STRESS RESILIENCE, SLEEP AND PHYSICAL ACTIVITY IN OLDER MANUAL WORKERS

by

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ABSTRACT

This thesis investigated the relationships between stress resilience, sleep and physical activity (PA) in older manual workers (OMW). The first study aimed to explore latent profiles of individuals at risk of ill health and being based on presenteeism, stress resilience and PA. Profiles of OMW differed on work-related affect and health perceptions, and high levels of PA were associated with lower levels of presenteeism. As such, implementing interventions that focus on high levels of PA may be efficient in the reduction of presenteeism in some groups of OMW and potentially in improving stress resilience. The aim of study two in this thesis was to explore the relationship between perceived psychological resilience and work-related factors (presenteeism and work engagement) and the physiological response to acute psychological stress in a group of OMW. The results indicated that psychological resilience was not associated with work-related factors. In contrast, cardiovascular reactivity was significantly related to work-related factors such that workers with high levels of presenteeism and low work engagement had high heart rate reactivity to stress. Thus, exaggerated cardiac reactivity in workers with high presenteeism may provide a pathway to cardiovascular disease (CVD). Study three examined the association of PA levels, BMI and undiagnosed obstructive sleep apnoea (OSA), which is common in OMW. Preliminary results indicated that undiagnosed OSA was associated with low levels of PA, although BMI was a stronger indicator, implying that PA may be a modifiable risk factor in OSA development. The aim of the fourth and final study of this thesis was to investigate the ability of a 12-week PA intervention to reduce moderate OSA independent of BMI in a group of older workers. The results indicated that the PA intervention was effective in the reduction of OSA independent of BMI and weight-loss and therefore, supports previous research that increasing PA may provide a means of managing OSA and improving cardiovascular health. In summary, increasing levels of PA, decreasing stress and promoting sufficient quality and duration of sleep may well be the pathway to

promoting good health and wellbeing in older workers, which will enable them to continue a long and efficient working life.

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List of Publications

This thesis comprises of three papers corresponding to three empirical studies and one additional study (Chapter 5).

1) Thogersen- Ntoumani, C., Black, J., Lindwall, M., Whittaker, A.C., Balanos, G.M., (2017) Presenteeism, stress resilience, and physical activity in older manual workers: A person-centred analysis. **Eur J Ageing** 14(4): 385-39.

2) Black, J.K., Balanos, G.M., Whittaker, A.C., (2017) Resilience, work engagement and stress reactivity in a middle-aged worker population. **Int J Psychophysiol** 116: 9-15.

3) Black, J.K., Whittaker, A.C., Balanos, G.M. (2018) Undiagnosed obstructive sleep apnoea and physical activity in older manual workers. **Journal of Aging and Physical Activity** 17: 1-25.

4) Activity to reduce obstructive sleep apnoea in a middle-aged worker population (AROSA) (Chapter 5) [***Paper in preparation***].

CONTENTS

CHAPTER ONE

1.0 Introduction

1.1.Ageing

1.1.1 The Ageing Workforce

The global working population is ageing and a reduction in birth rate means that the median age of workforces nationally and globally, is increasing (Billett et al., 2011). As such, the average population age is steadily increasing to the extent that by the year 2050, the median age in some countries such as Japan and Korea will have risen to greater than 50 years old (Billett et al., 2011). If this global trend is maintained over the coming years, the world will have many people approaching pensionable age (65 years). The above trend has previously been termed in the United States as the "silver tsunami" (ACOEM, 2009). Further, research indicates that the ratio of active workers to pensioners in the UK is 3:3, however, as life expectancy increases, it is predicted that by 2032 this ratio will shift to 2:9 respectively (Crawford et al., 2010). This evidence implies that there is likely to be a shortage of workers within the UK if sufficient numbers of older workers are not retained. In light of this, the default retirement age in the UK has now been phased out, and workers are encouraged to continue working beyond the previously recognised retirement age of 65 years old (Government Office for Science, 2016). It would appear that workers in other countries are in a similar situation and are now also encouraged to work beyond the age of retirement to sustain the economy. Indeed, a survey of the Australian workforce conducted in 2007 by the Australian Bureau of Statistics (Trewin, 2007), indicated that the average age of retirement for men and women was 61.5 and 58.3 years respectively. However, following the economic downturn and a depletion of pension funds of up to 40%, Australian workers are also now also required to work beyond the age of 65 years (Billett et al., 2011). Notably, it is also likely that the fewer younger workers under the age of 45 years old, will be in high demand and therefore, less inclined to select low status manual jobs such as aged care, which workers in their 50s and 60s often occupy (Billett et al., 2011). Thus, it is inevitable that older workers will need to be retained to avoid deficits in the labour market, particularly in manual jobs. Although work is something that many older workers find rewarding and purposeful, many others may need to work for financial reasons and thus, the choice to leave the workforce is not an option. Thus, when considering how best to keep manual workers in employment longer, greater consideration is required as to how feasible this is given that ageing is very much associated with poor and declining health and that the psychological and physical burden of daily work becomes greater with increasing age (Siegrist et al., 2012, Fragar and Depczynski, 2011). Indeed, age-related losses such as physical strength, cognitive speed and reasoning abilities are some of the negative declines that may make working life more difficult for the older worker (Fragar and Depczynski, 2011). On the other hand, older workers are reported to focus on positive aspects of their work and therefore have better emotional regulation. Moreover, they often make up for age-related physical and mental declines such as cognitive speed, reasoning and a decreased ability to complete physical work by relying on knowledge gained from years of work experience and by focusing on a few chosen tasks to complete at a slower pace, this is known as job crafting (Kooij, 2015). Additionally, job autonomy, whereby the older worker has more freedom and responsibility within their work means that the individual feels more in control and as such this leads to higher work engagement (Zacher, 2018).

In scenarios where it is not possible to adapt ways to make the job better fit the older worker may result in the workload and the capacity of the older worker being mismatched. This can lead to psychological stress in the form of anxiety in response to not being able to meet the demands of the job which in time may also result in physiological stress e.g. hypertension (Anbazhagan and Rajan 2013). There are many types of stress depending on the context in which stress is being considered. The focus of stress in this thesis refers to the role of perceived psychological stress, i.e. one's ability to cope with current demands (Folkman and Lazarus, 1985) in response to job-related factors that interact with the worker to disrupt psychological or physiological homeostasis (Anbazhagan and Rajan 2013). As such, if we are to comprehend how best to keep older manual workers healthy and working longer, it is necessary to understand how older manual workers can remain in the workforce successfully. As well as utilising methods such as job crafting, to enable better person job-fit over time as previously described by Kooij (2015), consideration needs to be given as to what sort of lifestyle behaviours, such as physical activity, might be useful as a way to promote positive health and wellbeing within this group. Further, it is of paramount importance to recognise the effect of daily work on the health and wellbeing of this population. As such, understanding of how to promote the health and wellbeing of older manual workers is needed in order for them to stay healthy and be an efficient part of an economically sustainable workforce (McDermott et al., 2010). To this end, the theoretical framework of successful ageing at work is a useful guide for the development of the studies within this thesis (Kooij, 2015). The framework of Kooij (2015) is based on the theory of person-job fit as the route to maintaining health, motivation and the ability to continue working both presently and in the future.   In other words, what resources can an older worker utilise to ensure current and future person to job fit over time. Within this framework, Kooij (2015) advises that the sustainability of an older worker to remain in work is one in which the role of an older worker is an active one. To clarify, one of the key resources in which the older worker might actively seek help to remain in work is proactive behaviour, i.e. that which the individual can do to adapt to age-related changes to sustain the ability to continue working. For example, developing new skills, planning future career changes and building social networks are all examples of resources that the older worker may find useful. Kooij (2015) also hints at proactive behaviours to maintain health, however, deciding which health behaviours that might be useful as resources to modify the effects of work demands on the older worker is largely unexplored. Most focus is given to job modification, flexible working hours etc. Additionally, there is little evidence indicating how interventions may be used to promote health and wellbeing in the older worker and presently none that specifically address the needs of older manual workers (Crawford et al., 2010). Therefore, with the framework of Kooij (2015) in mind, this thesis aims to address the lack of research on proactive health behaviours mentioned within the framework and as such, explores the role of **stress resilience, sleep** and **physical activity** as potential resources to sustain **health and wellbeing** within older manual workers. Each of these potential resources is visited within the introduction of this thesis and further explored within the studies that comprise the chapters of this thesis. Of note, although each of the above-mentioned variables has the potential to act as resources to promote and influence health and thus serve individually as independent variables (resources), they could also be the dependent variables or inter-related outcomes, which influence one another. For example, sufficient sleep or a higher level of stress resilience may impact positively on wellbeing, but sufficient sleep or stress resilience may themselves impact on an individual's likelihood of taking up physical activity, and vice versa. The same resources also have the potential to become negative outcomes, such that, insufficient sleep may lower one's resilience to job stress leaving the individual with lower energy levels available for physical activity (Stults-Kolehmainen and Sinha, 2014). Thus, it is important to explore how these potential resources occur in relation to the older worker's ability to perform their work to their full potential. Chapter two of this thesis addresses this gap and explores the interaction of stress resilience, physical activity and presenteeism (attending work whilst ill/not fully functioning) in older manual workers. In observational studies, such as those integrated into this thesis, it is of course impossible to determine causal direction, and the analysis in Chapter two takes this into account through exploring characteristics of older manual workers by creating typologies (groups) based on stress resilience, physical activity and presenteeism (attending work whilst ill) (Bierla et al., 2013) to understand how these factors relate to one another. The later empirical studies in this thesis each suggest a parsimonious direction of effects between variables, however, they still acknowledge that causal direction of effect cannot be claimed without randomised controlled experimental designs.

1.2. Older Manual Workers

As mentioned earlier, the need to recruit or retain older workers within the labour force is growing and is of huge organizational concern. In particular, there is a huge shortage in the UK of manual labour specifically in manual production and services (EDGE, 2018). Further, within the healthcare sector worldwide, employees such as nurses find their jobs increasingly difficult with passing age and as such it is estimated that there will be a shortage of almost 13 million workers in total by the year 2035 (WHO, 2013). Therefore, the subject of older worker recruitment and retention needs to be a major consideration within organisations.

In the UK, an older worker is defined as an individual who is engaged in work and aged 50 years old and over (Department for Work and Pensions, 2011). In 2011, the Department for Work and Pensions (DWP) recorded over 65% of older workers (aged 50-64 years) in total, employed in the UK. Although the number of those in manual labour was not specified, BUPA (2015) identified manual jobs as being the worst for cardiovascular health compared to others such as medical professionals. Further, it was indicated that the difference between a manual worker's chronological age and their physical heart age was + 8.7 years compared to the average worker whose heart age is +3.3 years compared to their chronological age. This is of huge concern given that heart disease is the number one cause of death globally (British Heart Foundation, 2015). Additionally, the above information highlights the relationship between work and heart health. However, through the introduction of health and wellbeing initiatives, there is much that an employer can do to alleviate this. As such, work may then play a positive role in future health and wellbeing (BUPA, 2015). Indeed, previous research has suggested that continuing to work into older age may be beneficial to health and wellbeing and that employers can benefit greatly from employing older workers (McDermott et al., 2010). For example, Ng and Feldman (2013), demonstrated that older workers tend to be in better control of their emotions and engage in less counterproductive behaviour such as tardiness. However, Di Gessa et al. (2018) found that those who are forced to stay in work, may be due to financial reasons, suffer from poorer quality of life compared to those who chose to stay in order to remain active. Additionally, from an important but negative angle, ageing is inevitably associated with increased negative health risks such as cardiovascular disease (CVD) and despite the efforts of companies to ensure the health and wellbeing of older manual workers, poor health compromises the ability to carry out daily work efficiently; likewise, work also takes its toll on health in terms of psychological and physical health (e.g. stress and back pain) (Taylor et al., 2004). Further, McPhedran (2012) demonstrated that older manual workers involved in trades, labour and production are more likely to exit the labour force early owing to ill-health than their counterparts in other occupations. Notably, other less obviously physical jobs, such as teaching, which require variety of physical demands such as standing up all day, bending in awkward positions, involvement in physical education together with the psychological demands of the job can lead to a combination of physical and psychological stress and as such can result in teachers attending work whilst not fully functioning (presenteeism) (Chong and Chan, 2010, Beyen et al., 2013, Erick and Smith, 2015).

