _____ am/pm	_____ am/pm _____ am/pm
Day 2 ___/___/___ _____ am/pm	_____ am/pm	Work Non-work	_____ am/pm	_____ am/pm _____ am/pm	_____ am/pm	Yes / no	_____ am/pm	_____ am/pm _____ am/pm	_____ am/pm _____ am/pm
Day 3 ___/___/___ _____ am/pm	_____ am/pm	Work Non-work	_____ am/pm	_____ am/pm _____ am/pm	_____ am/pm	Yes / no	_____ am/pm	_____ am/pm _____ am/pm	_____ am/pm _____ am/pm

Date: ___/___/___ Waking up time?	What time did you put the waist device on?	Is today a work or non-work day?	What time did you start working?	Did you have a lunch break?	What time did you finish working?	Did you go to sleep with the waist device?	At what time did you go to bed?	Did you remove the thigh device?	Did you remove the waist device?
Day 4 ___/___/___ ____ am/pm	____ am/pm	Work Non-work	____ am/pm	____ am/pm ____ am/pm	____ am/pm	Yes / no	____ am/pm	____ am/pm ____ am/pm	____ am/pm ____ am/pm
Day 5 ___/___/___ ____ am/pm	____ am/pm	Work Non-work	____ am/pm	____ am/pm ____ am/pm	____ am/pm	Yes / no	____ am/pm	____ am/pm ____ am/pm	____ am/pm ____ am/pm
Day 6 ___/___/___ ____ am/pm	____ am/pm	Work Non-work	____ am/pm	____ am/pm ____ am/pm	____ am/pm	Yes / no	____ am/pm	____ am/pm ____ am/pm	____ am/pm ____ am/pm
Day 7 ___/___/___ ____ am/pm	____ am/pm	Work Non-work	____ am/pm	____ am/pm ____ am/pm	____ am/pm	Yes / no	____ am/pm	____ am/pm ____ am/pm	____ am/pm ____ am/pm

Do you have any comments about the daily log?

____

____

____

THANKS FOR FILLING IN THE QUESTIONNAIRE

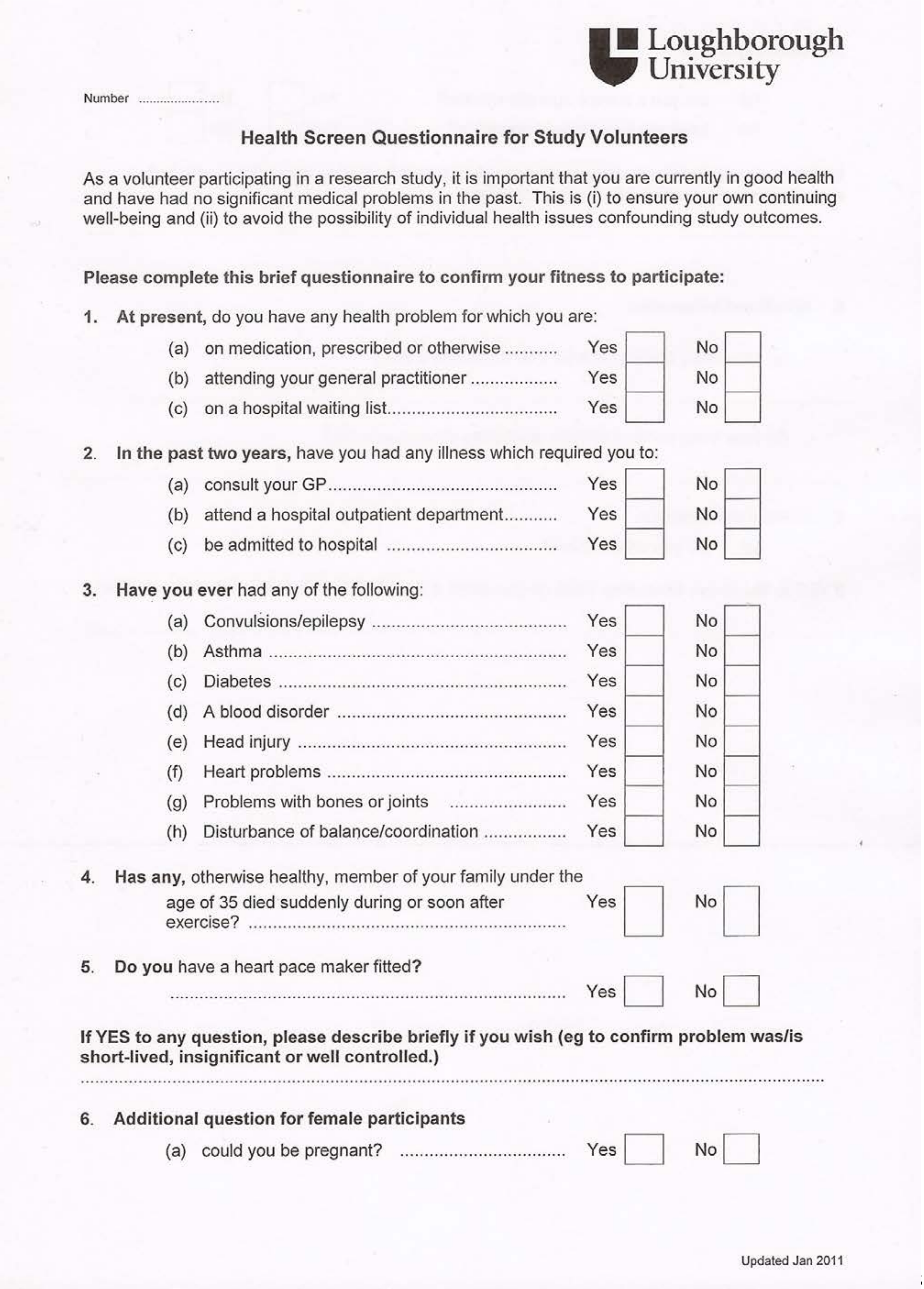
Please, remember to return this log with the devices to us once you have finished the measurement period. The returning date is on your participant pack.

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

NHS
National Institute for
Health Research

Loughborough
University

11.11 Health Screen Questionnaire



Loughborough
University

Number ....

Health Screen Questionnaire for Study Volunteers

As a volunteer participating in a research study, it is important that you are currently in good health and have had no significant medical problems in the past. This is (i) to ensure your own continuing well-being and (ii) to avoid the possibility of individual health issues confounding study outcomes.

Please complete this brief questionnaire to confirm your fitness to participate:

1. **At present,** do you have any health problem for which you are:
   - (a) on medication, prescribed or otherwise .... Yes ☐ No ☐
   - (b) attending your general practitioner .... Yes ☐ No ☐
   - (c) on a hospital waiting list.................................. Yes ☐ No ☐

2. **In the past two years,** have you had any illness which required you to:
   - (a) consult your GP... Yes ☐ No ☐
   - (b) attend a hospital outpatient department........... Yes ☐ No ☐
   - (c) be admitted to hospital .... Yes ☐ No ☐

3. **Have you ever** had any of the following:
   - (a) Convulsions/epilepsy .... Yes ☐ No ☐
   - (b) Asthma .... Yes ☐ No ☐
   - (c) Diabetes .... Yes ☐ No ☐
   - (d) A blood disorder .... Yes ☐ No ☐
   - (e) Head injury .... Yes ☐ No ☐
   - (f) Heart problems .... Yes ☐ No ☐
   - (g) Problems with bones or joints .... Yes ☐ No ☐
   - (h) Disturbance of balance/coordination .... Yes ☐ No ☐

4. **Has any,** otherwise healthy, member of your family under the age of 35 died suddenly during or soon after exercise? .... Yes ☐ No ☐

5. **Do you** have a heart pace maker fitted**?** .... Yes ☐ No ☐

If YES to any question, please describe briefly if you wish (eg to confirm problem was/is short-lived, insignificant or well controlled.)

....

6. **Additional question for female participants**
   - (a) could you be pregnant? .... Yes ☐ No ☐

Updated Jan 2011

7. Smoking status

(a) are you a current cigarette smoker? Yes ☐ No ☐
(b) have you ever smoked cigarettes? Yes ☐ No ☐

If YES to any of the above, please provide additional information about the amount of cigarettes smoked/ when you gave up smoking

....

8. Nutritional information

(a) How many portions of fresh fruit do you eat a day?

....

(b) How many portions of fresh vegetables do you eat a day?

....

9. Alcohol consumption

(a) Do you drink alcohol?

If YES to the above how many units do you drink a week? (2-3 units = 1 small glass of wine)

....

11.12 Participant’s feedback sheet

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

NHS
National Institute for
Health Research

Loughborough
University

ID Number: ____________

Sedentary behaviours and physical activity Study

Health report feedback

SHIFT

If you have any questions or concerns, please contact:

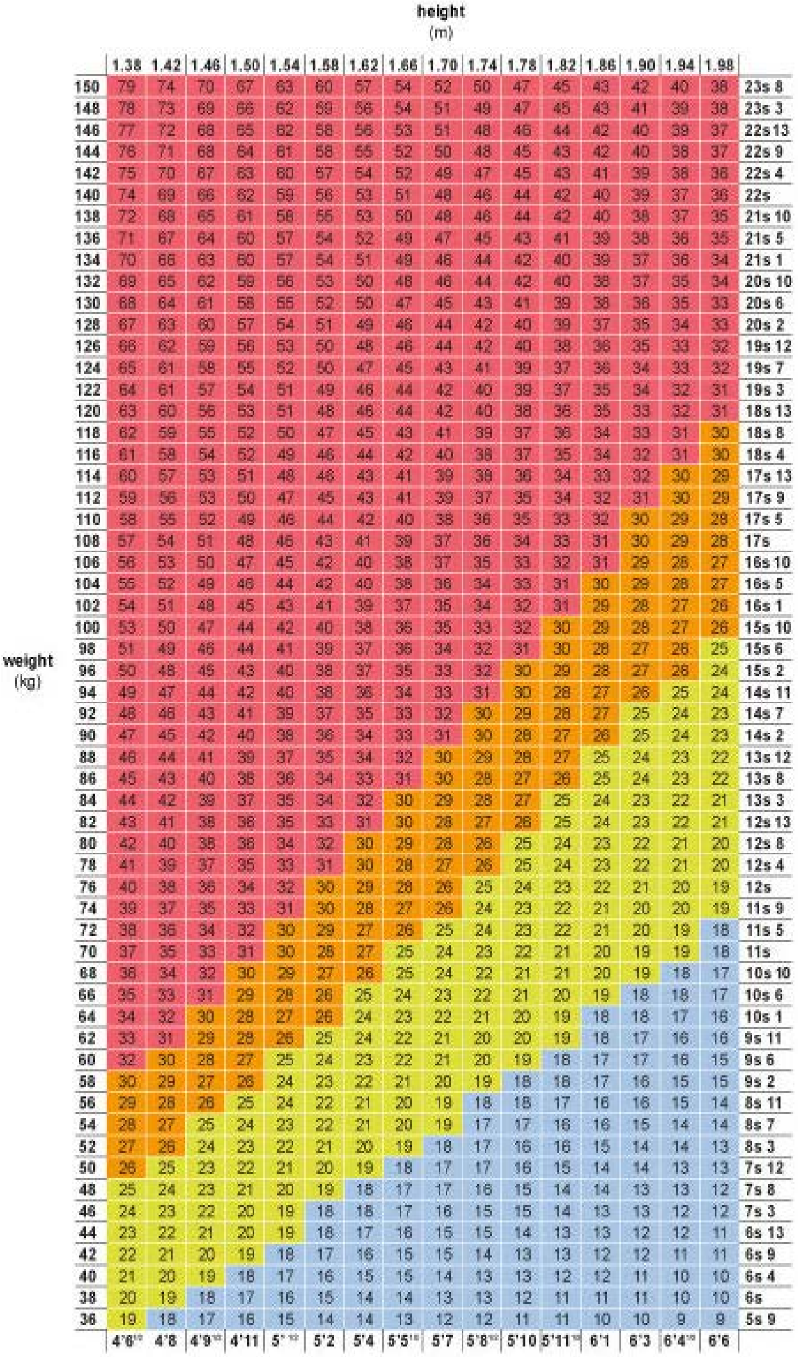
Veronica Varela (V.Varela-Mato@lboro.ac.uk or 01509886452)

James King (J.A.King@lboro.ac.uk or 01509226324)

Orlagh O'Shea (O.OShea-13@student.lboro.ac.uk)

1. Body Mass Index or BMI: amount of kg per square metre in your body. It gives you an idea of whether you're underweight, overweight or an ideal weight for your height. It's useful to know because when your weight increases (or decreases) outside of the ideal range, health risks may also increase.