1.2.1. The Effect of Manual Labour on the Older Worker.

The World Health Organisation defines health as “a state of complete physical, mental and social well-being and not merely the absence of disease of infirmity.” The available research into the health and wellbeing of older workers has demonstrated that manual workers employed in health care, education, government and industry over the age of 50 years, experience more age related problems, such as fatigue and muscle function decline than their younger counterparts (Koolhaas et al., 2012, Fragar and Depczynski, 2011, Jones et al., 2013). Manual workers in this thesis are defined as those whose jobs involve a substantial amount of time in physical movements such as long periods of standing, lifting heavy loads and bending in awkward positions e.g., construction workers, healthcare workers and PE teachers (Beyen et al., 2013, Chong and Chan, 2010, Fragar and Depczynski, 2011, Arndt et al., 2004)

Manual workers experience more musculoskeletal disorders and cardiovascular disease than non-manual workers and as a result may be more predisposed towards early exit from the workforce (Allesoe et al., 2015). Further, physically demanding jobs carried out over long periods of time may cause health problems in older workers (Peeters et al., 2008). For example, a cross-sectional survey study which examined the differences between chronological and functional age in manual workers (n = 3800) aged 45-64 years, in which participants were involved in heavy physical labour (including cleaning and healthcare), found that workers aged 55-64 years, demonstrated lower physical function, poorer general health and vitality than those younger than 50 years old. Additionally, of those aged 55-64 years old, 36% reported a chronic health condition (25% musculoskeletal and 11% mental), of which 50% added that it hindered their daily work (Koolhaas et al., 2012). Further, a focus group study of nurses (n = 80), aged over 50 years old, found increases in difficulty with manual handling, certain movements and postures, and a rise in fatigue and time required to recover from shifts (Fragar and Depczynski, 2011). Unfortunately, few workplace programmes designed to facilitate health, prevent disease and promote wellbeing have been targeted at older workers, as a result, the effectiveness of interventions in this age group is limited (Crawford et al., 2010). In this respect, some employers believe that an older workforce may cause financial repercussions as a result of increased absenteeism or reduced productivity, owing to illness and injury arising from decreased capabilities and motivation (Hwalek et al., 2008, Billett et al., 2011). Thus, before interventions can be implemented to make improvements in the health and wellbeing of this age group, it is necessary to understand the characteristics that exist and the associated problems that may interfere with daily work. However, research is limited as to the nature of health problems that may exist within older manual workers (Crawford et al., 2010). There is some evidence to suggest that as older workers in manual occupations, for example, healthcare and construction, get older, activities such as lifting and awkward positions become more difficult and result in physical aches and pains (e.g. backache) and psychological stress (e.g. anxiety, depression) (Koolhaas et al., 2012, Savinainen et al., 2004). Importantly, there are several determinants of health in older workers. The study of McFadden et al. (2008), demonstrated socio-economic status to be a determinant of health in older workers mean age 58 years. For example, those in manual work reported lower self-rated health over time than those in professional occupations of similar age (McFadden et al., 2008). Earlier support for this is found in the work of Marmot and Wilkinson (2005) who also highlight manual work as a determinant of health, indicating that manual workers report poorer health than non-manual workers. Poor health behaviours are also listed as determinants of health in older workers in that smoking and low levels of PA are risk factors for functional decline (McMunn et al., 2004). Notably, those in low status jobs such as manual occupations carry a higher risk of CVD in older workers, potentially via elevated plasma fibrinogen in response to stressful situations which causes blood and plasma viscosity and in turn CVD (Steptoe et al., 2003). It is advised that regular PA can potentially lower this risk and promote positive health and wellbeing (McMunn et al., 2004). However, health behaviours and their modification to potentially improve health and wellbeing in older manual workers remain largely unexplored. Indeed, consideration as to what kind of resources may be useful for improving health and wellbeing and guarding against illness and poor health have not been researched in respect to older manual workers. Thus, it is not understood whether physical activity (PA), sufficient sleep or developing resilience to stress may be useful as tools to preserve the working life of the older manual worker.

1.2.2. Social support

Another important determinant of health is social support, which is associated with morbidity and declines in functioning with age. For example, social support is believed to be a buffer for chronic illness and has been shown to mediate the relationship between economic position and health, such that those who are married and have a spouse to take care of them during illness may not have need for expensive medical care (McMunn et al., 2004). Further, social support can offset the physiological effects of a perceived psychologically stressful situation and thus, reduce the potential negative effects of stress within the body. For example, in response to perceived psychological stress, Phillips et al. (2006) demonstrated that spousal presence attenuated heart rate and systolic blood pressure reactivity in women. Thus, social support is believed to act as a buffer against stressful events and as such may prove useful as a tool in building resilience against stress (Howard and Hughes, 2012). However, a previous study into the effect of spousal support in a group of police officers found that being married only marginally offset the response to the psychological stress of police work (Zhao et al., 2003). As of yet there is no research that has examined the relationship of stress resilience, marital status and work in older manual workers. This gap is addressed in chapter three of this thesis, which explores the role of stress resilience in relation to work and acute psychological stress reactivity, but also considers marital status as a potential stress buffer.

1.2.3. Older Worker Health

The few studies that have been conducted into the health and wellbeing of older manual workers emphasise some common examples of problems in manual labour. For example, a reduction in aerobic capacity as a result of ageing will compromise the working life of those occupying physically demanding manual jobs. With passing age, a dysfunction of the endothelium and smooth muscle cells occurs resulting in stiffness and thickening of the cardiac myocytes (muscle cells) and impaired ability of arterial distensibility making cardiovascular work more difficult (Starodubtseva, 2011). Further, inflammatory and degenerative conditions causing pain and stiffness around the joints, namely, arthritis and osteoporosis are also associated with age-related musculoskeletal disorders (Starodubtseva, 2011). At a cellular level, ethrocytes (blood cells) suffer a depletion of adenosine triphosphate (ATP) (cellular energy) and an increase in calcium ions resulting in a loss of elasticity. Additionally, skeletal muscle fibres become stiffer with age thus, contributing to a loss of elasticity (Ochala et al., 2007). Thus, it is likely that chronic musculoskeletal disorders may become increasingly problematic in older workers (Starodubtseva, 2011, Shephard, 2000). Further, it has also been suggested that the duration, intensity and frequency of manual work are not sufficient to preserve or advance physical capacity (Shephard, 2000, Gall and Parkhouse, 2004). In terms of working life, machinery paced work which is set up in output (rate) or workload (weight) for a younger worker, for instance who is aged 25 years, will outstrip the capabilities of a worker age 50 years, who has less strength and aerobic capacity to cope with demand unless the older worker is fit (Crawford et al., 2010). If this overload of demand persists on a regular basis, an older worker may become highly predisposed to musculoskeletal problems, e.g., low back pain and muscle fatigue (Shephard, 2000). As a result of the above problems, work efficiency is compromised and can result in presenteeism (Bierla et al., 2013). Alongside other poor health behaviours such as insufficient sleep and psychological stress, physical inactivity has been previously linked to presenteeism in older workers (Guertler et al., 2015). Presenteeism is attending work but performing sub-optimally (Bierla et al., 2013) and is discussed more fully later on. Briefly, presenteeism is a great concern to organizations and has been termed the iceberg effect because it is largely unseen and often difficult to measure (Johns, 2009). However, some studies have attempted to estimate the cost of presenteeism. In their study, Warren et al. (2011) estimated that indirect costs associated with presenteeism in nurses and pharmacists in 2008 was $12,605 per person and found that conditions relating to presenteeism such as physical and mental symptoms (hypertension, chronic musculoskeletal pain, anxiety, depression and sleep problems) were found in 52.65% of 226 staff.

Thus, the need to promote positive health behaviours is essential if presenteeism is to be attenuated and working life enhanced. However, before we consider the role of presenteeism in older manual workers, it is necessary to consider the relationship of health and wellbeing, in respect to how engaged an employee is in their work. It is likely that the link between psychological wellbeing and presenteeism is also present in work engagement and thus affects health and wellbeing at work.

1.2.3.1 Work Engagement

Employees who have a sense of energy and connection with their work, are considered to be engaged with their work, and thus, feel able to cope with its demands (Schaufeli and Bakker, 2003). Work engagement has three dimensions: vigour (high energy and mental resilience in work), dedication (involvement in work, with enthusiasm, pride and inspiration) and absorption (being engrossed and happily absorbed in work) (Schaufeli et al., 2006). Recently, psychological wellbeing has been demonstrated to be predicted by work engagement. Torp et al. (2013) found that work engagement, especially the aspect of 'vigour', predicted psychological wellbeing in a group of 605 employees with mean age of 51 years (occupation not specified). Further, work engagement was significantly and negatively related to depression in respect of job resources, control and social support, in that high levels of work engagement mediated the effects of depression in relation to environment, but not to psychological job demands. A similar finding was present in an earlier study in a group of Turkish female bankers (n = 286), whereby a moderate relationship to psychological wellbeing was displayed. However, the mean age of the bankers was 40 years old and those older than 40 represented only 7% of the total sample (Koyuncu et al., 2006). Nevertheless, findings from the study demonstrated that high levels of 'dedication' were related to decreased psychosomatic symptoms, e.g. anxiety and insomnia and importantly a reduced intention to retire. Together, 'dedication' and 'absorption' also indicated increased job satisfaction, whilst high levels of 'vigour' indicated positive psychological wellbeing.

Given that the present thesis relates to older manual workers, it is necessary to understand the effect of work engagement across occupations. To this end, Schaufeli et al. (2006) examined the relationship between work engagement and psychological wellbeing in various occupations across 10 different countries. In their study, the authors pooled a sample of participants (aged 16-68 years) from 10 countries to examine the relationship between work engagement and occupational groups. The authors observed that in relation to white-collar workers (e.g. managers), healthcare and blue collar workers (i.e. those involved in manual labour), displayed the lowest scores on work engagement dimensions, thus, implying those in manual jobs had poorer psychological wellbeing. However, other research relating to work engagement and wellbeing in older manual workers is limited. In literature presently available, workers aged 50 and over are generally under-represented within a sample. For example, the study of Kanste (2011), only included 24% of older (over 50 years) hospital staff. However, although the percentage of older workers represented in the study was small, its findings agreed with previous studies regarding the relationship between work engagement and wellbeing (Koyuncu et al., 2006, van Berkel et al., 2013). Similar to Torp et al. (2013), Kanste (2011) also found that high levels of work engagement improved psychological wellbeing and also mediated the effect of the work environment on poor psychological health e.g. depression.

It is clear from the above evidence that work engagement is another way in which those at risk of poor health and wellbeing may be identified. Further, those with lower levels of work engagement who are more likely to display poor well-being, are also likely to have higher levels of presenteeism due to perceived psychological stress. Thus, it is possible to understand how work engagement and presenteeism may be inter-related and effect the health and wellbeing of older manual workers and their ability to remain healthy and efficient within the workforce. For instance, if an employee is suffering from depression and is not engaged effectively with work, it is logical to assume that the individual is not performing optimally within the workplace, and thus, displays signs of presenteeism in the form of depression and possibly anxiety in not being able to meet a given workload. In turn, the individual may also perceive their workload to be a source of stress which, if it continues over time, not only affects the ability to work effectively, but may also lead to negative physiological conditions such as hypertension (Landsbergis et al., 2013). Although, the above evidence demonstrates the link between job stress and hypertension, there is to date no research, which examines the role of work-related factors such as presenteeism in older manual workers.

1.2.3.2 Presenteeism in Older Manual Workers

Presenteeism as mentioned earlier, refers to attending work but performing sub-optimally due to poor health and is a useful indicator of ill-being at work. This can be represented physically, such as when low back pain hampers normal lifting duties, or psychologically, for example, where anxiety and or depression arises from the reduced ability of an individual to perform their job adequately (Bierla et al., 2013). The construct is one of the largest causes of reduced productivity in the workplace; thus, it is important to understand the associated health risks in older manual workers if it is to be reduced (Aronsson, 2000, Warren et al., 2011, Stewart et al., 2003). Presenteeism is a key concern to employers since its costs far outweigh those of absenteeism and therefore, are an important public health and organisational issue in the UK (Bierla et al., 2013, Brown, 2011). Although monetary values are difficult to obtain and compare owing to the varied measures companies have used to try and measure presenteeism, the US, has estimated that 71% of costs are due to reduced performance at work owing to presenteeism; this amounts to $226 billion (USD) annually (Schultz et al., 2009). Indeed, workers aged 50-65 years have been shown to be responsible for 21% of total lost productivity time (Stewart et al., 2003). The majority of costs are due to acute or chronic health conditions including pain (musculoskeletal, low back pain, arthritis) (Hallman et al., 2014), depressive symptoms (Stewart et al., 2003) and stress (Aronsson, 2000, Leineweber et al., 2011, Taloyan et al., 2012, Callen et al., 2013). Additionally, an increase in health conditions such as work related neck and shoulder pain (NSP) may also invite further health risks such as psychological stress and poor sleep. Indeed, Hallman et al. (2014), found that workers (mean age 41 years) with NSP reported higher levels of stress, fatigue and poor sleep quality when compared to a control group.