BMI



height (m)

weight (kg)

	1.38	1.42	1.46	1.50	1.54	1.58	1.62	1.66	1.70	1.74	1.78	1.82	1.86	1.90	1.94	1.98	
150	79	74	70	67	63	60	57	54	52	50	47	45	43	42	40	38	23s 8
148	78	73	69	66	62	59	56	54	51	49	47	45	43	41	39	38	23s 3
146	77	72	68	65	62	58	56	53	51	48	46	44	42	40	39	37	22s 13
144	76	71	68	64	61	58	55	52	50	48	45	43	42	40	38	37	22s 9
142	75	70	67	63	60	57	54	52	49	47	45	43	41	39	38	36	22s 4
140	74	69	66	62	59	56	53	51	48	46	44	42	40	39	37	36	22s
138	72	68	65	61	58	55	53	50	48	46	44	42	40	38	37	35	21s 10
136	71	67	64	60	57	54	52	49	47	45	43	41	39	38	36	35	21s 5
134	70	66	63	60	57	54	51	49	46	44	42	40	39	37	36	34	21s 1
132	69	65	62	59	56	53	50	48	46	44	42	40	38	37	35	34	20s 10
130	68	64	61	58	55	52	50	47	45	43	41	39	38	36	35	33	20s 6
128	67	63	60	57	54	51	49	46	44	42	40	39	37	35	34	33	20s 2
126	66	62	59	56	53	50	48	46	44	42	40	38	36	35	33	32	19s 12
124	65	61	58	55	52	50	47	45	43	41	39	37	36	34	33	32	19s 7
122	64	61	57	54	51	49	46	44	42	40	39	37	35	34	32	31	19s 3
120	63	60	56	53	51	48	46	44	42	40	38	36	35	33	32	31	18s 13
118	62	59	55	52	50	47	45	43	41	39	37	36	34	33	31	30	18s 8
116	61	58	54	52	49	46	44	42	40	38	37	35	34	32	31	30	18s 4
114	60	57	53	51	48	46	43	41	39	38	36	34	33	32	30	29	17s 13
112	59	56	53	50	47	45	43	41	39	37	35	34	32	31	30	29	17s 9
110	58	55	52	49	46	44	42	40	38	36	35	33	32	30	29	28	17s 5
108	57	54	51	48	46	43	41	39	37	36	34	33	31	30	29	28	17s
106	56	53	50	47	45	42	40	38	37	35	33	32	31	29	28	27	16s 10
104	55	52	49	46	44	42	40	38	36	34	33	31	30	29	28	27	16s 5
102	54	51	48	45	43	41	39	37	35	34	32	31	29	28	27	26	16s 1
100	53	50	47	44	42	40	38	36	35	33	32	30	29	28	27	26	15s 10
98	51	49	46	44	41	39	37	36	34	32	31	30	28	27	26	25	15s 6
96	50	48	45	43	40	38	37	35	33	32	30	29	28	27	26	24	15s 2
94	49	47	44	42	40	38	36	34	33	31	30	28	27	26	25	24	14s 11
92	48	46	43	41	39	37	35	33	32	30	29	28	27	25	24	23	14s 7
90	47	45	42	40	38	36	34	33	31	30	28	27	26	25	24	23	14s 2
88	46	44	41	39	37	35	34	32	30	29	28	27	25	24	23	22	13s 12
86	45	43	40	38	36	34	33	31	30	28	27	26	25	24	23	22	13s 8
84	44	42	39	37	35	34	32	30	29	28	27	25	24	23	22	21	13s 3
82	43	41	38	36	35	33	31	30	28	27	26	25	24	23	22	21	12s 13
80	42	40	38	36	34	32	30	29	28	26	25	24	23	22	21	20	12s 8
78	41	39	37	35	33	31	30	28	27	26	25	24	23	22	21	20	12s 4
76	40	38	36	34	32	30	29	28	26	25	24	23	22	21	20	19	12s
74	39	37	35	33	31	30	28	27	26	24	23	22	21	20	20	19	11s 9
72	38	36	34	32	30	29	27	26	25	24	23	22	21	20	19	18	11s 5
70	37	35	33	31	30	28	27	25	24	23	22	21	20	19	19	18	11s
68	36	34	32	30	29	27	26	25	24	22	21	21	20	19	18	17	10s 10
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62	33	31	29	28	26	25	24	22	21	20	20	19	18	17	16	16	9s 11
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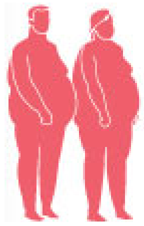
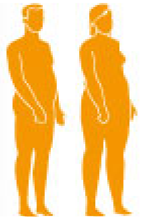
58	30	29	27	26	24	23	22	21	20	19	18	18	17	16	15	15	9s 2
56	29	28	26	25	24	22	21	20	19	18	18	17	16	16	15	14	8s 11
54	28	27	25	24	23	22	21	20	19	17	17	16	16	15	14	14	8s 7
52	27	26	24	23	22	21	20	19	18	17	16	16	15	14	14	13	8s 3
50	26	25	23	22	21	20	19	18	17	17	16	15	14	14	13	13	7s 12
48	25	24	23	21	20	19	18	17	17	16	15	14	14	13	13	12	7s 8
46	24	23	22	20	19	18	18	17	16	15	15	14	13	13	12	12	7s 3
44	23	22	21	20	19	18	17	16	15	15	14	13	13	12	12	11	6s 13
42	22	21	20	19	18	17	16	15	15	14	13	13	12	12	11	11	6s 9
40	21	20	19	18	17	16	15	15	14	13	13	12	12	11	10	10	6s 4
38	20	19	18	17	16	15	14	14	13	13	12	11	11	11	10	10	6s
36	19	18	17	16	15	14	14	13	12	12	11	11	10	10	9	9	5s 9
	4'6½	4'8	4'9½	4'11	5' ½	5'2	5'4	5'5½	5'7	5'8½	5'10	5'11½	6'1	6'3	6'4½	6'6	

Very overweight



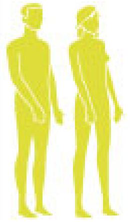
BMI 30+

Overweight



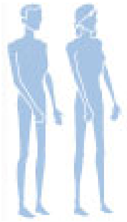
BMI 25 - 30

Healthy



BMI 18.5 - 25

Underweight



BMI less than 18.5

2. Fat percentage: Our body is composed of two types of fat:

2.1. Essential body fat, which is needed for the correct function of our body and we cannot lose it, which for men is about 3% of body mass.

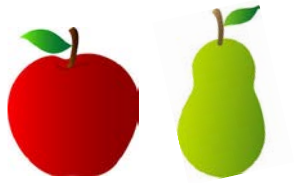
2.2. Storage fat, the fat that it is accumulated in our body due to an excess eating or lack of physical activity.

In general, the total body fat percentage for a male adult should be between 11% to 20% of body mass. Your fat percentage is______. Having excess body fat makes arteries become stiffer, increasing the risk of cardiovascular diseases such as high blood pressure, heart attacks or strokes.

Males	Females	Rating
5-10	8-15	Athletic
11-14	16-23	Good
15-20	24-30	Acceptable
21-24	31-36	Overweight
>24	>37	Obese

3. Waist circumference (WC): waist circumference is an important indicator of how healthy we are. We store spare body fat under the skin and also around the vital organs in our abdomen. Having a larger waist circumference (when compared to having fat around the bottom or thighs) than the healthy range is an indicator of greater risk of developing coronary heart disease, high blood pressure and diabetes.

Apple or pear shape?

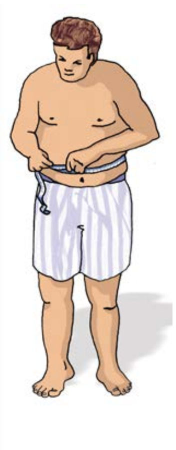


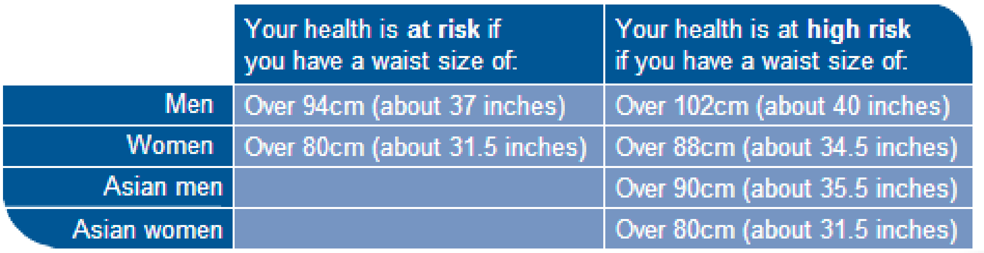
Your WC is_______ cm .

Your Hip Circumference: ________cm.

W-H ratio: _______(WC) : _______(HC)=_______ cm

W-H ratio results: ≥0.90cm (M); ≥0.85cm (F) = substantially increased risk.





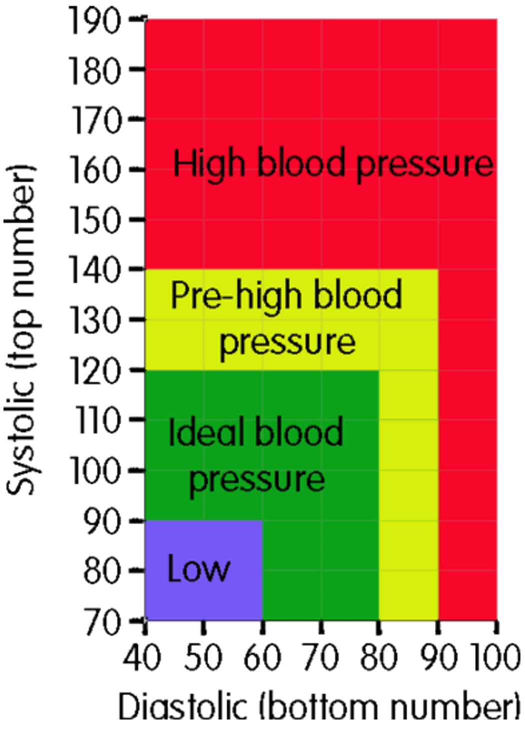
	Your health is **at risk** if you have a waist size of:	Your health is at **high risk** if you have a waist size of:
Men	Over 94cm (about 37 inches)	Over 102cm (about 40 inches)
Women	Over 80cm (about 31.5 inches)	Over 88cm (about 34.5 inches)
Asian men		Over 90cm (about 35.5 inches)
Asian women		Over 80cm (about 31.5 inches)

4. Blood pressure:

When measuring blood pressure we obtain 2 readings:

- The top number is your **systolic** blood pressure: the highest pressure when your heart beats and pushes the blood round your body.
- The bottom one is your **diastolic** blood pressure: the lowest pressure when your heart relaxes between beats.

In the chart below you can see what your values mean:



Systolic blood pressure	Diastolic blood pressure

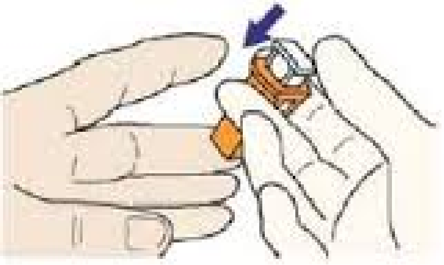
Did you know that these factors below can contribute to have high blood pressure?

- Not doing enough physical activity
- Being overweight or obese
- Having too much salt in our diet
- Regularly drinking too much alcohol
- Having a family history of high blood pressure.

5. Finger prick test:

When analysing a sample of blood we obtain information to measure:

Blood glucose: This is the main sugar found in the blood and the body's main source of energy. Keeping this within the ideal ranges is very important to prevent future health complications.



Triglycerides: It is a type of fat (lipid) in blood. Having a high level of triglycerides can increase the risk of heart disease.

HDL Cholesterol: It is known as the good cholesterol as it picks up excess cholesterol in the bloodstream and take it back to the liver where it's broken down. Having low levels of HDL Cholesterol increases the risk of cardiovascular diseases.

LDL Cholesterol: It is known as the bad type of cholesterol. LDL carries cholesterol from your liver to the cells that need it. Too much bad cholesterol (LDL) in your blood can cause fatty material to build up in your artery walls. Increasing the risk of cardiovascular diseases.

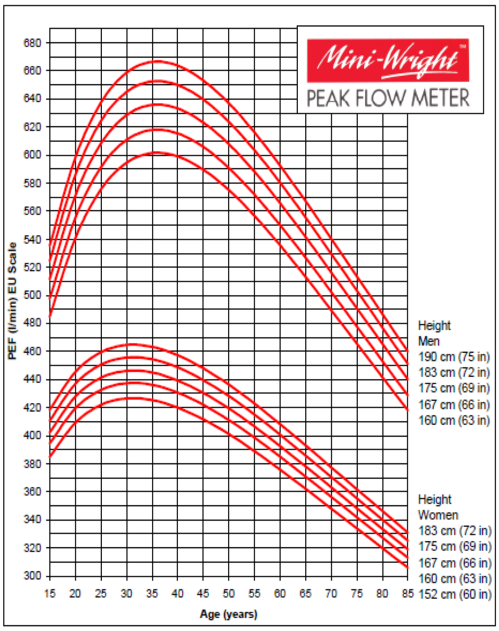
Total Cholesterol: It is the sum of both types of cholesterol.

In the table below you can see your results and compare them to the desirable ranges.

Blood components	mmol/litre	Desirable range
Glucose (sugar in blood)		3.9 - 5.5mmol/l
Triglycerides (fat in blood)		<1.7mmol/l
HDL Cholesterol (good cholesterol)		>1.6 mmol/l
LDL Cholesterol(bad cholesterol)		<2.0mmol/l
Total Cholesterol		<4.0mmol/l

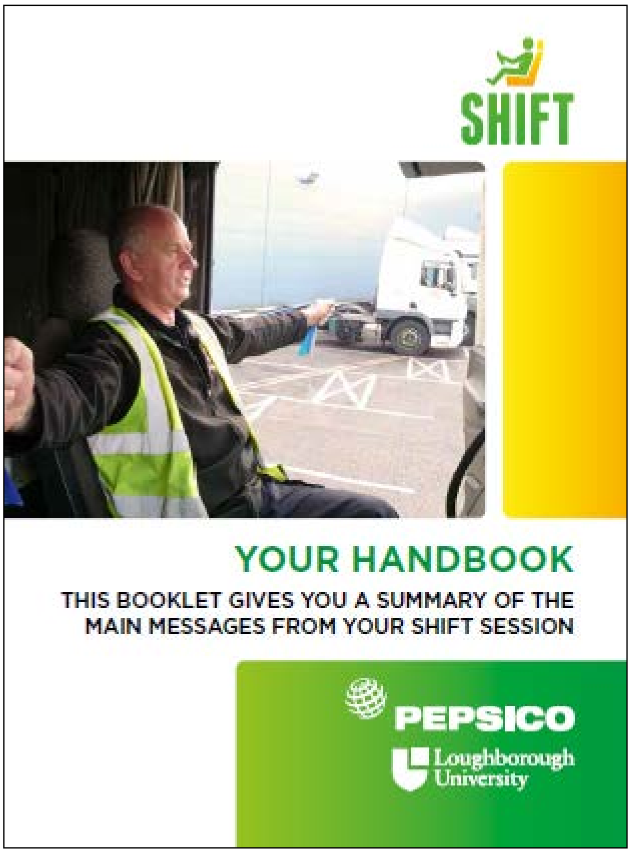
6: Peak flow test:

This test measures the lung capacity by measuring how much air you can blow out of your lungs in one blast. The



L/minute

11.13 Handbook booklet for the education session



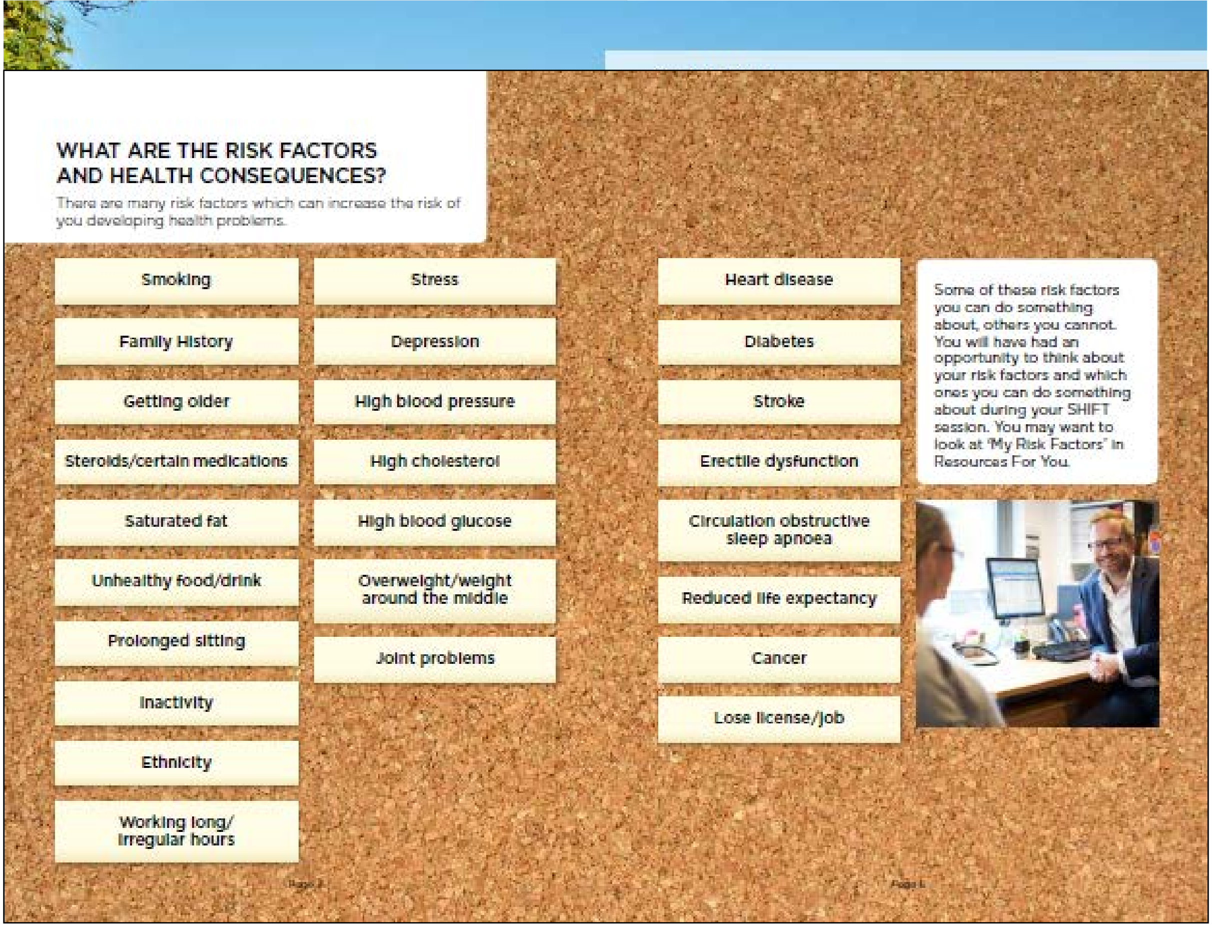
SHIFT

YOUR HANDBOOK

THIS BOOKLET GIVES YOU A SUMMARY OF THE MAIN MESSAGES FROM YOUR SHIFT SESSION

PEPSICO

Loughborough University



WHAT ARE THE RISK FACTORS AND HEALTH CONSEQUENCES?

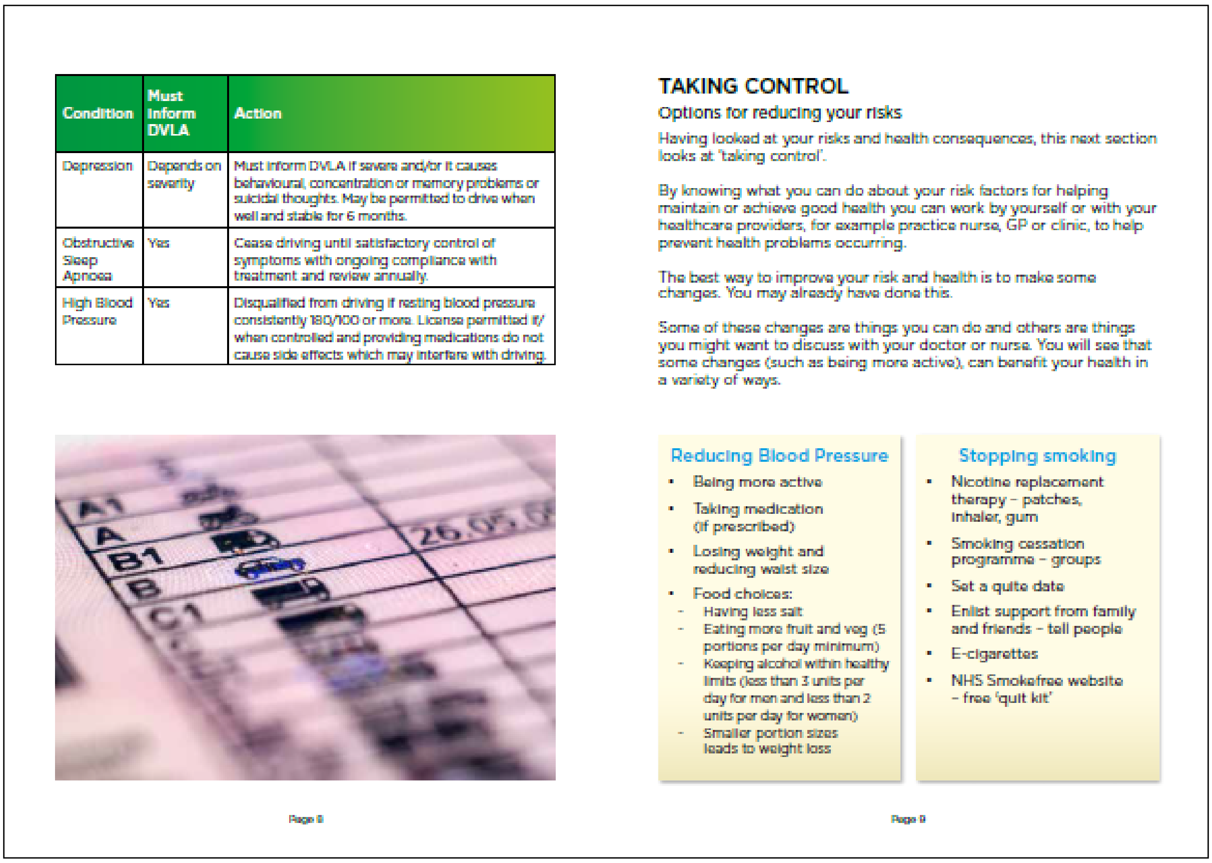
There are many risk factors which can increase the risk of you developing health problems.

- Smoking
- Family History
- Getting older
- Steroids/certain medications
- Saturated fat
- Unhealthy food/drink
- Prolonged sitting
- Inactivity
- Ethnicity
- Working long/ irregular hours

- Stress
- Depression
- High blood pressure
- High cholesterol
- High blood glucose
- Overweight/weight around the middle
- Joint problems

- Heart disease
- Diabetes
- Stroke
- Erectile dysfunction
- Circulation obstructive sleep apnoea
- Reduced life expectancy
- Cancer
- Lose license/job

Some of these risk factors you can do something about, others you cannot. You will have had an opportunity to think about your risk factors and which ones you can do something about during your SHIFT session. You may want to look at 'My Risk Factors' in Resources For You.