It is evident from the above research that a variety of health conditions are associated with presenteeism in older workers, however, it is important to understand an individual's capacity to cope with daily life and work, alongside potential health conditions. Thus, a useful approach is to consider resources that may be modifiable as interventions in order to foster improved health and wellbeing. Such resources may include a range of health behaviours and activities such as PA which has been shown to improve sleep quality and in turn, the ability to deal with psychological stress, thus, promoting positive health and wellbeing (Chen et al., 2009). Of note, a lack of sleep can make an individual more vulnerable to the effects of psychological stress, which in turn can interfere with sleep quality; thus, fostering positive habits in sleep quality might serve to offset the negative effects of stress and vice versa (Giese et al., 2013). As mentioned earlier, social support has also been shown to influence the effects of stress on an individual, thus, possibly acting as a form of resilience in the individual. However, the question as to whether stress resilience is a resource associated with potential work stress and, in turn, presenteeism and work engagement is unanswered in older manual workers. This gap is addressed in chapter three of this thesis in the study exploring resilience, work engagement, presenteeism and physiological reactivity to acute psychological stress.

In accordance with the theoretical framework of (Kooij, 2015), the present thesis considers the variable of stress resilience, PA and sleep as potential resources that may help an older worker maintain health and stay in work longer. Although, there is a focus on presenteeism as a reason why this is important, the key questions of this thesis are in the first instance, how do potential resources such as stress resilience and PA relate to presenteeism in older manual workers and how might additional resources such as sleep play their part in older manual worker health. Given that high levels of psychological stress, low levels of PA and insufficient sleep quality and or duration are prime contributors to presenteeism and importantly, have very negative influences on the efficient mental and physical functioning of an individual generally, the role of each will be considered in turn (Brown et al., 2013, Leineweber et al., 2011, Guertler et al., 2015). Attention in the first instance is given to PA, followed by reactivity to psychological stress and finally to sleep and sleep disorders.

1.3. Age-Related Health Conditions and Physical Activity.

With the progression of ageing, an annual decline of 1-2% in muscle strength and cardiorespiratory capacity is reported to occur (Ilmarinen, 2012, Ilmarinen et al., 1996). Individuals who are into their forties and lack regular engagement with PA have demonstrated physical reductions (i.e.reduced strength and aerobic capacity) of up to 25% over a four-year period (Ilmarinen, 2001). It is widely recognised that regular PA is of great benefit in maintaining strength and cardiovascular health through the use of resistance (using weights) and endurance training (e.g. running or cycling) (Shad et al., 2016) and also in minimising age-related weight gain (Hankinson et al., 2010). Additionally, PA has been well documented to induce major positive effects on mental wellbeing, including alleviating anxiety, depression, improving resilience to psychological stress (Gerber et al., 2013, Gerber et al., 2014a), reducing cognitive decline (Lindwall et al., 2012), improving mood and self-esteem (Miles, 2007) and improving sleep quality (Yang et al., 2012, Kredlow, 2015).

PA has been defined as any bodily movement produced by skeletal muscles that results in energy expenditure, meanwhile, exercise, on the other hand, is a sub category of PA and is often structured and planned such as running, cycling and swimming (Caspersen et al., 1985). PA may be measured in many ways for example through self-report whereby an individual records their own daily levels of PA e.g. in the form of a diary. Self-report methods although useful in very large participant samples can be subject to over-reporting and recall bias (Ainsworth et al., 2012). An alternative and more accurate method of measuring PA is through objective measures such as accelerometry where the participant wears a device for example on the hip or wrist which then records bodily movement in different planes of motion. Accelerometry is generally a more reliable method of collecting PA data, however, a certain number of hours and days wear time is required for the data to be valid and of use to the researcher (Freedson et al., 2012). This thesis uses both methods of recording PA and acknowledges advantages and limitations of each within each empirical study where used. Additionally, this thesis is concerned with the relationship of PA in respect to presenteeism, stress resilience, and sleep quality to promote the health and wellbeing of older workers.

1.3.1. Physical Activity and Presenteeism

In addition to the benefits of regular PA mentioned above, recent research has begun to explore the associations between PA and presenteeism (Brown, 2011, Cancelliere et al., 2011, Schultz and Edington, 2007). Previous reviews suggest there are negative associations between PA and presenteeism (Cancelliere et al., 2011, Schultz and Edington, 2007). Thus, employees who engage in PA are healthier, less likely to be ill, absent from work or underperform compared to their peers. Additionally, there is also evidence to suggest that it is possible to increase PA within the workplace (Conn et al., 2009). Indeed, a randomized controlled trial of male shift workers, demonstrated the potential of a PA intervention in reducing presenteeism (Morgan et al., 2012).

Although PA is performed in a range of contexts, little is presently known about how different domains of PA (i.e., work-related, leisure-time activity or structured sport and exercise) may relate to presenteeism. Research so far has not used multi-domain measures of PA (Brown et al., 2013, Edmunds et al., 2013). However, it is possible that different domains of PA relate to presenteeism in different ways. Interestingly, some prospective evidence suggests that high levels of occupational activity increase the risk of health problems such as CVD across different age groups (Holtermann et al., 2012a, Holtermann et al., 2012b). For example, Krause et al. (2007) found that high levels of occupational activity increased the risk of atherosclerosis 11 years later, even after controlling for leisure-time PA and other potential relevant confounders. This is relevant as health problems, such as atherosclerosis, are key risk factors of presenteeism (Goetzel et al., 2004). Thus, the nature of the associations between PA and presenteeism may be dependent on which domains of PA are examined. The first study of this thesis (Chapter 2) assesses several domains (work, leisure and sport/exercise) of PA in relation to presenteeism in older manual workers and thus, makes an important and original contribution to research in this area.

Meanwhile, it is also necessary to consider the role of PA as a resource in other aspects of poor health and wellbeing that may also contribute towards serious health conditions such as cardiovascular disease (CVD). Indeed, PA has been shown to increase resilience to psychological stress through its positive physiological and psychological benefits, namely, reducing excessive cardiovascular reactions to stress and improving mood and wellbeing (Silverman and Deuster, 2014). However, before suitable interventions can be developed for older manual workers, it is first necessary to understand the effect of psychological stress and the physiological reactions to that stress on health and wellbeing.

1.4. Reactivity to Stress and the Cardiovascular System.

Perceived psychological stress in relation to work has become a major occupational problem (Tripodi et al., 2012) and continues to be a growing issue in Europe (European Agency for Safety and Health at Work, 2012). In 2015, it was reported that work related stress in the UK accounted for 35% of all health-related work illness and 43% of work absence (Health and Safety Executive, 2015). Thus, workplace stress has a negative impact on physical and mental health, accentuates reduced productivity and is an important predictor of presenteeism (Cancelliere et al., 2011, Callen et al., 2013). Of particular concern are older workers occupying lower status jobs such as nursing, healthcare, industry and education (Fragar and Depczynski, 2011, Jones et al., 2013, Koolhaas et al., 2012). This is because older workers in manual occupations, such as construction, experience increasing levels of stress (Arndt et al., 2005, Dong et al., 2012). For example, the study of Fragar and Depczynski (2011) found that manual handling work in a group of 80 nurses became difficult in those aged 50 years and older, and leads to higher levels of musculoskeletal pain and psychological stress as a result of the workload, than in those who were younger. In this respect, perceived psychological stress, resulting from an overload of work demands, has the ability to trigger musculoskeletal pain and operate in a reciprocal feedback loop (Larsman et al., 2009).

Research into psychological stress and wellbeing has suggested that future health and wellbeing can depend on the extent of one's physiological responses to stressful situations (Obrist, 1981). Indeed, Lovallo (2011) states there is a normal reaction to stress and that deviations above or below bring about a disruption to homeostasis within the body. Such that, an exaggerated response (a reaction above the group average) to a stressful event causes an overstimulation of the sympathetic nervous system that increases HR, levels of adrenaline and cortisol, increased left ventricle thickness and blood viscosity increasing the risk of CVD and stroke. Conversely, blunted reactivity, i.e. that which is considered to be below the considered norm/group average, is associated with dysregulation of the motivational centres in the brain responsible for healthy survival e.g. motivation to exercise, eating a healthy diet and are characteristic of obesity (reaction to food) and depression (reaction to reward and pleasure). However, the ways in which a dysregulation of the motivational centres develops is not fully understood (Lovallo, 2011). Thus, it is possible to see that both exaggerated and blunted responses may potentially relate to poor health and increased risk of CVD, either directly through exaggerated stimulation of the sympathetic nervous system or indirectly via possible negative correlates of blunted reactivity such as obesity.

As mentioned above, physiological reactivity to acute psychological stress is related to an increased risk of CVD (Carroll et al., 2012b, Carroll et al., 2011, Carroll et al., 2001) carotid arteriosclerosis (Everson et al., 1997) and even cardiovascular disease mortality (Carroll et al., 2012a). Additionally, elevated cortisol (a stress hormone) secretion in response to acute mental stress is associated with the development of hypertension (Hamer and Steptoe, 2012). However, negative health outcomes including depression, obesity and addiction are also related to blunted reactivity to acute psychological stress (Heaney et al., 2011, Phillips, 2011). Thus, how older manual workers respond physiologically to psychological stress, is key to understanding the potential risk of damage that may later affect health and wellbeing across working life and into retirement. In this respect, a physiological response to immediate danger, produces metabolic activity e.g. increased heart rate and blood flow to muscles sufficient to remove us from harm and thus is a healthy response (Sapolsky, 1998). However, psychological stress such as that experienced in the workplace, which incites a similar amount of metabolic activity disproportionate to the energy expenditure at the time of an event, is considered to be metabolically exaggerated, and thus, an unhealthy and maladaptive response (Balanos et al., 2010, Carroll et al., 2009). A frequent maladaptive response to work stress is harmful to physical health and from the age of 50 years, the cardiovascular system undergoes significant changes, which heighten the risk of CVD (Fleg and Strait, 2012, McEniery et al., 2007). Recently, a review of 29 studies evidenced the relationship between work-related stress and elevated ambulatory blood pressure (BP), and suggested a stronger association of increased BP and job strain in those aged 50 years and over (Landsbergis et al., 2013). Additional evidence suggests that those who experience high job strain (high demand, low control) are at risk of sustained cardiovascular dysfunction over time (Clays et al., 2007, Steptoe, 2001, Steptoe and Willemsen, 2004).

There has been scant research into stress reactivity and the association with job-related factors in older workers. Of the available studies, one found that men aged 55-65 years with high job strain had pronounced cardiovascular responses to mental stress (Steptoe et al., 1993). A further study found cardiovascular reactivity was positively associated with job strain in a group of workers with a mean age of 51.9 years, and was higher among those over 50 years of age (Clays et al., 2007). Equally, work-related stress has also been associated with higher cortisol reactivity (Hausser et al., 2011, Karhula et al., 2016, Steptoe et al., 2000). However, current evidence suggests that the relationship between work and stress reactivity is complex (Rudolph et al., 2016) and the majority of studies have not measured or found consistent results for both cardiovascular and cortisol responses to acute stress, or have not measured resilience. The consideration of resilience is important since psychological resilience may offer protection from the effects of physiological stress reactivity and as such, may help identify those with low resilience who may be at increased risk of the negative effects of stress reactivity (Schure et al., 2013). The second study of this thesis (Chapter 3) addresses these gaps by assessing the relationship between perceived psychological resilience and work-related factors such as presenteeism, and the physiological response to acute psychological stress in a group of older manual workers.

1.4.1. Stress Resilience

Recent research has begun to explore whether perceived high levels of psychological resilience might buffer against the effects of stress (de Paula Couto et al., 2011, Galatzer-Levy et al., 2014). Stress resilience has been defined as the ability to ‘bounce back’ from stress; and high levels of stress resilience foster wellbeing at work (Smith et al., 2008, Avey et al., 2010). It has been suggested that one way people can become more resilient to stress is by exercising or engaging in PA (Gerber and Puhse, 2009, Hegberg and Tone, 2015). Indeed, exercise can buffer the negative effects of stress on health and wellbeing (von Haaren et al., 2016). These findings may be partly explained by the cross-stressor adaptation hypothesis, which suggests that regular exercise can lead to a reduction in physiological responses to psychological stress (Sothmann et al., 1996). The research examining associations between resilience and PA has focused on the role of moderate-to–vigorous PA engaged in during leisure time. However, associations between resilience and different domains of PA remain unknown. A cross-sectional study of healthcare and insurance workers (n= 2,600), found that groups of resilient workers tended to be more physically active than those exhibiting lower levels of resilience (Gerber et al., 2014b). However, due to the measure of PA used (a global measure of PA), it was not possible to show whether the links between activity and resilience may have varied depending on the domain of PA examined.