Condition	Must Inform DVLA	Action
Depression	Depends on severity	Must inform DVLA if severe and/or it causes behavioural, concentration or memory problems or suicidal thoughts. May be permitted to drive when well and stable for 6 months.
Obstructive Sleep Apnoea	Yes	Cease driving until satisfactory control of symptoms with ongoing compliance with treatment and review annually.
High Blood Pressure	Yes	Disqualified from driving if resting blood pressure consistently 180/100 or more. License permitted if/when controlled and providing medications do not cause side effects which may interfere with driving.

TAKING CONTROL

Options for reducing your risks

Having looked at your risks and health consequences, this next section looks at 'taking control'.

By knowing what you can do about your risk factors for helping maintain or achieve good health you can work by yourself or with your healthcare providers, for example practice nurse, GP or clinic, to help prevent health problems occurring.

The best way to improve your risk and health is to make some changes. You may already have done this.

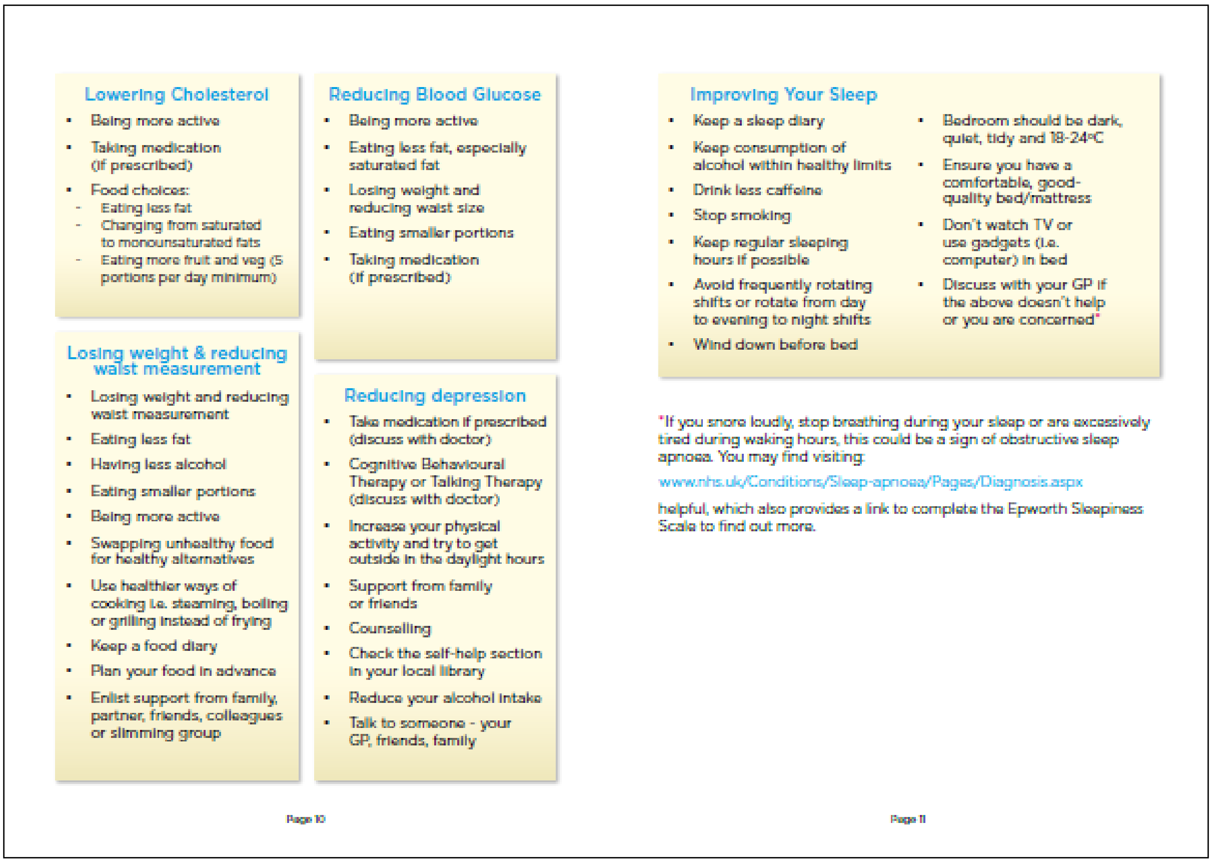
Some of these changes are things you can do and others are things you might want to discuss with your doctor or nurse. You will see that some changes (such as being more active), can benefit your health in a variety of ways.

Reducing Blood Pressure

- Being more active
- Taking medication (if prescribed)
- Losing weight and reducing waist size
- Food choices:
  - Having less salt
  - Eating more fruit and veg (5 portions per day minimum)
  - Keeping alcohol within healthy limits (less than 3 units per day for men and less than 2 units per day for women)
  - Smaller portion sizes leads to weight loss

Stopping smoking

- Nicotine replacement therapy – patches, inhaler, gum
- Smoking cessation programme – groups
- Set a quite date
- Enlist support from family and friends – tell people
- E-cigarettes
- NHS Smokefree website – free 'quit kit'



Lowering Cholesterol

- Being more active
- Taking medication (if prescribed)
- Food choices:
  - Eating less fat
  - Changing from saturated to monounsaturated fats
  - Eating more fruit and veg (5 portions per day minimum)

Losing weight & reducing waist measurement

- Losing weight and reducing waist measurement
- Eating less fat
- Having less alcohol
- Eating smaller portions
- Being more active
- Swapping unhealthy food for healthy alternatives
- Use healthier ways of cooking i.e. steaming, boiling or grilling instead of frying
- Keep a food diary
- Plan your food in advance
- Enlist support from family, partner, friends, colleagues or slimming group

Reducing Blood Glucose

- Being more active
- Eating less fat, especially saturated fat
- Losing weight and reducing waist size
- Eating smaller portions
- Taking medication (if prescribed)

Reducing depression

- Take medication if prescribed (discuss with doctor)
- Cognitive Behavioural Therapy or Talking Therapy (discuss with doctor)
- Increase your physical activity and try to get outside in the daylight hours
- Support from family or friends
- Counselling
- Check the self-help section in your local library
- Reduce your alcohol intake
- Talk to someone - your GP, friends, family

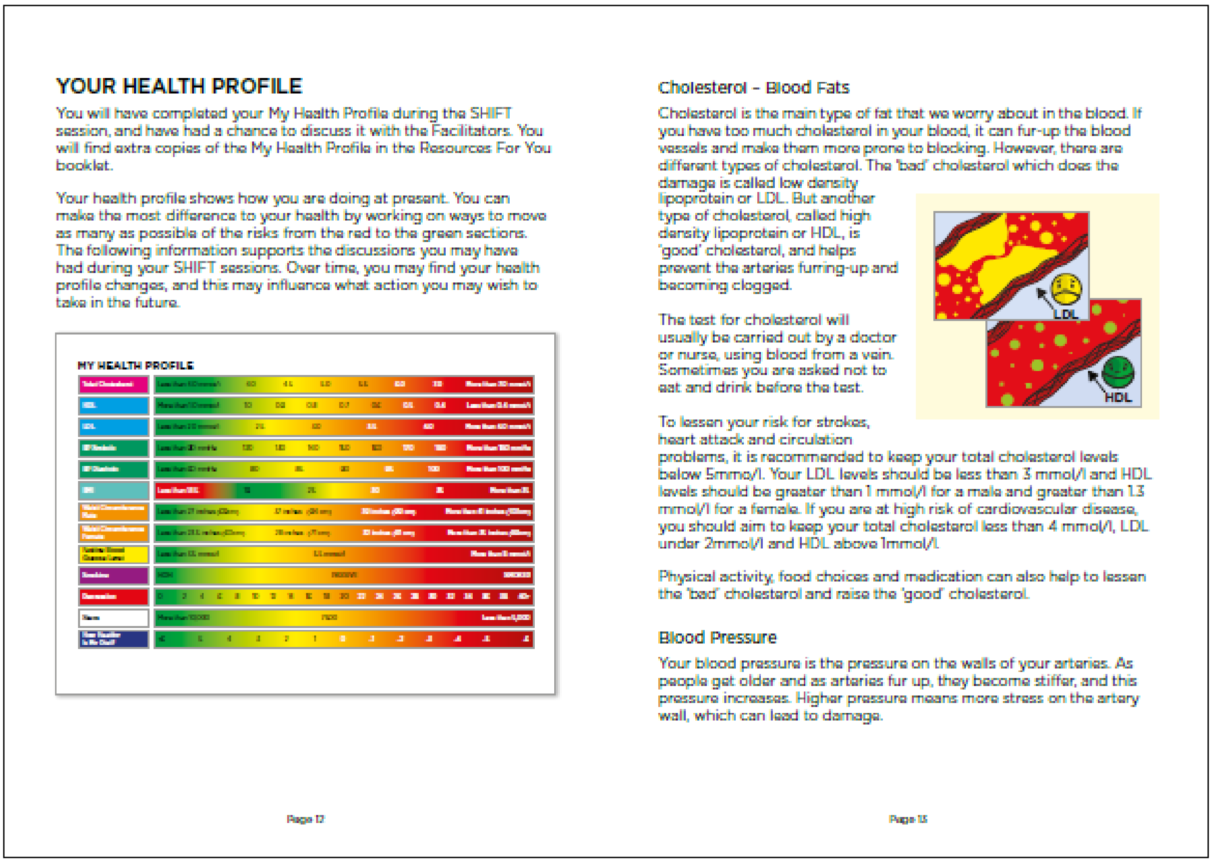
Improving Your Sleep

- Keep a sleep diary
- Keep consumption of alcohol within healthy limits
- Drink less caffeine
- Stop smoking
- Keep regular sleeping hours if possible
- Avoid frequently rotating shifts or rotate from day to evening to night shifts
- Wind down before bed
- Bedroom should be dark, quiet, tidy and 18-24ºC
- Ensure you have a comfortable, good-quality bed/mattress
- Don't watch TV or use gadgets (i.e. computer) in bed
- Discuss with your GP if the above doesn't help or you are concerned*

*If you snore loudly, stop breathing during your sleep or are excessively tired during waking hours, this could be a sign of obstructive sleep apnoea. You may find visiting:

www.nhs.uk/Conditions/Sleep-apnoea/Pages/Diagnosis.aspx

helpful, which also provides a link to complete the Epworth Sleepiness Scale to find out more.



YOUR HEALTH PROFILE

You will have completed your My Health Profile during the SHIFT session, and have had a chance to discuss it with the Facilitators. You will find extra copies of the My Health Profile in the Resources For You booklet.

Your health profile shows how you are doing at present. You can make the most difference to your health by working on ways to move as many as possible of the risks from the red to the green sections. The following information supports the discussions you may have had during your SHIFT sessions. Over time, you may find your health profile changes, and this may influence what action you may wish to take in the future.

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Cholesterol – Blood Fats

Cholesterol is the main type of fat that we worry about in the blood. If you have too much cholesterol in your blood, it can fur-up the blood vessels and make them more prone to blocking. However, there are different types of cholesterol. The 'bad' cholesterol which does the damage is called low density lipoprotein or LDL. But another type of cholesterol, called high density lipoprotein or HDL, is 'good' cholesterol, and helps prevent the arteries furring-up and becoming clogged.

The test for cholesterol will usually be carried out by a doctor or nurse, using blood from a vein. Sometimes you are asked not to eat and drink before the test.

To lessen your risk for strokes, heart attack and circulation problems, it is recommended to keep your total cholesterol levels below 5mmo/l. Your LDL levels should be less than 3 mmol/l and HDL levels should be greater than 1 mmol/l for a male and greater than 1.3 mmol/l for a female. If you are at high risk of cardiovascular disease, you should aim to keep your total cholesterol less than 4 mmol/l, LDL under 2mmol/l and HDL above 1mmol/l.

Physical activity, food choices and medication can also help to lessen the 'bad' cholesterol and raise the 'good' cholesterol.

Blood Pressure

Your blood pressure is the pressure on the walls of your arteries. As people get older and as arteries fur up, they become stiffer, and this pressure increases. Higher pressure means more stress on the artery wall, which can lead to damage.

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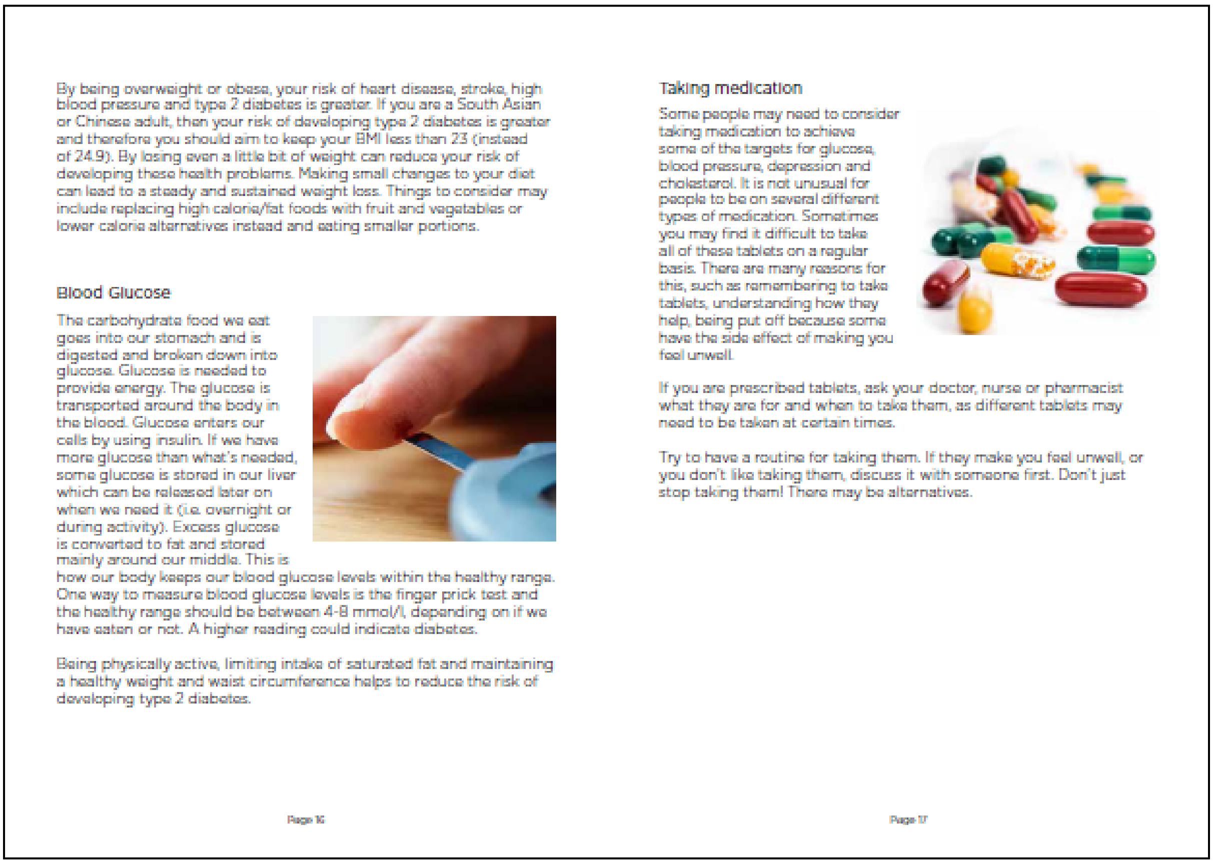

By being overweight or obese, your risk of heart disease, stroke, high blood pressure and type 2 diabetes is greater. If you are a South Asian or Chinese adult, then your risk of developing type 2 diabetes is greater and therefore you should aim to keep your BMI less than 23 (instead of 24.9). By losing even a little bit of weight can reduce your risk of developing these health problems. Making small changes to your diet can lead to a steady and sustained weight loss. Things to consider may include replacing high calorie/fat foods with fruit and vegetables or lower calorie alternatives instead and eating smaller portions.

Blood Glucose

The carbohydrate food we eat goes into our stomach and is digested and broken down into glucose. Glucose is needed to provide energy. The glucose is transported around the body in the blood. Glucose enters our cells by using insulin. If we have more glucose than what's needed, some glucose is stored in our liver which can be released later on when we need it (i.e. overnight or during activity). Excess glucose is converted to fat and stored mainly around our middle. This is how our body keeps our blood glucose levels within the healthy range. One way to measure blood glucose levels is the finger prick test and the healthy range should be between 4-8 mmol/l, depending on if we have eaten or not. A higher reading could indicate diabetes.

Being physically active, limiting intake of saturated fat and maintaining a healthy weight and waist circumference helps to reduce the risk of developing type 2 diabetes.

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Taking medication

Some people may need to consider taking medication to achieve some of the targets for glucose, blood pressure, depression and cholesterol. It is not unusual for people to be on several different types of medication. Sometimes you may find it difficult to take all of these tablets on a regular basis. There are many reasons for this, such as remembering to take tablets, understanding how they help, being put off because some have the side effect of making you feel unwell.

If you are prescribed tablets, ask your doctor, nurse or pharmacist what they are for and when to take them, as different tablets may need to be taken at certain times.

Try to have a routine for taking them. If they make you feel unwell, or you don't like taking them, discuss it with someone first. Don't just stop taking them! There may be alternatives.

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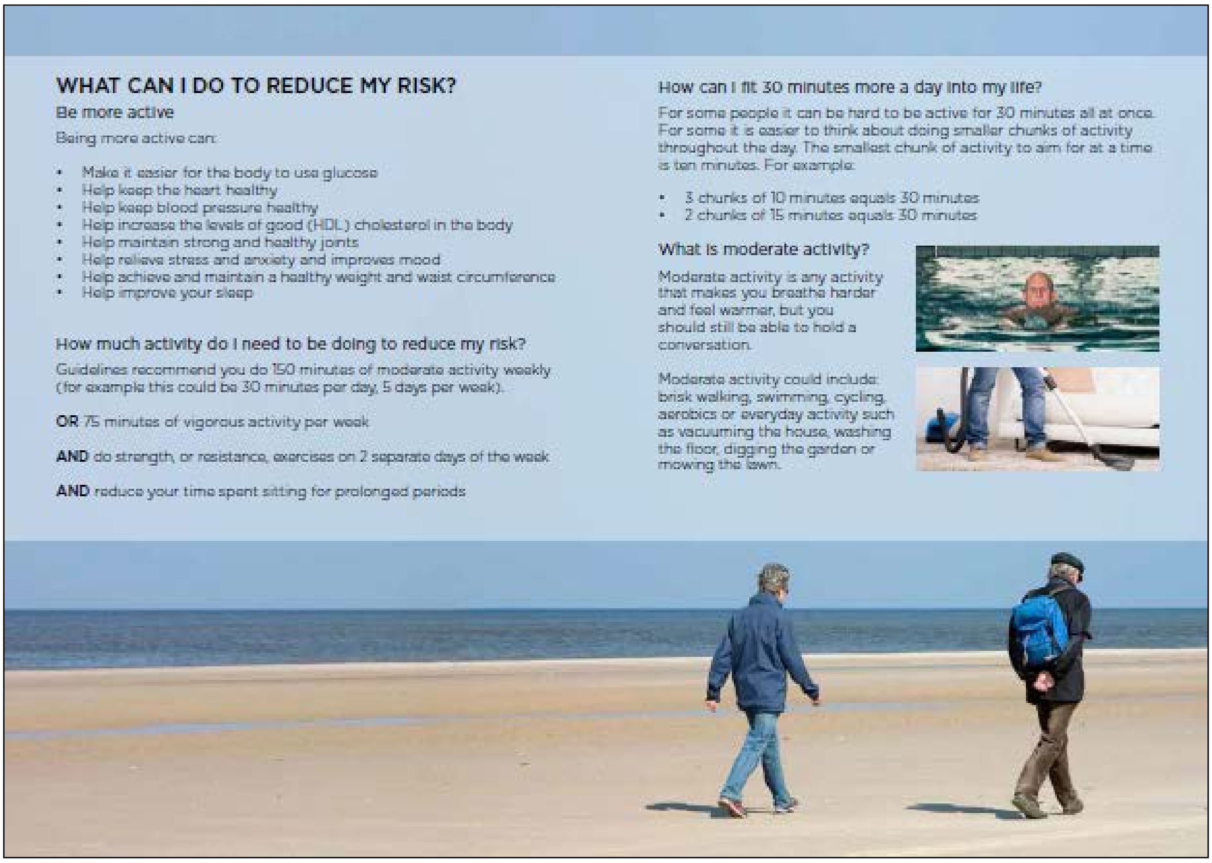


WHAT CAN I DO TO REDUCE MY RISK?

Be more active

Being more active can:

- Make it easier for the body to use glucose
- Help keep the heart healthy
- Help keep blood pressure healthy
- Help increase the levels of good (HDL) cholesterol in the body
- Help maintain strong and healthy joints
- Help relieve stress and anxiety and improves mood
- Help achieve and maintain a healthy weight and waist circumference
- Help improve your sleep

How much activity do I need to be doing to reduce my risk?

Guidelines recommend you do 150 minutes of moderate activity weekly (for example this could be 30 minutes per day, 5 days per week).

OR 75 minutes of vigorous activity per week

AND do strength, or resistance, exercises on 2 separate days of the week

AND reduce your time spent sitting for prolonged periods

How can I fit 30 minutes more a day into my life?

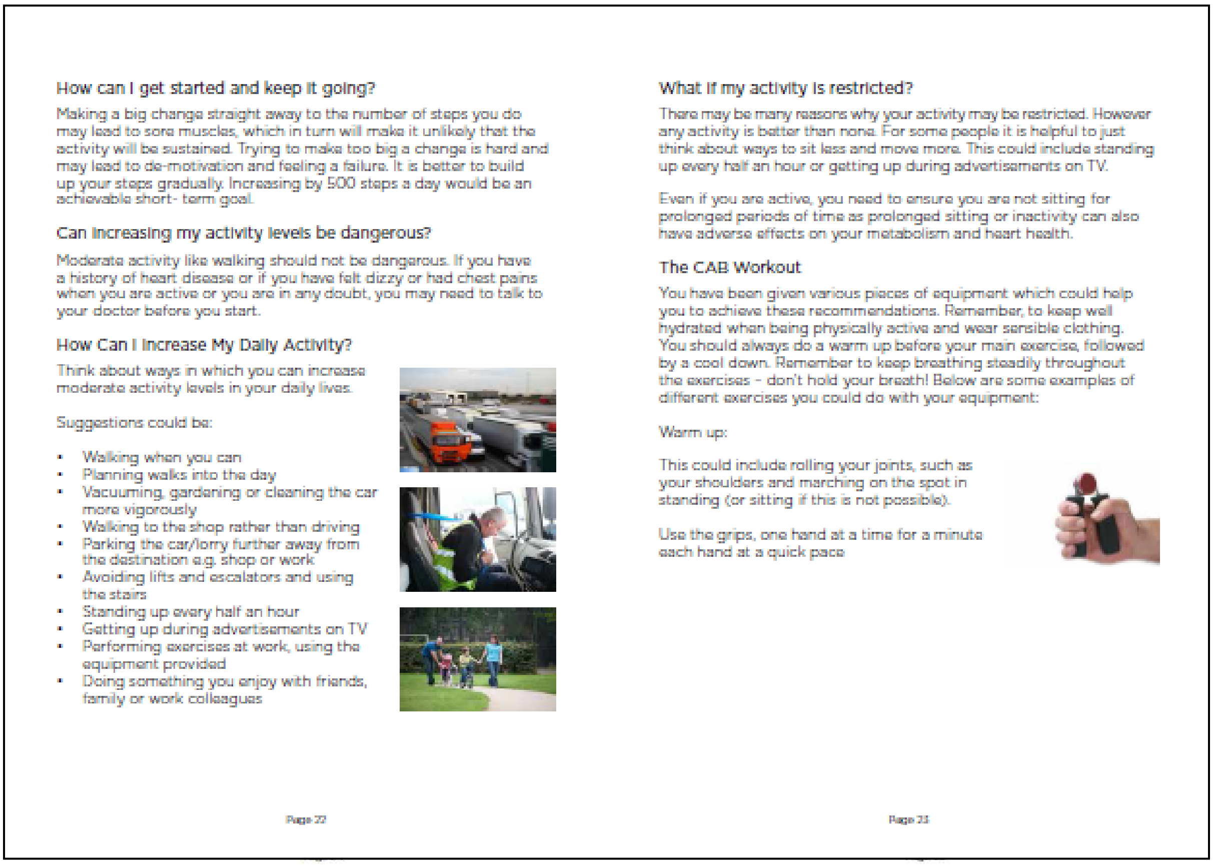
For some people it can be hard to be active for 30 minutes all at once. For some it is easier to think about doing smaller chunks of activity throughout the day. The smallest chunk of activity to aim for at a time is ten minutes. For example:

- 3 chunks of 10 minutes equals 30 minutes
- 2 chunks of 15 minutes equals 30 minutes

What is moderate activity?