Research has also found that resilient individuals are less likely to be absent from work due to ill health (Kotze, 2012). In a study of adults over 55 years old, high resilience was associated with good physical and mental health, whilst those with low resilience had high levels of depression (Schure et al., 2013). Further, de Paula Couto et al. (2011) demonstrated that high levels of resilience were associated with more positive wellbeing in adults with a mean age of 68 years. Additionally, younger policemen aged 27-32 years who were resilient displayed a significant cortisol increase (healthy) in response to acute psychological stress, while those less resilience showed a blunted (unhealthy) response (Galatzer-Levy et al., 2014). Thus, by inference, resilient employees should function better at work (i.e. exhibit low levels of presenteeism). There is also evidence to suggest that social support plays a role in promoting resilience to psychological stress; those who are married or cohabiting have been shown to have higher levels of resilience than those who live alone (Guinn et al., 2009). Additionally, in occupations such as the police force where there are high levels of psychological stress, employees with greater levels of support from colleagues have higher resilience than their colleagues (de Terte et al., 2014).

The above evidence highlights that research into the relationships between resilience and work-related factors and physiological responses to acute psychological stress in this age group is limited. Further, those aged 45-54 years old have been found to be less resilient than those younger or older (Bonanno et al., 2007). Given that high levels of psychological stress and extremes of reactivity to acute psychological stress are a risk factor for cardiovascular pathology, and that after age 50 years, the risk of physiological health problems such as hypertension increases (McEniery et al., 2007), the second study of this thesis (Chapter 3) also seeks to understand the relationships between these factors among older workers.

1.4.2. Stress, Sleep and the Cardiovascular System.

Resilience has also been shown to buffer the effects of perceived stress on sleep disturbance; indeed, perceived stress is associated with sleep disturbance, whilst individuals with high levels of resilience, are less likely to experience sleep disturbance (Liu et al., 2016). Further, poor sleep quality has been shown to increase the risk of coronary heart disease (CHD) incidence, and together with short sleep duration ($\leq$ 6 hours), also increases the risk for CVD and CHD (Hoevenaar-Blom et al., 2011). Thus, poor sleep quality, chronic stress and lack of PA not only increase the risk of presenteeism mentioned above, they predispose an individual to CVD. Ageing is also an independent predictor of future CVD owing to alterations in arterial function such as increased arterial stiffness, less elastin, and an impaired resistance to oxidative stress and inflammation (Thijssen et al., 2016, Fleg and Strait, 2012). The age-related deterioration of cardiovascular health is further impacted by the disruption to sleep caused by increasing older age (Stanley, 2005).

It is clear from evidence above that sufficient quality and duration of sleep is vital for restoring physical and mental functions and essential to positive health and wellbeing. However, with ageing, sleep patterns change, become more disrupted and less efficient. For example, fragmented sleep which disrupts the normal phases of sleep patterns impairs daytime alertness and performance (Stanley, 2005). For the purpose of this thesis, sleep loss refers to sleep duration that is disrupted or regularly falls short of 7 hours per night (Shen et al., 2016). Among its variety of functions, sleep provides physical and psychological rest, strengthens the immune system and ensures emotional wellbeing and memory consolidation (Stanley, 2005). Unfortunately, ageing decreases overall sleep time, efficiency and essential restorative sleep, and can lead to chronic sleep loss over time. As such, sleep loss can increase cortisol (stress hormone) levels causing further wakefulness and wear and tear on the body including the cardiovascular system (Stanley, 2005). Additionally, continued lack of sleep causes an increase in blood pressure and results in the chronic stimulation of the sympathetic nervous system, a pathway through which the cardiovascular system is put under persistent strain (Sekine et al., 2009). Chronic psychological and physiological stress as mentioned above, interferes with adequate sleep quality and duration, and sleep loss results in higher vulnerability to stress, leading to a vicious cycle of psychological stress and lack of sleep (Van Laethem et al., 2015, Gangswich, 2009, Giese et al., 2013). Additionally, sleep loss also inclines an individual to overeat. Weight-gain is among the many negative outcomes of sleep deprivation and arises as a result of imbalance between, leptin (a signal of body fat stores) and ghrelin (appetite stimulant) the two hormones responsible for regulating body weight. It has been demonstrated that sleep loss or short sleep durations, results in an increase in ghrelin and a decrease in leptin levels thereby, leading to increased hunger and weight gain (Taheri et al., 2004, Cummings and Foster, 2003, Cappuccio et al., 2011). Together with the naturally occurring tissue changes associated with ageing mentioned earlier, increased body weight increases the risk of a respiratory disorder known as obstructive sleep apnoea (OSA) (Wu et al., 2014, Cowie, 2017, Veldi et al., 2004).

1.5. Obstructive Sleep Apnoea (OSA)

OSA is caused by upper airway collapse resulting in repeated incidence of airflow cessation (apnoea) or airflow reduction (hypopnoea) during sleep. The severity ranges from mild to severe and is measured as the number of respiratory interruptions that coincide with a decrease in oxygen saturation (apnoea-hypopnoea index) (AHI). The AHI indicates the number of apnoea and hypopnoea episodes detected in one hour of sleep (Laitinen et al., 2003). Importantly, OSA increases the risk of negative health conditions such as CVD, hypertension and type-2 diabetes (Floras, 2014, Zhang and Si, 2012, Pamidi and Tasali, 2012).

In 2014, it was estimated that 1.5 million adults in the UK presented with OSA, although only approximately 330,000 are actually diagnosed and treated (Rejon-Parrilla et al., 2014). Thus, many adults may unknowingly have OSA. Recently, Webber et al. (2011) illustrated the incidence of undiagnosed OSA in a group of male rescue workers with a mean age of 44.2 years and found that only 13.9% who were deemed at risk for OSA were actually diagnosed. Owing to an increasingly older population (Government Office for Science, 2016) and rising obesity levels (NHS, 2013), the prevalence of OSA is likely to worsen over time (Rejon-Parrilla et al., 2014).

1.5.1. OSA, the Older Worker and Cardiovascular Disease Risk.

As many companies need to retain older workers beyond retirement age, it is important to bear in mind the impact of ageing-related diseases on health and wellbeing and ability to work, particularly in respect to OSA (Billett et al., 2011). It has been suggested that moderate to severe OSA is prevalent in males below retirement age and that the incidence peaks around the age of 50-59 years old (Laitinen et al., 2003). Indeed age-related physiological changes believed to contribute to the development of OSA include tissue and systemic alterations. For example, one suggested mechanism of OSA, a greater stiffness of the soft palate, found in middle-aged sleep apnoea patients, is brought about by the pharyngeal fatty infiltration caused by ageing (Veldi et al., 2004). As such, the above age-related physiological tissue changes mean that growing older increases the risk for development of OSA and together with age-related structural alterations to the heart, compound the likelihood of CVD (McEniery et al., 2007).

1.5.2. OSA and Lifestyle Behaviours

Additional factors that influence the risk of OSA development include poor lifestyle behaviours, such as excess alcohol consumption, smoking and a lack of regular engagement in PA (Al Lawati et al., 2009, Koyama et al., 2012, Simpson et al., 2015).

Although, Franklin and Lindberg (2015), imply that smoking is not an established risk factor for OSA, the negative impact of smoking on the cardiovascular system makes it an important consideration. Further, although alcohol is thought to relax upper airway dilator muscles and cause airway resistance, its role in OSA is inconclusive (Al Lawati et al., 2009). Nonetheless, given that alcohol adversely affects the homeostatic sleep drive, it is a likely contributor to sleep loss and thus a cardiovascular risk over time (Stanley, 2005). It is clear from the above evidence that the physiological effects of growing older together with poor lifestyle behaviours are likely co-contributors to the development of OSA.

1.5.3. The Effects of OSA in the Workplace

The health implications of OSA have enormous impact on quality of life and the ability to function effectively at work. For example, certain features of OSA such as excessive daytime sleepiness due to regular arousals during sleep and morning headaches, may present their own problems during the course of the working day (Banno and Kryger, 2005), such that work efficiency may be compromised and could result in sickness presenteeism (Guertler et al., 2015). Further, sleep loss owing to OSA becomes a real problem in the workplace in terms of production and even health and safety and as such, is costly to businesses (Gaultney and Collins-McNeil, 2009). This is particularly true of older workers in manual occupations, where non-health related outcomes of OSA such as lack of concentration, may lead to an increased risk of workplace injury (Heaton et al., 2010). For instance, occupations that involve driving, carry a high risk of road traffic accidents where OSA is concerned (Lemos et al., 2008). Road traffic accidents relating to OSA are costly to industry and to lives and have been evidenced to warrant that commercial drivers are screened before being deemed fit for work (Gurubhagavatula et al., 2008).

1.5.4. Association of PA and OSA

An employee who is sleepy due to complete or partial sleep loss owing to non-medical reasons such as going to bed late, may improve daytime sleepiness through good sleep hygiene (good sleep hygiene refers to positive habits used to prepare for sleep, e.g., taking a bath, having a hot non-caffeine drink, withdrawing screen use at least an hour before bedtime) (NIH Medline Plus, 2015). However, medically related involuntary causes of partial sleep disruption such as OSA often require resolution by medical (e.g. continuous positive airway pressure (CPAP) or behavioural intervention such as weight loss and or physical activity interventions (Gaultney and Collins-McNeil, 2009). OSA related sleepiness might also be even more of a problem in older manual workers who are already likely to experience age-related fatigue and tend to need longer recovery periods between work shifts than their younger counterparts (Kiss et al., 2008). As such, daytime sleepiness in adults aged 50 years and over with OSA are unlikely to practice helpful and positive lifestyle behaviours such as regular PA, a lack of which has been shown to be associated with moderate to severe OSA (Peppard and Young, 2004, Simpson et al., 2015). The suggestion of Chennaoui et al. (2015) that OSA limits PA is questionable, since other research attributes limited exercise capacity to age and body weight (Butner et al., 2013). Either way, previous research implies that the severity of OSA increases with age and weight, and that regular PA may alleviate age-related worsening of cardiorespiratory function, promote weight loss, and potentially reduce the severity of OSA (Butner et al., 2013, Vanhecke et al., 2008). Recent evidence highlights the potential of PA for reducing the severity of OSA (Aiello et al., 2016), however, there is limited evidence regarding the association between OSA and PA in those older than 50 years. The available literature generally suggests that low levels of daily PA is associated with increased severity of OSA independent of BMI in those older than 50 years old (Peppard and Young, 2004, Simpson et al., 2015, Verwimp et al., 2013). Research is also sparse in respect of PA and the occurrence of undiagnosed OSA in older manual workers. If PA is to be used as a potential indicator of presence of undiagnosed OSA in the older worker, it is first of all important to determine whether a relationship exists between the two in this age group. Study three in chapter four of this thesis explores the association of PA with undiagnosed OSA in a sample of manual workers aged 50 years and over (Ejaz et al., 2011). Although, previous research is unclear about the potential of PA to attenuate OSA, it is worthy of consideration given that current gold standard treatment, namely continuous positive airway pressure (CPAP), often presents adherence issues causing the patient to terminate its use (Tyrrell et al., 2006).

1.5.5. OSA Treatment and Prevention.

CPAP, as indicated above, is the recommended treatment for those suffering with OSA, however, despite its ability to resolve OSA by keeping the airways open during use, its compliance is often suboptimal (Cvengros et al., 2016). Previous research has identified some of the issues using CPAP as physical discomfort with the mask and noise from the machine (Tyrrell et al., 2006). This is concerning since failure to continue the use of CPAP reinstates the occurrence of OSA and thus, its negative health risks (Yetkin et al., 2008). Further, Yetkin et al. (2008) also discovered an interesting relationship between the severity of OSA and CPAP compliance; only those with very severe OSA used CPAP regularly; those with moderate to severe (AHI 15-30) were found to have poor adherence to the treatment.