Moderate activity is any activity that makes you breathe harder and feel warmer, but you should still be able to hold a conversation.

Moderate activity could include: brisk walking, swimming, cycling, aerobics or everyday activity such as vacuuming the house, washing the floor, digging the garden or mowing the lawn.



How can I get started and keep it going?

Making a big change straight away to the number of steps you do may lead to sore muscles, which in turn will make it unlikely that the activity will be sustained. Trying to make too big a change is hard and may lead to de-motivation and feeling a failure. It is better to build up your steps gradually. Increasing by 500 steps a day would be an achievable short- term goal.

Can increasing my activity levels be dangerous?

Moderate activity like walking should not be dangerous. If you have a history of heart disease or if you have felt dizzy or had chest pains when you are active or you are in any doubt, you may need to talk to your doctor before you start.

How Can I Increase My Daily Activity?

Think about ways in which you can increase moderate activity levels in your daily lives.

Suggestions could be:

- Walking when you can
- Planning walks into the day
- Vacuuming, gardening or cleaning the car more vigorously
- Walking to the shop rather than driving
- Parking the car/lorry further away from the destination e.g. shop or work
- Avoiding lifts and escalators and using the stairs
- Standing up every half an hour
- Getting up during advertisements on TV
- Performing exercises at work, using the equipment provided
- Doing something you enjoy with friends, family or work colleagues

What if my activity is restricted?

There may be many reasons why your activity may be restricted. However any activity is better than none. For some people it is helpful to just think about ways to sit less and move more. This could include standing up every half an hour or getting up during advertisements on TV.

Even if you are active, you need to ensure you are not sitting for prolonged periods of time as prolonged sitting or inactivity can also have adverse effects on your metabolism and heart health.

The CAB Workout

You have been given various pieces of equipment which could help you to achieve these recommendations. Remember, to keep well hydrated when being physically active and wear sensible clothing. You should always do a warm up before your main exercise, followed by a cool down. Remember to keep breathing steadily throughout the exercises - don't hold your breath! Below are some examples of different exercises you could do with your equipment:

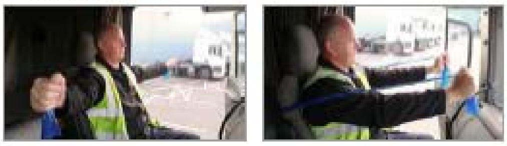
Warm up:

This could include rolling your joints, such as your shoulders and marching on the spot in standing (or sitting if this is not possible).

Use the grips, one hand at a time for a minute each hand at a quick pace

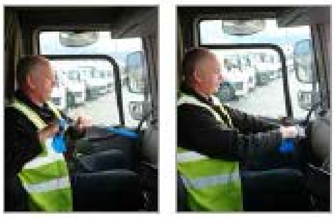
Chest flies:

Hold the end of the band in each hand and place the middle of the band around the back of a chair/seat. Start with your arms outstretched to the side of you at shoulder level. Keeping your arms straight, move your arms from the side to the centre, then return back to the starting position.



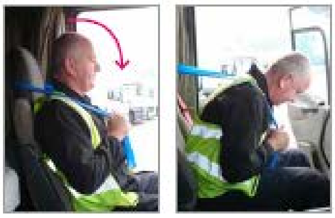
Oblique abs:

Put the band through the handle to one side and hold both ends of the band with both hands. Rotate your trunk, pulling upwards and to the opposite side, keeping your back in a neutral position. Slowly return back to starting position. Once completed the required sets on this side, move the band to a handle on the opposite side and repeat with the other side of the body.



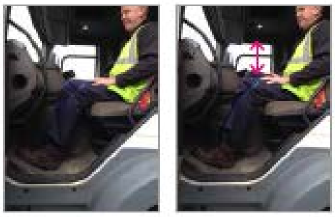
Rectus abs:

Loop the band behind the chair/seat and hold both ends with both hands. Keep your arms tucked into your side. Move upper body down into a crunch and then slowly return to starting position.



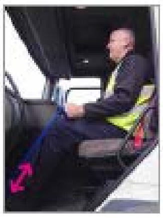
Quadriceps:

Loop the band around the thigh, slightly above the knee, stabilise the ends of the band by stepping on it with the opposite foot. Raise the knee (with the band over it) straight up, keeping the knee bent. Slowly return to the starting position. Repeat with the other leg.



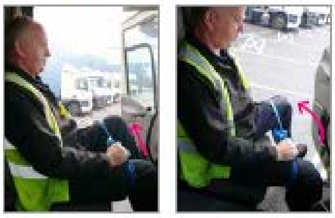
Calves:

Hold both ends of the band with both hands. Put the loop underneath the balls of your feet, keeping your toes pointing up towards you, so there is tension in the band. Move feet downwards, against the resistance band and repeat.



Thigh abductors:

Place the band around the thighs and make a secure knot. Raise one leg, move it outwards and then return to starting position. Repeat with opposite leg.

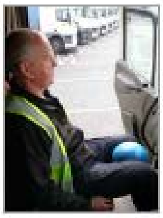


Fitness ball:

For these exercises, aim to do 2-3 sets of 8-15 repetitions. Ensure you keep your back in a neutral position and adequately supported where necessary.

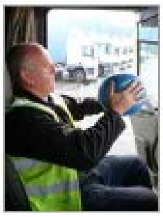
Thigh adductors:

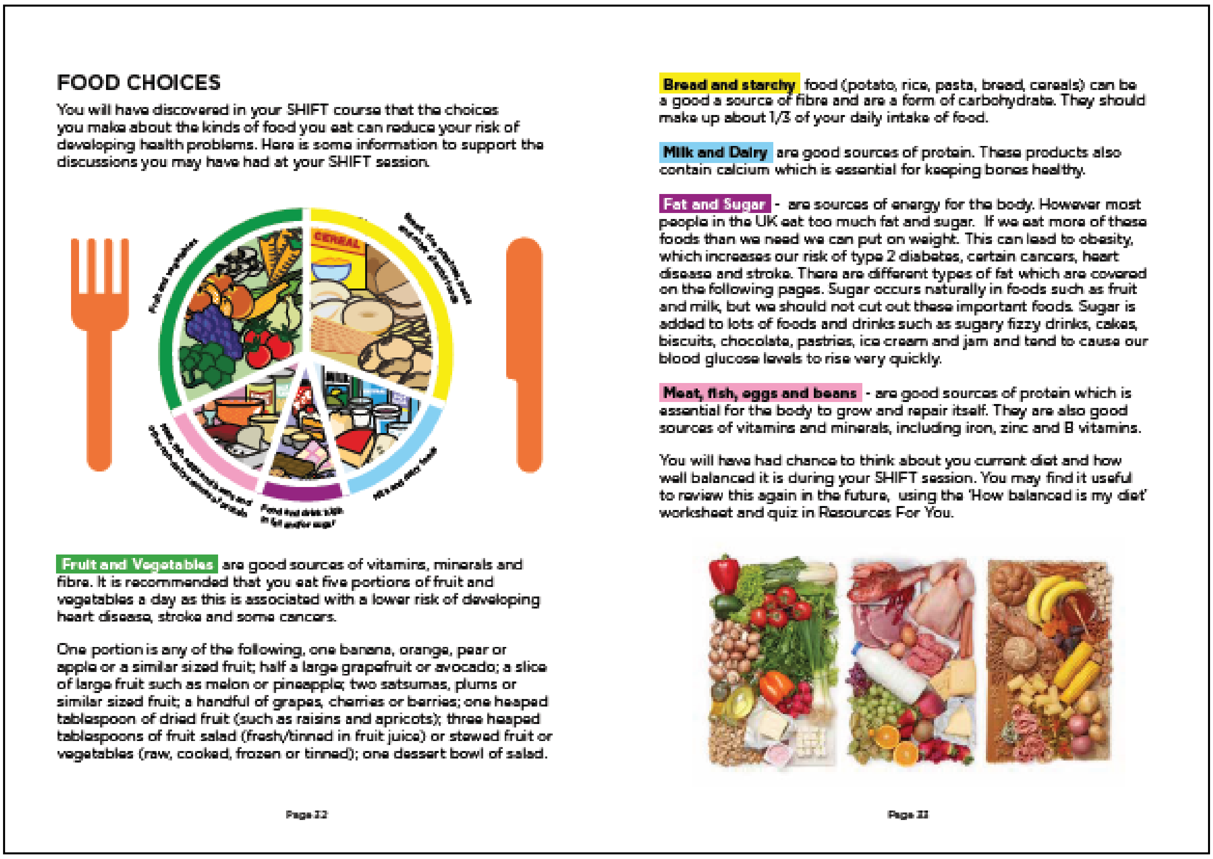
Place the fitness ball in between your knees. Squeeze your legs together and then relax and repeat.



Arms and chest:

Hold the fitness ball at chest height. Squeeze hands together and then relax and repeat.





Fruit and vegetables
Bread, rice, potatoes, pasta and other starchy foods
Milk and dairy foods
Food and drinks high in fat and/or sugar
Meat, fish, eggs, beans and other non-dairy sources of protein
CEREAL

FOOD CHOICES

You will have discovered in your SHIFT course that the choices you make about the kinds of food you eat can reduce your risk of developing health problems. Here is some information to support the discussions you may have had at your SHIFT session.

Fruit and Vegetables are good sources of vitamins, minerals and fibre. It is recommended that you eat five portions of fruit and vegetables a day as this is associated with a lower risk of developing heart disease, stroke and some cancers.

One portion is any of the following, one banana, orange, pear or apple or a similar sized fruit; half a large grapefruit or avocado; a slice of large fruit such as melon or pineapple; two satsumas, plums or similar sized fruit; a handful of grapes, cherries or berries; one heaped tablespoon of dried fruit (such as raisins and apricots); three heaped tablespoons of fruit salad (fresh/tinned in fruit juice) or stewed fruit or vegetables (raw, cooked, frozen or tinned); one dessert bowl of salad.

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Bread and starchy food (potato, rice, pasta, bread, cereals) can be a good a source of fibre and are a form of carbohydrate. They should make up about 1/3 of your daily intake of food.

Milk and Dairy are good sources of protein. These products also contain calcium which is essential for keeping bones healthy.

Fat and Sugar - are sources of energy for the body. However most people in the UK eat too much fat and sugar. If we eat more of these foods than we need we can put on weight. This can lead to obesity, which increases our risk of type 2 diabetes, certain cancers, heart disease and stroke. There are different types of fat which are covered on the following pages. Sugar occurs naturally in foods such as fruit and milk, but we should not cut out these important foods. Sugar is added to lots of foods and drinks such as sugary fizzy drinks, cakes, biscuits, chocolate, pastries, ice cream and jam and tend to cause our blood glucose levels to rise very quickly.

Meat, fish, eggs and beans - are good sources of protein which is essential for the body to grow and repair itself. They are also good sources of vitamins and minerals, including iron, zinc and B vitamins.

You will have had chance to think about you current diet and how well balanced it is during your SHIFT session. You may find it useful to review this again in the future, using the 'How balanced is my diet' worksheet and quiz in Resources For You.