1.5.6. OSA Management and PA.

Recently, research has begun to explore other additional or alternative ways to manage OSA (Aiello et al., 2016). Interestingly, a considered modifiable risk factor for both OSA development and cardiovascular risk is PA. In respect of OSA, several studies have sought to demonstrate the ability of regular PA to attenuate or even prevent OSA and thus CVD (Schobersberger, 2013, Giebelhaus, 2000, Peppard and Young, 2004, Sengul et al., 2011). One suggested mechanism is that regular endurance exercise strengthens and stabilizes the respiratory muscles of the upper airways (Vincent et al., 2002). Other evidence proposes that OSA might be alleviated by way of rostral fluid shift during walking, which is thought to discourage fluid accumulation around the neck region during sleep (Redolfi, 2015). Although evidence in general is inconclusive, PA has many varied health benefits to offer and thus, is considered a legitimate mode of management for OSA (Aiello et al., 2016, Iftikhar et al., 2017, Iftikhar et al., 2014). Current recommendations for daily PA levels to preserve health are suggested as 30 minutes of PA at moderate to vigorous intensity (MPVA) five days a week (Haskell et al., 2007), however, other research recommends that general PA should be encouraged throughout a 24 hour period to benefit overall health (Chaput et al., 2014). Further, regular PA has many benefits in alleviating the effects of physical decline normally associated with ageing and preserving health across the lifespan (Miles, 2007). As such, study four in chapter 5 of this thesis, investigates the potential of gradual increased daily levels of overall PA to attenuate OSA in older workers.

1.6. Promoting Health and Wellbeing in Older Workers

Given that the ability of an older worker to continue to participate within the workforce relies on good health and wellbeing, it is necessary for this to be promoted as much as possible. It is evident from the subjects discussed above that each factor, namely stress, PA, and sleep, have a vital role to play in ageing health and wellbeing and that they are all very much interwoven. In order that we can begin to understand whether one factor is likely to be a higher trigger than the others, i.e. does sleep loss/deprivation lead to other problems or vice versa, and how these factors might interact within an individual requires that we explore the health and wellbeing characteristics of this age group.

In summary, the literature summarised in this introduction suggests that there are several gaps in our understanding of the factors relating to health and wellbeing in older manual workers. 1. That, although positive lifestyle behaviours may be helpful as resources to help promote health and wellbeing and sustain an older worker within the workforce, those which may potentially modify the effects of work on older manual workers wellbeing remain unexplored. Additionally, there is at present no evidence of interventions that may help to maintain and improve older manual worker health. Given the increasing shortage of manual workers within the UK, it is necessary to understand which aspects of health behaviours may serve as useful resources for this participant group and, as such, the variables of stress resilience and physical activity are considered in chapter two in the first study of this thesis. 2. As previously mentioned in the introduction, social support is a determinant of health, however it is unknown if social support, plays a role in the perceived psychological resilience to psychological stress in older manual workers in relation to work. Further, the role of stress resilience in relation to perceived psychological stress and work-related variables including sickness presenteeism and work engagement remains unexplored in older manual workers. This research is important to understand the potential pathways through which the effects of work may contribute to poor health and wellbeing in this group. Thus, this gap is addressed in chapter three in the second study of this thesis. 3. Given the potential resources mentioned above are not completely exhaustive, it is necessary to consider other important health behaviours such as sleep, which is known to play an important role in the maintenance of health and wellbeing across the lifespan. Sleep, if insufficient in duration or fragmented owing to other health conditions such as sleep disorders (e.g. sleep apnoea), may contribute to negative future health such as diabetes and CVD in an individual. Given the increased risk for development of CVD with age and the large number of individuals who remain undiagnosed with OSA within the UK, identifying individuals who may unknowingly have OSA is imperative if their health is to be preserved and improved across working life. However, research into undiagnosed OSA in older manual workers is absent and its relationship to PA levels and potential to manage OSA through PA in this same group is also lacking. To this end, these gaps are addressed in the second half of this thesis in chapters four and five.

This thesis comprises four empirical chapters: 1) The first empirical chapter in chapter two, aims to explore the existence of typologies of older manual workers based on stress-resilience, PA and presenteeism and to examine differences between these profiles on other relevant indicators of health and wellbeing. It also aims to explore any differences between the profiles in socio-demographic characteristics, which if any, could be useful in identifying profiles as risk of poor health and wellbeing. It was hypothesized that one group would exhibit high levels of leisure PA, low levels of presenteeism and high levels of stress resilience. The other profile of individuals was expected to exhibit the opposite pattern of characteristics. 2) The second empirical chapter (chapter three), aims to identify the relationship between the physiological response to acute psychological stress and perceived psychological resilience to stress and work-related variables (work engagement and presenteeism) in older manual workers. It was hypothesized that those who exhibited maladaptive (exaggerated or blunted) responses to acute psychological stress would have low levels of perceived stress resilience, and display lower levels of work engagement and higher levels of presenteeism. 3) The third empirical chapter (chapter 4), aims to explore whether PA is associated with undiagnosed OSA in a sample of older manual workers. It was hypothesized that those with an undiagnosed presence of OSA would report low levels of PA, independent of BMI. 4) The fourth and final empirical chapter (chapter 5) of this thesis is an intervention study, which aims to determine whether a 12-week PA intervention would reduce the severity of OSA independent of weight-loss or body mass index (BMI) in older manual workers.

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CHAPTER TWO

2.0. PRESENTEEISM, STRESS RESILIENCE, AND PHYSICAL ACTIVITY IN OLDER MANUAL WORKERS: A PERSON-CENTRED ANALYSIS

2.1. Abstract

This study used a person-centred approach to explore typologies of older manual workers based on presenteeism, stress resilience, and physical activity. Older manual workers (*n*=217; 69.1% male; age range: 50 – 77; *M* age = 57.11 years; *SD*= 5.62) from a range of UK-based organisations, representing different manual job roles, took part in the study. A cross-sectional survey design was used. Based on the three input variables: presenteeism, stress resilience and physical activity, four distinct profiles were identified on using Latent Profile Analysis. One group ('High sport/exercise and well-functioning'; 5.50%) engaged in high levels of sport/exercise and exhibited low levels of stress resilience and all types of presenteeism. Another profile ('Physically burdened'; 9.70%) reported high levels of work and leisure-time physical activity, low stress resilience, as well as high levels of presenteeism due to physical and time demands. A 'Moderately active and functioning' group (46.50%) exhibited moderate levels on all variables. Finally, the fourth profile ('Moderately active with high presenteeism'; 38.20%) reported engaging in moderate levels of physical activity and had relatively high levels of stress resilience, yet also high levels of presenteeism. The profiles differed on work affect and health perceptions largely in the expected directions. There were no differences between the profiles in socio-demographics. These results highlight complex within-person interactions between presenteeism, stress resilience, and physical activity in older manual workers. The identification of profiles of older manual workers who are at risk of poor health and functioning may inform targeted interventions to help retain them in the workforce for longer.

Keywords: ageing workers; well-being; occupational activity; exercise; leisure-time activity; Latent Profile Analysis

Note: It is important to mention that the Latent Profile Analysis performed in this study was carried out by Dr Cecilie Thorgersen-Ntoumani. Apart from this analysis, the whole of the work in chapter 2 was carried out by myself Julie Black, the author of this thesis.

Presenteeism, stress resilience, and physical activity in older manual workers: A person-centred analysis

2.2. Introduction

The global workforce population is ageing and a reduction in birth rate means that the current median age of workforces is increasing (Billett et al., 2011). Research indicates that the ratio of active workers to pensioners in the UK is currently 1:1, however, as life expectancy increases, it is predicted that by 2032 this ratio will shift to 2:9 respectively (Crawford et al., 2010). This evidence suggests that there is likely to be a shortage of workers within the UK workforce if sufficient numbers of older workers (defined as workers aged 50 or above; (Department for Work and Pensions, 2011) are not retained. This could have a detrimental impact on the British labour economy.

Manual workers may be susceptible to early exit from the labour market because they tend to suffer more with musculoskeletal disorders and cardiovascular disease than non-manual workers (Allesoe et al., 2015). Not surprisingly, older manual workers also experience more age related problems, such as fatigue and muscle function decline, than their younger counterparts (Fragar and Depczynski, 2011, Koolhaas et al., 2012, Jones et al., 2013). Indeed, physically demanding jobs carried out over long periods of time contribute to health problems in this population (Peeters et al., 2008). Thus, older manual workers may be at particular risk of ill being, which may lead to individuals having to retire earlier than planned and/or reduced health and morbidity into older age. At a societal level, this could have implications for public health care expenditures.

2.2.1. Presenteeism in older workers

Presenteeism is a useful indicator of ill being at work. Presenteeism has been defined as attending work but performing sub-optimally due to poor health or ill-being (Brown et al., 2011). The construct is of key concern to employers as its costs outweigh those associated with absenteeism (Bierla et al., 2013). It has been reported that older workers are at particular risk of presenteeism with 21% of total lost productivity time arising from acute or chronic health conditions including pain (musculoskeletal, low back pain, arthritis; (Hallman et al., 2014), depressive symptoms (Stewart et al., 2003) and stress (Aronsson, 2000)Callen et al., 2013; Leinewber et al., 2011; Taloyan et al., 2012). However, levels of presenteeism vary among groups of older workers and this variation may depend on a range of individual, health and behavioural characteristics. While a range of factors may be important predictors of presenteeism in older workers (in particular a variety of health conditions; Schulz & Edington, 2007), research has tended to focus on the impact of negative conditions (e.g., allergies, arthritis; Schulz & Edington, 2007) rather than the role of positive health behaviours and characteristics. This is an important omission because it neglects to take into account the individual's capacity to cope with daily life challenges and to function despite the potential presence of health conditions. In the present study we focus on two important positive resources, stress resilience and physical activity (PA), because both of these are potentially modifiable via appropriate interventions.

2.2.1.2. Stress resilience

High stress has been identified as an important predictor of presenteeism (Cancelliere et al., 2011). As stress is ubiquitous in many jobs and its presence may be difficult to control, when exploring well-being, stress resilience is of particular interest. Stress resilience has been defined as the ability to 'bounce back' from stress (Smith et al., 2008), and high levels of stress resilience foster well-being at work (e.g., (Avey et al., 2010). It has been proposed that it might serve as a malleable personal resource (Smith et al., 2010). For example, mindfulness programmes appear to be a promising means by which to increase resilience in workers (Robertson, Cooper, Sarkar, & Curran, 2015). Other research has found that resilient individuals are less likely to be absent from work due to ill health (Kotze, 2012). Thus, by inference resilient employees should function better at work (i.e., exhibit low levels of presenteeism), although this possibility remains largely unexplored. However, one recent large-scale (*n*=8,015) cross-sectional study indicated that a concept of vitality, which included the dimension of resilience (in addition to energy and motivation) negatively predicts costs of presenteeism (van Steenbergen, van Dongen, Wendel-Vos, Hildebrandt, & Strijk, 2015). This preliminary evidence provides some support for further investigating associations between resilience and presenteeism.

It has been suggested that one way people can become more resilient to stress is by exercising or engaging in PA, and there is some support for this argument (Gerber and Puhse, 2009, Hegberg and Tone, 2015). Indeed, exercise can buffer the negative effects of stress on health and well-being (von Haaren, Ottenbcher, Muenz, Neumann, Boes, & Ebner-Priemer, 2016). These findings may be partly explained by the cross-stressor adaptation hypothesis, which suggests that regular exercise can lead to a reduction in physiological responses to psychological stress (Sothmann, 2006).

The research examining associations between resilience and PA has focused on the role of moderate-to-vigorous PA engaged in during leisure time. However, associations between resilience and *different* domains of PA remain unknown. A cross-sectional study, which adopted Latent Profile Analysis with a sample of 2,660 health care and insurance workers, found that groups of resilient workers tended to be more physically active than those exhibiting lower levels of resilience (Gerber et al., 2014). However, due to the measure of PA, which was used (a global measure of PA), it was not possible to show whether the links between activity and resilience may have varied depending on the domain of PA examined. Similar issues relate to the literature focusing on the associations between PA and presenteeism.

2.2.1.3. Physical activity and presenteeism

It is only fairly recently that research has begun to explore associations between PA and presenteeism (e.g., (Brown, 2011); Cancelliere et al., 2011; (Schultz and Edington, 2007). The premise is that employees who engage in PA are healthier and therefore less likely to be ill; hence they are less likely to be absent from work and less likely to underperform at work compared to their less active peers. Indeed, reviews of literature in this area suggest negative associations between PA and presenteeism (Cancelliere et al., 2011; Schultz, & Edington, 2007). Experimental research shows that PA can be increased in the workplace (Conn, Hafdahl, Cooper, Brown, and Lusk, 2009), and one randomized controlled trial with overweight male shiftworkers demonstrated the potential of a complex PA intervention in reducing presenteeism (Morgan, Collins, Plotnikoff, Cook, Berthon, Mitchell, and Callister, 2012).

PA is performed in a range of contexts and little is currently known about how different domains of PA (i.e., activity performed as part of work, during leisure-time and structured sport and exercise activities) may relate to presenteeism. The research conducted so far has not tended to use multi-domain measures of PA (e.g., (Brown et al., 2013, Edmunds et al., 2013). However, it is conceivable that different domains of PA relate with presenteeism in different ways. Indeed, some prospective evidence suggests that high levels of occupational activity increase the risk of health problems across different age groups (e.g., (Holtermann et al., 2012b, Krause et al., 2007). For example, Krause et al (2007) found that high levels of occupational activity increased the risk of atherosclerosis 11 years later, even when controlling for leisure-time PA and 20 other potential relevant confounders. This is relevant as health problems (such as atherosclerosis) are key risk factors of presenteeism (Goetzel et al., 2004). Thus, the nature of the associations between PA and presenteeism may be dependent on which domains of PA are examined. Thus, an important contribution of the present study is the assessment of several domains (work, leisure and sport/exercise) of PA.

2.2.1.4. The contribution of person-centred approaches

Studies examining the links between the constructs reviewed above have used between-subjects, variable-centred designs. Person-centred analyses, in which profiles of individuals are identified based on scores on variables that are relatively similar, are useful for two main reasons. First, they can enhance understanding of the complexity of the associations between variables of interest. Specifically, this type of analysis can help enhance understanding of how interactions (in particular between more than two variables at the same time) occur within-persons, and how these interactions relate to outcome variables. Second, they can reveal sub-groups at risk (e.g., of ill-being), who could be targeted in future interventions. In the present study, we employ a specific type of person-centred analysis, latent profile analysis (LPA), to examine the profiles of older workers based on presenteeism, stress resilience, and domain-specific PA. Compared to the more commonly used cluster analysis, LPA have a number of advantages (Marsh et al., 2009; Pastor et al., 2007). For example, although LPA, like cluster analyses is exploratory in its nature, LPA is a model-based technique that offers more flexibility in terms of model specification. LPA also provides several fit indices, giving researchers an important tool when comparing different models, ultimately resulting in a stronger platform for making less arbitrary and potentially biased choices in terms of determining the number of profiles. The present study will make a unique contribution to this extant research by examining how presenteeism characteristics cluster with individual resources (stress resilience and PA) that may protect older workers from poor health and ill being.

To help support the validity of profile solutions it is useful to compare the profiles on variables on which the profiles are likely to be conceptually distinguishable. In the present study, we examine differences between profiles in variables of relevance to work-related wellbeing, specifically affective well-being at work and self-rated health. Job-related affective well-being is a key constituent of work-related well-being (Warr, 1990) and predicts work performance (Wright and Cropanzano, 2000). It is also a work-related variable closely associated with PA (Thøgersen-Ntoumani et al., 2014, Thogersen-Ntoumani et al., 2015). Further, self-rated health has been associated in previous research with presenteeism, stress resilience and PA (e.g., (Froom et al., 2004) Smith, 2006; (Taloyan et al., 2012).

2.2.1.5. Aims and hypotheses

The aim of the study was to explore the existence of typologies of older manual workers based on presenteeism, stress resilience, and PA, and to examine differences between these profiles on other conceptually relevant indicators of health and well-being. It also aimed to explore whether any differences existed between the profiles in socio-demographic characteristics (age, gender, education and job role). If profiles differed on any of these, the measurement of these could provide an easy practical means of identifying profiles at risk of ill being.

The lack of previous studies using person-centred analyses to identify profiles based on the constructs of interest precludes specific hypotheses pertaining to the exact composition of profiles. However, previous research provided us with some likely possible predictions. First, given extant research reviewed previously on associations between PA and presenteeism (Cancelliere et al., 2011; Schultz and Edington, 2007) and resilience and presenteeism (van Steenbergen et al., 2015), it was is tentatively hypothesized that one group would exhibit relatively high levels of (non-occupational) PA, low levels of presenteeism and high levels of stress resilience. The other profile of individuals is expected to exhibit the opposite pattern of characteristics. Further, for individuals with low levels of stress resilience, high levels of non-occupational PA may compensate for negative effects of stress. Therefore, a profile depicting low-moderate levels of presenteeism, high levels of non-occupational (i.e., sport/exercise and/or leisure-time) PA and low stress resilience was also hypothesised (H1). Second, it was hypothesized that the profiles would differ on perceived health and work-related affect. Specifically, it was expected that profiles characterised by high levels of presenteeism accompanied by low levels of stress resilience and/or non-occupational PA would report the lowest scores on perceived health and positive work-related affect, plus higher scores on negative work affect (H2). No hypotheses were proposed with regards to differences on socio-demographic characteristics.

2.3. Methods

2.3.1. Participants

Participants *n*= 216 (69.1% male) with a mean age of 57.1 years (*SD* = 5.62 years) were recruited from various types of organisations, including supermarkets, postal service, police force, and fire and rescue services. Most participants were married (69.9%), non-smokers (83.6%), with 38.4% having left school at 16 years old. Most participants worked in manual occupations including healthcare, fire service, engineering and manufacturing (66.7%), followed by craft/labour (12.2%) and construction (8.5%). Additionally, 46.3% of participants reported back/neck/shoulder pain. Eligibility criteria included skilled and unskilled manual workers (i.e., individuals *not* engaged mainly in office work and working with PCs, thus, this also included professionals such as teachers whose workday often includes long periods of standing, bending in awkward positions and teaching physical education activities) aged ≥50 years who were in paid employment for at least three months at commencement of the study, and those who were able to write and understand English and provide informed consent. Exclusion criteria included those in non-paid voluntary work, those in paid employment for less than three months, individuals aged < 50 years or whose occupation was not manual, as defined by OPCS Registrar General's Classification of Occupation (Szreter, 1984).

2.3.2. Procedure

The ethics review committee of [the identity of the University has been removed for blinding purposes] granted ethical approval of the study. Participants within companies deemed to employ manual workers were initially approached via e-mail (or otherwise as decided by the company representative), then followed up via telephone calls. An information sheet detailing the nature of the study and an online link via Survey Monkey or paper copy (depending on preference) of the questionnaire was provided. Additional study information was obtained via the online link and by hard copies when requested. Participants were required to complete written informed consent online to access the survey (i.e., a series of tick boxes). Participants who wished to complete the survey via hard copy were sent paper copies of the information sheet, consent forms and the questionnaire. A researcher either collected completed surveys and consent forms in person or provided self-addressed envelopes for postal return by the participants.

2.3.3. Design and Measures

The present study used a cross-sectional survey design. A range of measures was used to assess the variables of interest.

Demographics. Demographic information was extracted via the survey using items to assess age (date of birth), gender, education level (age at which participants left school), and job role.

Physical Activity. The Baecke Questionnaire (Baecke et al., 1982) was used to measure habitual levels of PA. The Baecke Questionnaire measures PA across three contexts: sport/exercise, occupational (referred to as work), and leisure-time PA in the past month, and provides total and domain-specific unit less scores. The questionnaire includes a rating of amount (hours per week, months per year) and type (swimming, jogging etc) of activity that individuals typically engage in. Example items include "do you play sport or exercise" yes/no; if yes, "how many hours a week", "how many months a year?" (sport/exercise), "at work I walk" (work), and "how many minutes do you walk and/or cycle per day to and from work, school and shopping" (leisure-time PA) with categories provided. The Baecke questionnaire has been tested in a group of workers over 1 month with a test- retest reliability of .71 (Philippaerts and Lefevre, 1998). Congruent validity and concurrent validity have been supported across three professions (Philippaerts et al., 1999). More recently, Hertogh et al. (2008) reported in a validation study that the scale can correctly classify low and high activity, but is less accurate in identifying moderate activity. The internal consistency for the full scale in the present study was α = .70 (sport/exercise: α = .76; work: α = .81, leisure-time PA: α = .56)

Presenteeism. As in previous studies, the 25-item Work Limitations Questionnaire (WLQ) (Lerner et al., 2001) was used to represent presenteeism over the past 30 days (e.g., Brown et al., 2013; (Gates et al., 2008). The scale measures the degree to which illness or poor health impairs an employee's ability to work productively (Lerner et al., 2001; Cancelliere et al., 2011). For example, it measures the amount of difficulty experienced in performing job demands involving mental and interpersonal demands such as concentrating or communicating with others, and physical elements such as lifting and carrying loads. Given that presenteeism refers to being at work but performing below par due to health conditions or illness (Cooper & Dewe, or 2008) and reduces the individual's ability to work productively (Hemp, 2004), the WLQ is conceptually a suitable measure of presenteeism. Moreover, the WLQ has been identified in a review as being one of the most appropriate indicators of presenteeism when examining the associations between PA and presenteeism (Brown et al., 2014). The scale includes four subscales related to demands placed on the worker. Participants are asked how much time they are able to do a range of activities at work with response options ranging from 1 (*none of the time*) to 5 (*all of the time*). These include items measuring time demands (e.g., "stick to routine or schedule"), physical demands (e.g., "lift, carry, move objects"), mental demands (e.g., "concentrate on work"), interpersonal demands ("help others to work"), , and output demands (e.g. "work without mistakes"). These subscales were used in the analysis. Evidence for the adequate validity and reliability of the WLQ has been reported (Lerner et al., 2001). In the present study, the full scale had an internal consistency of α = .90 (time demands: α = .62; physical demands: .87; mental demands: α = .73; interpersonal demands: α = .57; output demands: α = .78).

Stress Resilience. The tendency to recover from stress was measured using the Brief Resilience Scale (Smith et al., 2008). This is a one-dimensional self-report questionnaire containing six items e.g. "I tend to bounce back after hard times" with a possible response of 1 (*strongly disagree*) to 5 (*strongly agree*). Odd items were positively worded and even items were negatively worded. Scores were calculated by reverse coding the negative statements then adding them to the positive statements. A mean of the 6 items is taken to represent level of stress resilience with higher scores indicating greater levels of stress resilience. The questionnaire has previously demonstrated high internal consistency of α = .80 - .91 (Smith et al., 2008). In the present study, the internal consistency was also high (α = .86).

Job Related Well-being. The shortened version of the Job-Related Affective Well-Being Scale (Van Katwyk et al., 2000) was used to assess emotional reactions to the individual's job in the past 30 days. This is a two-dimensional scale, which has an arousal and a valence (pleasure) dimension. In this study, 20 of the original 30 items were used. Twenty items were split into four dimensions: high pleasure/low arousal (HPLA; akin to contentment; an example item is “My job made me feel relaxed”), high pleasure/high arousal (HPHA; akin to feelings of energy; e.g. “My job made me feel inspired”), low pleasure/low arousal (LPLA; akin to depression; e.g., “My job made me feel depressed”) and low pleasure/high arousal (LPHA; akin to stress or anxiety; e.g., “My job made me feel anxious”). Items were selected according to their relevance to the study whilst ensuring that all dimensions were represented equally. The four dimensions were used as indicators in the analysis. Respondents were required to indicate how often they had experienced each emotion in the last 30 days. Responses were rated using a 5 point scale (*1 = never; 5 = always*) with high values representing high levels of that affective state. The scale has been shown to be internally consistent with a Cronbach’s alpha of .95 (Van Katwyk et al., 2000). The scale was internally consistent when examined in the present study (α= .89). The sub-scales also demonstrated satisfactory levels of internal reliability (HPLA: α = .83; HPHA: α = .89; LPLA: α = .76; LPHA: α = .79).

Self-rated health. Self-rated health was assessed using a single item asking participants to rate their overall health in the past 12 months. Response options ranged from 1 (*excellent*) to 5 (*poor*), and the item was reverse scored before it was entered into the analysis so that higher scores indicated better health.