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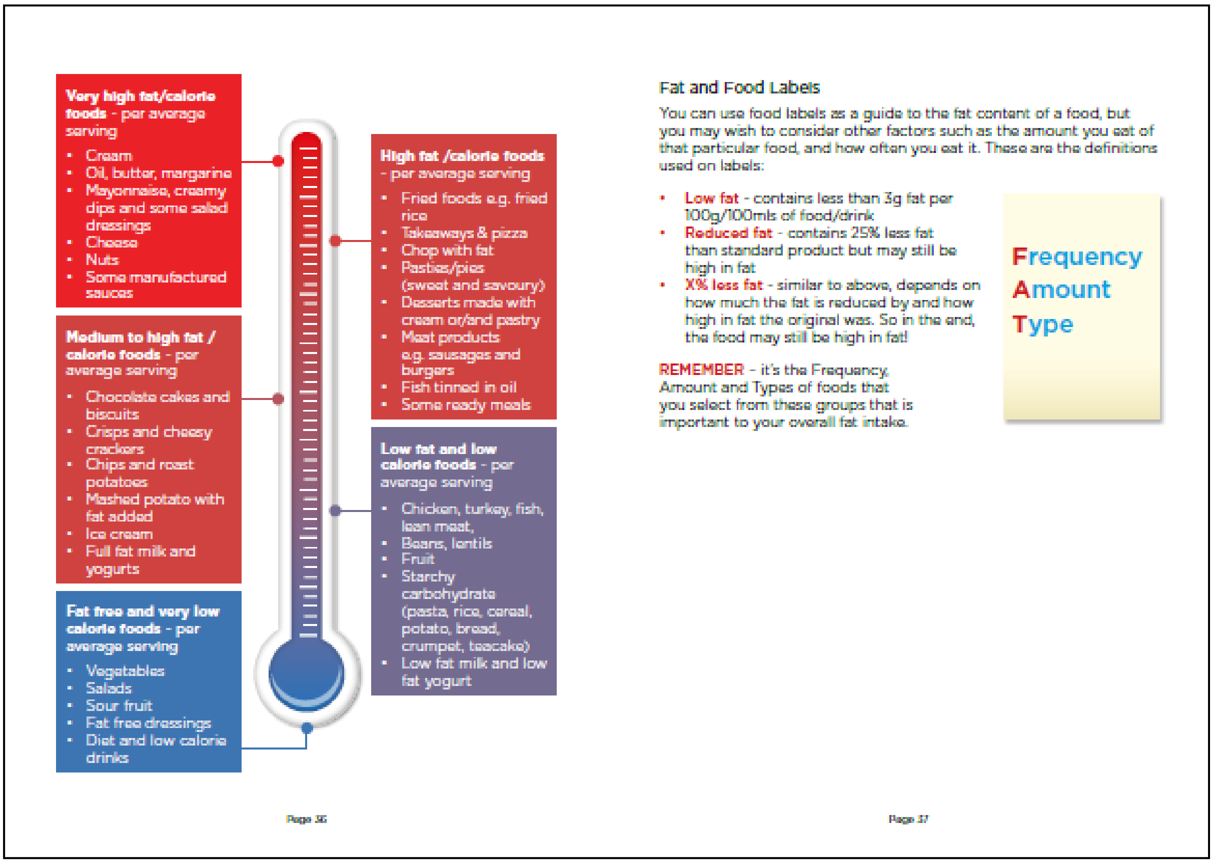

Very high fat/calorie foods - per average serving

- Cream
- Oil, butter, margarine
- Mayonnaise, creamy dips and some salad dressings
- Cheese
- Nuts
- Some manufactured sauces

Medium to high fat / calorie foods - per average serving

- Chocolate cakes and biscuits
- Crisps and cheesy crackers
- Chips and roast potatoes
- Mashed potato with fat added
- Ice cream
- Full fat milk and yogurts

Fat free and very low calorie foods - per average serving

- Vegetables
- Salads
- Sour fruit
- Fat free dressings
- Diet and low calorie drinks

High fat /calorie foods - per average serving

- Fried foods e.g. fried rice
- Takeaways & pizza
- Chop with fat
- Pasties/pies (sweet and savoury)
- Desserts made with cream or/and pastry
- Meat products e.g. sausages and burgers
- Fish tinned in oil
- Some ready meals

Low fat and low calorie foods - per average serving

- Chicken, turkey, fish, lean meat,
- Beans, lentils
- Fruit
- Starchy carbohydrate (pasta, rice, cereal, potato, bread, crumpet, teacake)
- Low fat milk and low fat yogurt

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Fat and Food Labels

You can use food labels as a guide to the fat content of a food, but you may wish to consider other factors such as the amount you eat of that particular food, and how often you eat it. These are the definitions used on labels:

- **Low fat** - contains less than 3g fat per 100g/100mls of food/drink
- **Reduced fat** - contains 25% less fat than standard product but may still be high in fat
- **X% less fat** - similar to above, depends on how much the fat is reduced by and how high in fat the original was. So in the end, the food may still be high in fat!

REMEMBER - it's the Frequency, Amount and Types of foods that you select from these groups that is important to your overall fat intake.

Frequency
Amount
Type

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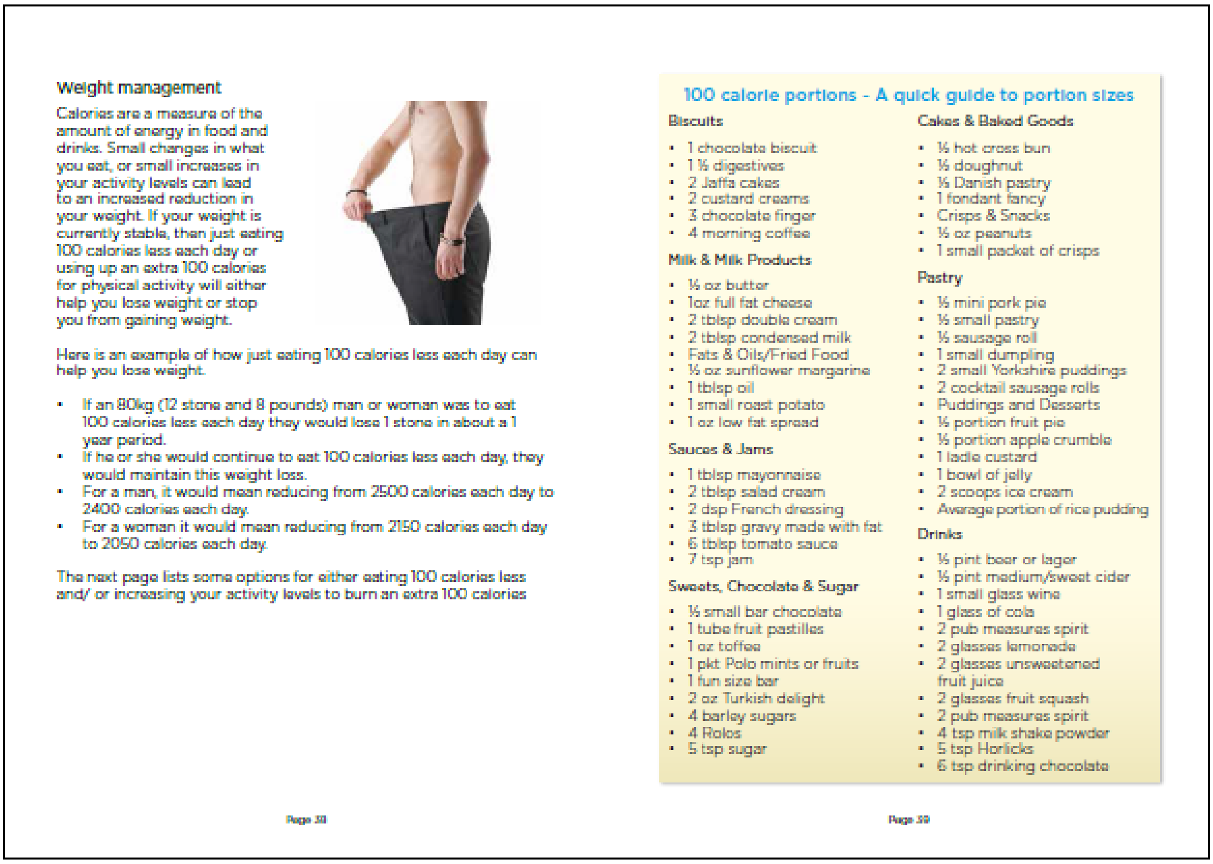


Weight management

Calories are a measure of the amount of energy in food and drinks. Small changes in what you eat, or small increases in your activity levels can lead to an increased reduction in your weight. If your weight is currently stable, then just eating 100 calories less each day or using up an extra 100 calories for physical activity will either help you lose weight or stop you from gaining weight.

Here is an example of how just eating 100 calories less each day can help you lose weight.

- If an 80kg (12 stone and 8 pounds) man or woman was to eat 100 calories less each day they would lose 1 stone in about a 1 year period.
- If he or she would continue to eat 100 calories less each day, they would maintain this weight loss.
- For a man, it would mean reducing from 2500 calories each day to 2400 calories each day.
- For a woman it would mean reducing from 2150 calories each day to 2050 calories each day.

The next page lists some options for either eating 100 calories less and/ or increasing your activity levels to burn an extra 100 calories

100 calorie portions - A quick guide to portion sizes

Biscuits

- 1 chocolate biscuit
- 1 ½ digestives
- 2 Jaffa cakes
- 2 custard creams
- 3 chocolate finger
- 4 morning coffee

Milk & Milk Products

- ½ oz butter
- 1oz full fat cheese
- 2 tblsp double cream
- 2 tblsp condensed milk
- Fats & Oils/Fried Food
- ½ oz sunflower margarine
- 1 tblsp oil
- 1 small roast potato
- 1 oz low fat spread

Sauces & Jams

- 1 tblsp mayonnaise
- 2 tblsp salad cream
- 2 dsp French dressing
- 3 tblsp gravy made with fat
- 6 tblsp tomato sauce
- 7 tsp jam

Sweets, Chocolate & Sugar

- ½ small bar chocolate
- 1 tube fruit pastilles
- 1 oz toffee
- 1 pkt Polo mints or fruits
- 1 fun size bar
- 2 oz Turkish delight
- 4 barley sugars
- 4 Rolos
- 5 tsp sugar

Cakes & Baked Goods

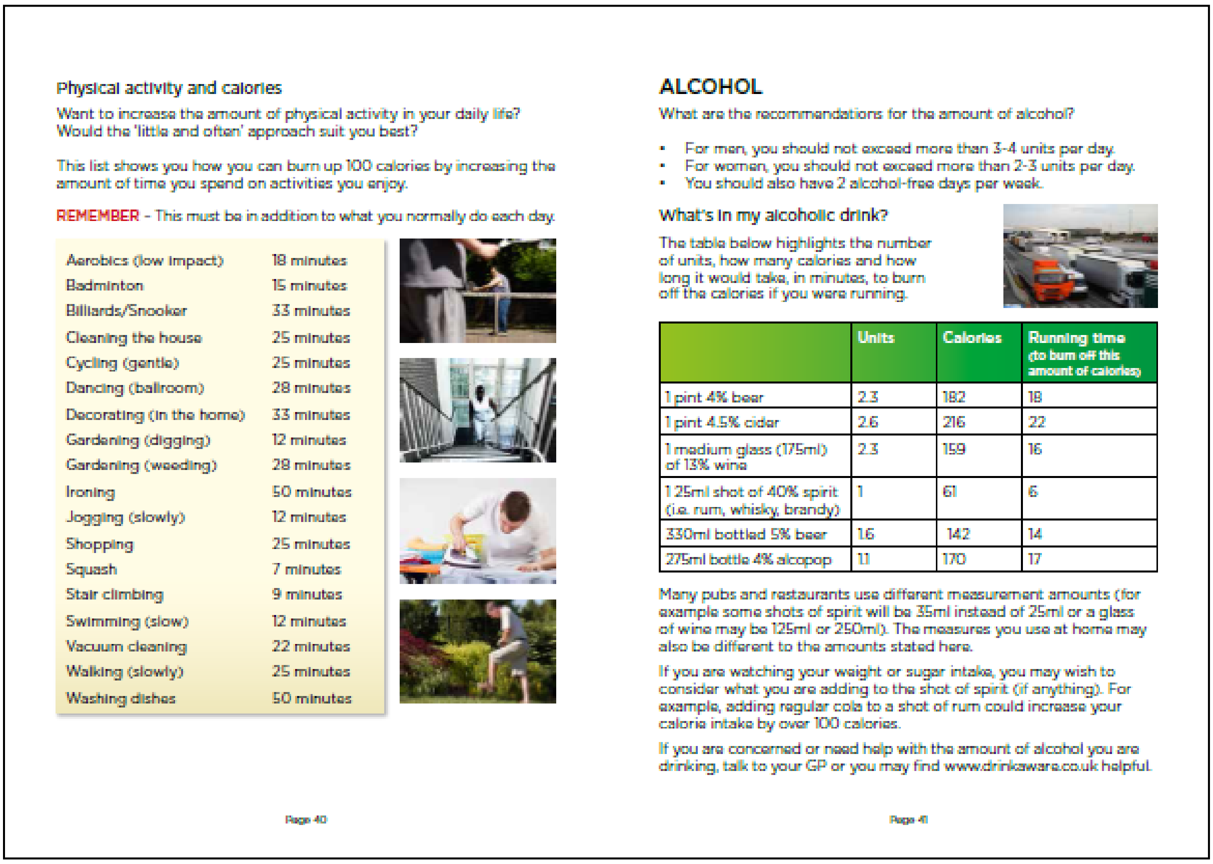
- ½ hot cross bun
- ½ doughnut
- ½ Danish pastry
- 1 fondant fancy
- Crisps & Snacks
- ½ oz peanuts
- 1 small packet of crisps