2.3.4. Data Analysis

First, descriptive analysis was conducted and bivariate correlations were computed using IBM SPSS version 22. Latent Profile Analysis (LPA) using MPlus (version 7.1; Muthén and Muthén, 2012) was used as the main analysis in the study. Stress resilience, leisure-time PA, work PA, sport/exercise participation and the four presenteeism sub-scales were used as input variables. Models with 2-5 profiles were tested to determine the most suitable solution. Various criteria were inspected to determine the most suitable solution. The Bayesian Information Criterion (BIC; (Nyland, 2007), and the sample-size adjusted BIC (SSABIC; Yang, 2006) were used, whereby lower values indicate better model fit. The Lo-Mendell-Rubin likelihood test (LMR; (Lo, 2001) and the Bootstrapped Likelihood Ratio Test (BLRT; (Arminger, 1999) were inspected to compare the fit of two competing models; the target solution compared to a solution with one less profile. Statistically significant LMR and BLRT values indicate that the profile solution in question fits better than a profile solution including one less profile. The precision of assigning latent class membership is interpreted using the entropy index (Aldridge and Roesch, 2008). Here, higher probability values indicate greater precision of classification. Maximum likelihood estimation was used to identify model parameters. As recommended by Geiser (2013), for relatively complex latent models, 500 sets of start values were requested in the first step of the optimization, then re-checked using 1000 sets. Further, iterations were also increased from 10 (default setting on MPlus) to 50 in the first step of the optimisation (Uebersax, 1999). To validate the selected profile solutions, one-Way MANOVA and ANOVA tests were conducted in IBM SPSS v22 to examine differences between the profiles in the auxiliary variables

2.4. Results

2.4.1. Descriptive statistics, reliability analyses, and bivariate correlations

Descriptive statistics for older manual workers in this study are shown in Table 2.1. The sample as a whole reported to engage in average levels of PA in each index

(Baecke et al., 1982), moderate to high levels of presenteeism, and moderate levels of stress resilience. Most participants reported relatively high levels of LPHA (e.g. anxious, angry) ($M = 4.0$, $SD = 0.8$) and low levels of HPHA (e.g. energetic, inspired). Health perceptions were generally high ($M = 3.5$, $SD = 1.0$). No differences existed between males and females. Small significant negative correlations between stress resilience and each of the dimensions of presenteeism were evident. Fewer significant associations existed between PA and the presenteeism dimensions existed. Specifically, only the physical demands dimension was significantly and positively correlated with work PA and leisure-time PA.

All variables (range)	*M (SD)*	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Age	57.07 (6.63)	-.03	.07	.12	-.24**	.03	.13	.01	.02	-.11	-.09	-.02	.10	.05	-.02
2. Resilience (1-5)	3.76 (.70)		.10	-.21**	-.27**	-.20**	-.16*	-.10	.09	.06	.24**	.21**	.22**	.31**	.21**
3. Physical demands (1-5)	2.00 (.78)			.45**	.48**	.25**	.50**	.39**	.17*	-.03	-.15*	.03	.03	.09	.07
4. Time demands (1-5)	2.49 (.44)				.48**	.25**	.48**	-.10	.06	.08	-.15*	-.22**	-.23**	-.16*	-.17*
5. Mental demands (1-5)	2.16 (.53)					.37**	.61**	-.16*	-.04	.04	-.04	-.17*	-.31**	-.27**	-.06
6. Interpersonal demands (1-5)	3.27 (.66)						.41**	.02	-.08	-.06	-.21**	-.22**	-.23**	-.22**	-.17*
7. Output demands (1-5)	2.32 (.49)							-.04	-.07	.08	-.03	-.18**	-.25**	-.17*	-.11
8. Work index (1-5)	2.94 (.60)								.16*	.05	.004	-.05	-.03	-.19**	-.03
9. Leisure index (1-5)	2.72 (.75)									.34**	.25**	.29**	-.05	.02	.12

10. Sport index	2.73 (.77)	.12	.10	-.10	-.12	.24**
11. HPHA (1-5)	2.83 (1.01)		.80**	.05	.24**	.15*
12. HPLA (1-5)	3.24 (1.02)			.32**	.42**	.16*
13. LPHA (1-5)	4.00 (.75)				.66**	.16*
14. LPLA (1-5)	3.71 (.70)					.13
15. Health (1-5)	3.48 (1.00)					

Table 2.1. Means, Standard Deviations and Bivariate Correlation Among All Variables.

2.4.1.2. Extraction of Latent Classes

We examined the fit of models extracting between two and five classes. The fit indices for each different model tested are included in Table 2.2. The BIC was lowest in the four-profile solution, although the SSABIC was lowest for the five-profile solution. The BLRT suggested that each subsequent model fitted data better than a model with one less profile. The Adjusted Lo-Mendell-Rubin Likelihood ratio test (LMR) showed that a three and four-profile solution fitted better than one with one less profile. However, the five-profile model did not fit better than the four-profile model. Further, the entropy indices increased from two to four profiles but then stabilised as the five-profile solution was added. Thus, from a statistical standpoint, the four-profile solution represented the most suitable solution. However, to decide the optimal number of classes, we also examined the interpretability of each class solution. Inspecting the pattern of responses across the profiles, the results indicated that the four-profile model constituted the most substantive and parsimonious solution.

2.4.1.3. Interpretation of the best fitting four-profile solution

A description of the four different profiles is presented in Table 2.3 and it is graphically depicted in Figure 2.1 (using standardised z scores to ease interpretation). Profile one (*n*= 12; 5.5%) is characterized by low levels of stress resilience, average levels of leisure-time and work-related PA, but high levels of sport and exercise participation. Further, individuals in this profile display low levels of presenteeism. This profile is labelled 'High sport/exercise well-functioning'. Profile two (*n*=21; 9.7%) exhibit average levels of stress resilience, high levels of leisure-time and work PA, yet average levels of sport/exercise participation. In terms of presenteeism, this profile scores relatively high on time and physical demands, very low on interpersonal

Table 2.2.

Fit Indices, Entropy, and Model Comparisons for Estimated Latent Profile Analyses Models

Model	LL	BIC	SSABIC	Entr	LMR	BLRT
2 profile	-1742.99	3419.67	3330.94	.80	149.72**	-1767.68**
3 profile	-1691.03	3403.78	3283.36	.83	101.99*	-1634.51**
4 profile	-1648.55	**3402.05**	**3249.95**	**.85**	83.37*	**-1599.67** **
5 profile	-1626.20	3404.92	3221.12	.85	43.86	-1571.91**

The selected solution is indicated in bold font

LL = Log-likelihood; BIC = Bayesian Information Criterion; SSABIC = Sample Size Adjusted Bayesian Information Criterion; LMR = p-value for Adjusted Lo-Mendell-Rubin likelihood ratio test; BLRT = bootstrap likelihood ratio test.

*p<.05

**p<.01

demands and display average levels of mental and output demands. This profile is therefore labelled *'Physically burdened'*. The third profile (n=101; 46.50%) display moderate scores on most variables, although has relatively low levels of stress resilience and presenteeism due to physical demands. These individuals have moderate levels of presenteeism due to other demands. We called this profile '*Moderately active and functioning'*. The fourth and final profile (n=83; 38.20%) is characterized by moderate levels of stress resilience, and moderate levels of leisure-time, work and sport/exercise behaviour. However, in contrast to profile three, this profile displays relatively high levels of presenteeism across the board. This profile was called *'Moderately active, high presenteeism'*.

Table 2.3

M (SE) of the Four Latent Profiles (Raw Scores)

Variables	High sport/exercise well-functioning	Physically burdened	Moderately active and functioning	Moderately active with high presenteeism
Resilience	3.18 (.21)	3.45 (.31)	3.72 (.08)	3.97 (.09)
Leisure-time PA	2.41 (.21)	3.09 (.21)	2.63 (.09)	2.79 (.09)
Work PA	2.68 (.13)	3.56 (.19)	2.74 (.14)	3.06 (.10)
Sport/Exercise	3.19 (.31)	2.73 (.24)	2.63 (.09)	2.80 (.09)
Time demands	1.82 (.26)	2.75 (.15)	2.33 (.05)	2.71 (.06)
Physical demands	1.02 (.14)	2.54 (.26)	1.43 (.14)	2.65 (.09)
Mental demands	1.45 (.17)	2.18 (.21)	1.91 (.08)	2.53 (.09)
Interpersonal demands	2.61 (.16)	2.30 (.12)	3.12 (.10)	3.79 (.05)
Output demands	1.25 (.16)	2.33 (.16)	2.17 (.07)	2.64 (.07)

PA=Physical Activity

*Values with different subscripts in the same row differ significantly at p < .05.

2.4.1.4. Differences in well-being across latent profiles

The four profiles were compared on the four categories of work affect (HPHA, HPLA, LPHA, and LPLA). In conducting the MANOVA, the four classes (dummy coded 1-4) served as the independent variable, with the four dimensions of work affect serving as the dependent variables. The MANOVA was significant: Pillai's Trace = .123; F(12, 615) = 2.20; p = .01; partial η^2= .04. Between-subjects analysis showed that the profiles differed on HPLA (F(3, 206) = 2.67; p = .049), LPHA (F(3, 206)= 4.94; p = .002), and LPLA(F(3, 206) = 3.51; p = .016). Post-hoc tests reveal non-significant differences between the profiles on HPLA, although the highest scores were found for 'High sport/exercise well-functioning'. With regard to LPHA, post-hoc tests revealed that the 'High sport/exercise well-functioning' individuals had significantly lower scores on this variable than individuals in the other two clusters. A similar pattern was evident for LPLA, with lower scores for High sport/exercise well-functioning compared to the 'Moderately active and functioning' and moderately active with high presenteeism' profiles.

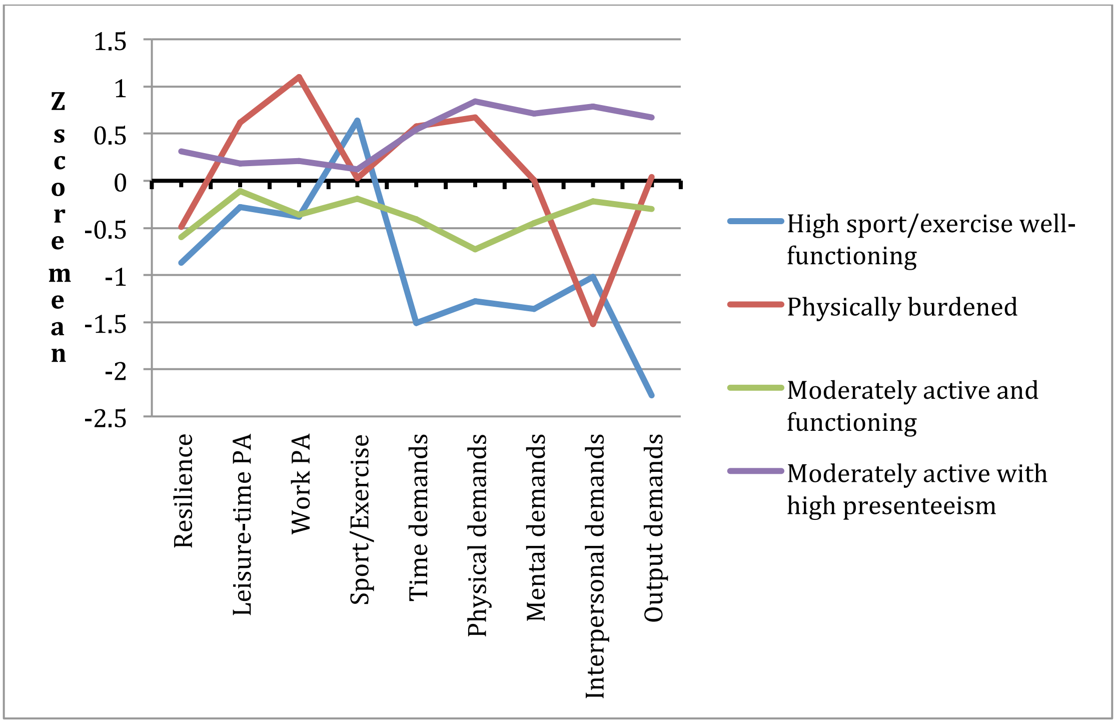

Figure 2.1. Presenteeism, Stress Resilience and Physical Activity Profiles in Best Fitting Model (4 Profiles; All Scores are Standardized).

An additional one-way ANOVA analysis was conducted to compare differences between the classes in health perceptions. Again, dummy coding representing the classes (1-4) was used as the independent variable. This analysis revealed significant differences in health perceptions: $F(3, 213) = 5.51$; $p = .001$; $\eta^2 = .07$. The post-hoc tests revealed that individuals in the 'Moderately active with high presenteeism' clusters reported significantly lower scores on health perceptions than participants in the other profiles. The means and standard errors for the analyses are presented in Table 2.4.

2.4.1.5. *Comparing classes on socio-demographic characteristics*

Pearson chi-square tests showed no differences in gender distribution between the classes ($\chi^2(3) = 2.46$; $p = .48$), level of education ($\chi^2(21) = 12.82$; $p = .92$), or type of occupation ($\chi^2(24) = 32.72$; $p = .11$). One-way ANOVA analyses further revealed no differences between the classes in age of leaving school ($F(3, 207) = .81$; $p = .49$; $\eta^2 = .01$), and no differences in age distribution ($F(3, 201) = .74$; $p = .53$; $\eta^2 = .01$).