Pastry

- ½ mini pork pie
- ½ small pastry
- ½ sausage roll
- 1 small dumpling
- 2 small Yorkshire puddings
- 2 cocktail sausage rolls
- Puddings and Desserts
- ½ portion fruit pie
- ½ portion apple crumble
- 1 ladle custard
- 1 bowl of jelly
- 2 scoops ice cream
- Average portion of rice pudding

Drinks

- ½ pint beer or lager
- ½ pint medium/sweet cider
- 1 small glass wine
- 1 glass of cola
- 2 pub measures spirit
- 2 glasses lemonade
- 2 glasses unsweetened fruit juice
- 2 glasses fruit squash
- 2 pub measures spirit
- 4 tsp milk shake powder
- 5 tsp Horlicks
- 6 tsp drinking chocolate



Physical activity and calories

Want to increase the amount of physical activity in your daily life? Would the 'little and often' approach suit you best?

This list shows you how you can burn up 100 calories by increasing the amount of time you spend on activities you enjoy.

REMEMBER - This must be in addition to what you normally do each day.

Aerobics (low impact)	18 minutes
Badminton	15 minutes
Billiards/Snooker	33 minutes
Cleaning the house	25 minutes
Cycling (gentle)	25 minutes
Dancing (ballroom)	28 minutes
Decorating (in the home)	33 minutes
Gardening (digging)	12 minutes
Gardening (weeding)	28 minutes
Ironing	50 minutes
Jogging (slowly)	12 minutes
Shopping	25 minutes
Squash	7 minutes
Stair climbing	9 minutes
Swimming (slow)	12 minutes
Vacuum cleaning	22 minutes
Walking (slowly)	25 minutes
Washing dishes	50 minutes

ALCOHOL

What are the recommendations for the amount of alcohol?

- For men, you should not exceed more than 3-4 units per day.
- For women, you should not exceed more than 2-3 units per day.
- You should also have 2 alcohol-free days per week.

What's in my alcoholic drink?

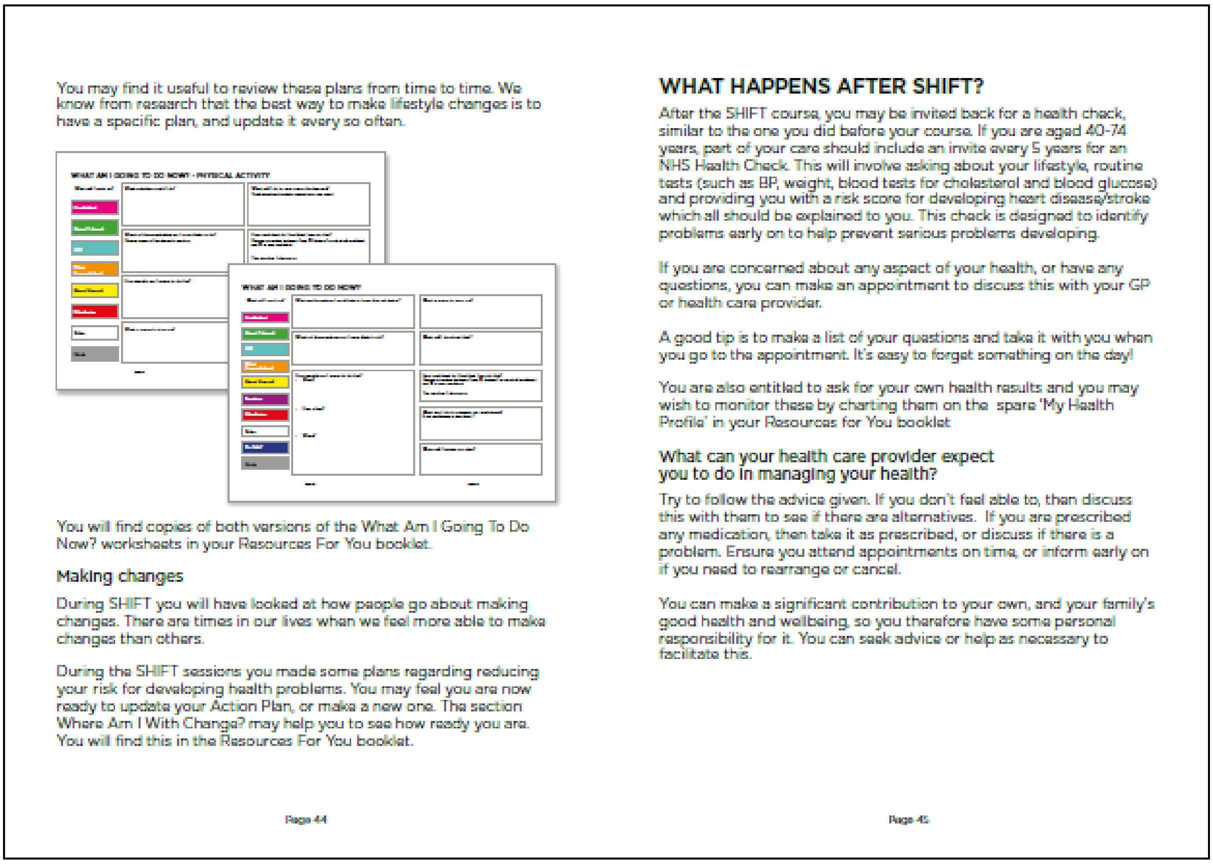
The table below highlights the number of units, how many calories and how long it would take, in minutes, to burn off the calories if you were running.

	Units	Calories	Running time (to burn off this amount of calories)
1 pint 4% beer	2.3	182	18
1 pint 4.5% cider	2.6	216	22
1 medium glass (175ml) of 13% wine	2.3	159	16
1 25ml shot of 40% spirit (i.e. rum, whisky, brandy)	1	61	6
330ml bottled 5% beer	1.6	142	14
275ml bottle 4% alcopop	1.1	170	17

Many pubs and restaurants use different measurement amounts (for example some shots of spirit will be 35ml instead of 25ml or a glass of wine may be 125ml or 250ml). The measures you use at home may also be different to the amounts stated here.

If you are watching your weight or sugar intake, you may wish to consider what you are adding to the shot of spirit (if anything). For example, adding regular cola to a shot of rum could increase your calorie intake by over 100 calories.

If you are concerned or need help with the amount of alcohol you are drinking, talk to your GP or you may find www.drinkaware.co.uk helpful.



You may find it useful to review these plans from time to time. We know from research that the best way to make lifestyle changes is to have a specific plan, and update it every so often.

You will find copies of both versions of the What Am I Going To Do Now? worksheets in your Resources For You booklet.

Making changes

During SHIFT you will have looked at how people go about making changes. There are times in our lives when we feel more able to make changes than others.

During the SHIFT sessions you made some plans regarding reducing your risk for developing health problems. You may feel you are now ready to update your Action Plan, or make a new one. The section Where Am I With Change? may help you to see how ready you are. You will find this in the Resources For You booklet.

WHAT HAPPENS AFTER SHIFT?

After the SHIFT course, you may be invited back for a health check, similar to the one you did before your course. If you are aged 40-74 years, part of your care should include an invite every 5 years for an NHS Health Check. This will involve asking about your lifestyle, routine tests (such as BP, weight, blood tests for cholesterol and blood glucose) and providing you with a risk score for developing heart disease/stroke which all should be explained to you. This check is designed to identify problems early on to help prevent serious problems developing.

If you are concerned about any aspect of your health, or have any questions, you can make an appointment to discuss this with your GP or health care provider.

A good tip is to make a list of your questions and take it with you when you go to the appointment. It's easy to forget something on the day!

You are also entitled to ask for your own health results and you may wish to monitor these by charting them on the spare 'My Health Profile' in your Resources for You booklet.

What can your health care provider expect you to do in managing your health?

Try to follow the advice given. If you don't feel able to, then discuss this with them to see if there are alternatives. If you are prescribed any medication, then take it as prescribed, or discuss if there is a problem. Ensure you attend appointments on time, or inform early on if you need to rearrange or cancel.

You can make a significant contribution to your own, and your family's good health and wellbeing, so you therefore have some personal responsibility for it. You can seek advice or help as necessary to facilitate this.

OTHER USEFUL SOURCES

As well as your GP or health care provider. You may also find some of the following helpful

NHS Choices
www.nhs.uk

Change for Life
Phone 0300 123 4567*
Minicom 0300 123 1003*

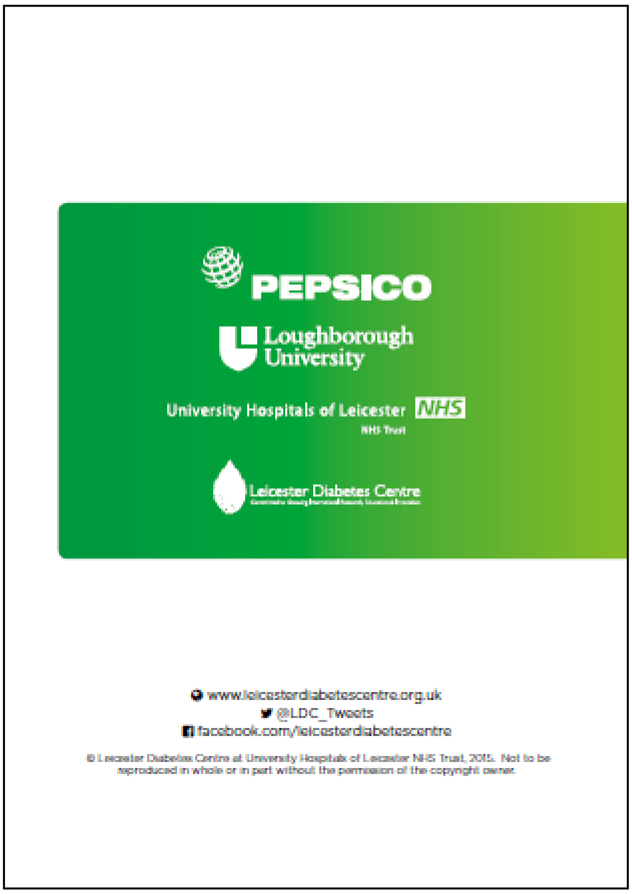
Our offices are open from 9am - 8pm every day

* Calls to 03 numbers should cost no more than geographic 01 or 02 UK-wide calls, and may be part of inclusive minutes subject to your provider and your call package.

www.nhs.uk/change4life

DVLA
Drivers' medical enquiries
Drivers' medical enquiries
DVLA
Swansea
SA99 1TU
Telephone: 0300 790 6806
Monday to Friday, 8am to 5:30pm
Saturday, 8am to 1pm
Fax: 0845 850 0095
www.gov.uk

YOUR NOTES



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