Table 2.4.

Differences Between Latent Profiles in Well-Being

Variables	High sport/exercise well-functioning	Physically burdened	Moderately active and functioning	Moderately active with high presenteeism
	M (SE)	*M (SE)*	*M (SE)*	*M (SE)*
HPHA (1-5)	2.98 (.27)$_a$	2.54 (.19)$_a$	2.93 (.09)$_a$	2.99 (.10)$_a$
HPLA (1-5)	2.98 (.25)$_a$	3.07 (.18)$_a$	3.29 (.09)$_a$	3.51 (.09)$_a$
LPHA (1-5)	3.32(.22)$_a$	3.95 (.16)$_{ab}$	3.94 (.08)$_b$	4.17 (.08)$_b$
LPLA (1-5)	3.16 (.21)$_a$	3.49 (.15)$_{ab}$	3.73 (.07)$_b$	3.79 (.08)$_b$
Health Perceptions (1-5)	2.67 (.28)$_{ab}$	3.00 (.21)$_a$	2.66 (.10)$_a$	2.21 (.11)$_b$

HPHA=High Pleasure/High Arousal; HPLA=High Pleasure/Low Arousal;

LPHA=Low Pleasure/High Arousal; LPLA=Low Pleasure/Low Arousal

*Values with different subscripts in the same row differ significantly at $p < .05$.

2.5. Discussion

The aim of the present study was to explore latent profiles of presenteeism, stress resilience and different domains of PA in a diverse group of older manual workers aged >50 years. Four distinct profiles were identified, suggesting that it is possible to identify distinct typologies on these characteristics in older manual workers. Moreover, the profiles differed on aspects of self-rated health and well-being.

The nature of the profiles highlighted the heterogeneity in levels on the constructs across groups. In other words, as expected, the combinations of variables differ by group. The results partially confirm the hypotheses. As expected, those engaging in high levels of structured PA (i.e., the 'High sport/exercise well-functioning' cluster) reported low levels of presenteeism, and levels of stress resilience were rather low. This result aligns with previous research, using variable-driven approaches, showing that engagement in high levels of sport or exercise is associated with lower levels of presenteeism (Cancelliere et al., 2011; Schultz & Edington, 2007).

In contrast to the rather expected results for the 'High sport/exercise well-functioning' profile, the composition of other profiles was more surprising. In particular, the results also revealed that other older workers who were relatively physically active overall experienced relatively high levels of presenteeism (i.e., the 'Moderately active with high presenteeism' cluster). This cluster can be considered the group most at risk of poor health and well-being, as participants in this profile also displayed significantly greater levels of LPHA (akin to stress or anxiety) and LPLA (akin to depression), and rated their health as poorer, compared to participants in some of the other clusters. The finding pertaining to this profile illustrates the complex associations between PA and presenteeism. It reiterates our point made earlier that it may be critical to examine multiple domains of PA and presenteeism to clarify associations between these variables. Although we cannot infer causality from this study, it is possible that engagement in structured and planned PA that is of a relatively high intensity (i.e., sport and exercise) is needed to reduce presenteeism. In other words, engaging in other types of PA that is of lower intensity may not be sufficiently effective. This possibility, as well as dose-response issues, should be examined in future experimental research. In future, researchers should also examine for whom and under which circumstances PA is effective as a buffer against stress.

Prior research suggests that high levels of occupational activity are associated with increased risks of health problems controlling for leisure-time PA (Krause et al., 2007). However, of note, participants in the ‘Physically burdened’ group who reported both very high levels of occupational and leisure-time activity reported better health than those in the ‘Moderately active with high presenteeism’ group. Participants in the ‘Physically burdened’ profile may be those of particularly good health who are able to deal (physically and/or psychologically) with the physical demands of work. It is possible that for these individuals, physical activity acts as buffer against stress (Gerber et al., 2014, Gerber, Lindwall, Lindegård, Börjesson and Jonsdottir, 2013). Further, given the age group we sampled, perhaps individuals with poorer health profiles would be more likely to have retired early due to ill health and were therefore not included in the study. In other words, a selection effect may partly account for these results. Indeed, ill-health combined with heavy physical workload in workers aged >50 years, is a prime reason for early/involuntary retirement (Dhaval, 2008, van den Berg et al., 2010).

Interestingly, stress resilience did not discriminate well between the profiles, although the ‘high sport/exercise well-functioning’ group had relatively low scores on this variable. This could be interpreted in different ways. First, it could be interpreted as support for the buffering role of physical activity. Alternatively, it could mean that in our sample of older manual workers, stress resilience did not serve as a particularly meaningful resource in the protection against presenteeism. Indeed, the participants reporting the highest level of resilience (although still moderate) were those in the ‘Moderately active with high presenteeism’ profile. However, this finding could be partly due to the scale we used to measure stress resilience. Indeed, while the Brief Resilience Scale assesses a disposition to bounce back from stress, Bonanno et al. (2015) suggest that resilience likely fluctuates over time and this may account for stronger effects. Given the research design, we were unable to assess changes in stress resilience over time. Further, due to the cross-sectional research design, we cannot infer causality; thus, it is possible that people who perceive themselves to be less resilient engage in structured sport and exercise as a means of building such resilience or to compensate for relatively low levels of resilience. It is important to examine in future research whether PA is a determinant or outcome of stress resilience in longitudinal designs

2.5.1. Practical Implications

We examined whether demographic variables could discriminate between the classes, as this would allow for a seemingly obvious and easy way to identify individuals at risk. However, the profiles did not differ on any of the socio-demographic characteristics we examined. This result suggests that simple socio-demographic profiling will not be a useful way of identifying workers ‘at risk’ of poor health and well-being; more sophisticated assessments of health and well-being will likely be needed, i.e., those that were used in the present study.

While it is difficult to stipulate at this stage which interventions will be effective for which groups, the results of our study suggest that for some individuals (“high sport/exercise well functioning”), focusing interventions on maintaining high levels of PA engagement (in particular sport and exercise activities) may be a promising way of improving or retaining levels of wellbeing and functioning at work. For these individuals, employers could provide facilities for such activities on-site (which may not be possible for all companies) and access to showers for example, but could also implement flexible working time, and development of a workplace health climate in which such activities are valued and actively encouraged. Additionally, extensive research suggests that to maintain such high levels of engagement, an autonomy supportive environment (in which individuals' feelings of autonomy, competence and relatedness are supported) should be provided which fosters high quality of motivation (Ng, et al., 2012).

However, for other groups of older workers, the solution may be more complex and require more multi-faceted interventions targeting several different components, with some components tackling directly work-specific issues. Research suggests that important work-related factors needing consideration include workload, fairness, rewards, and work control (Aronsson and Gustafsson, 2005; Pohling, Buruck, Jungbauer, and Leiter, 2016). Future studies should attempt to develop and test profile specific interventions to allow for an assessment of which interventions may be most suitable for each of the individual profiles.

2.5.2. Limitations and Strengths

It is important to note the limitations of the study. As already alluded to, due to the cross-sectional nature of our study, causal inferences should be avoided. Further, the stability of the profiles is unknown. It would be interesting in future research to examine predictors of profile stability over time adopting Latent Transition Analysis, in particular across important periods of life-events and transitions, such as the retirement transition (see Henning, Lindwall and Johansson, 2016) Using self–report rather than objective measures of PA is another limitation of this study due to the tendency for individuals to overestimate their PA levels using self-report measures (e.g., (van Sluijs, 2007). The unit less scores derived from the PA questionnaire used in this study also precludes the identification of the level of PA that participants in each cluster engaged in. Objective measures of PA (i.e., using accelerometry) could be employed to form profiles in the future.

Notwithstanding these limitations, our study had a number of strengths. First, the use of Latent Profile Analysis to identify typologies provided a complementary view of the interactional patterns of associations within different types of individuals. More specifically, the use of person-centred analysis may afford a different perspective on how the three constructs of presenteeism, PA and resilience simultaneously interact within-persons to create unique patterns that impact other relevant outcomes linked to work and health. More traditional variable-oriented analyses are less able to capture such complex simultaneous interplay (Bergman and Andersson, 2010).

It also enabled the identification of older manual workers at risk of poor health and ill-being. Second, PA was differentiated into work, leisure and sport/exercise domains, and presenteeism was assessed using multi-dimensional measure capturing four distinct components. This enabled a more detailed understanding of associations between the variables. Finally, the study provided insight into heterogeneity in health and well-being characteristics among a group of individuals usually underserved in this type of research (i.e., older manual workers).

2.5.3. Conclusion

The findings from the present study add unique insight to previous literature by using a person-centred perspective to enhance understanding of health and well-being profiles of older (aged >50) manual workers. The findings suggest that the associations between presenteeism, stress resilience and PA in this group are more complex than typically depicted in the literature. The results may be useful to enhance understanding of older manual workers who may be at greatest risk of involuntary retirement and ill health into old age. Given the dramatic changes in the distribution of active workers to pensioners, it is critical to understand more about factors that help retain older workers in the workforce.

Conflict of interest: The authors declare that they have no conflict of interest.

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CHAPTER THREE

3.0. RESILIENCE, WORK ENGAGEMENT AND STRESS REACTIVITY IN A MIDDLE-AGED MANUAL WORKER POPULATION.

Resilience, Work Engagement and Stress Reactivity in a Middle-Aged Manual Worker Population.

The first study of this thesis sought to understand the health and wellbeing characteristics of older workers and identify those at risk of ill health. It was explorative in nature and served to inform the direction for study in the rest of the thesis.

In the first instance, the role of stress resilience in the health and wellbeing of older manual workers was unclear. Since older workers are believed to have heterogeneous needs (individual needs), it may be that within a larger group of participants such as the previous study (chapter two) the role of resilience may not have been fully demonstrated (Bal & Jansen, 2015). Thus, given that stress is associated with sickness presenteesim and numerous negative health outcomes relating to cardiovascular disease, the second study of this thesis, explored the relationship between the physiological response to acute psychological stress and perceived psychological resilience to stress and work-related variables (work engagement and sickness presenteeism).

Abstract

Work stress is a growing problem in Europe. Together, the negative physiological effect of stress on health, and increasing age increases the risk of developing cardiovascular disease in those aged over 50 years. Therefore, identifying older workers who may be at risk of work-related stress, and its physiological effects, is key to promoting their health and wellbeing in the workforce. The present study examined the relationship between perceived psychological resilience and work-related factors (work engagement and presenteeism) and the physiological response to acute psychological stress in older manual workers in the UK. Thirty-one participants, mean (SD) age 54.9 (3.78) years reported perceived levels of resilience, work engagement, and presenteeism using standardized questionnaires. Cardiovascular measurements (heart rate (HR) and blood pressure (BP) and salivary cortisol were used to assess their physiological response to an acute psychological stress task. Resilience was not associated with work-related factors or reactivity. However, workers with higher work engagement showed lower SBP (p = .02) and HR (p = .001) reactivity than those with lower work engagement. Further, those with higher sickness presenteeism also had higher HR reactivity (p = .03). This suggests a potential pathway by which higher work stress might contribute to the risk of future cardiovascular disease.

Keywords: cortisol; cardiovascular reactivity; older workers; resilience.

3.1. Introduction

Recently, perceived psychological stress has become a major occupational problem (Tripodi et al. 2012) and continues to be a growing issue in Europe (European Agency for Safety and Health at Work 2012). In 2014/2015, the Health and Safety Executive (2015) reported that work related stress in the UK accounted for 35% of all health-related work illness and 43% of work absence. Of particular concern are older workers occupying lower status jobs such as nursing, healthcare, industry and education (Fragar and Depczynski 2011; Jones et al. 2013; Koolhaas et al. 2012). This is because frequent, maladaptive response to work stress, is harmful to physical health and from the age of 50 years, the cardiovascular system undergoes significant changes which heighten the risk of cardiovascular disease (Lupien et al. 2009; McEniery et al. 2007).

Due to work-related sickness absence and the increasing problem of sickness presenteeism (attending work whilst not fully well), promoting the health and wellbeing of employees, is of growing interest, especially those who are termed ‘older workers’ (50+ years) (Department for Work and Pensions 2011), and particularly in manual occupations (Crawford et al. 2010). Manual workers aged over 50 years experience increasing levels of stress in occupations such as construction (Arndt et al. 2005; Dong et al. 2012). Further, there is evidence to suggest that work-related stress is related to low levels of work engagement and presenteeism in workers aged $\geq$ 50 years (Callen et al. 2013; Fiabane et al. 2013; Jones et al. 2013; Leineweber et al. 2011). However, to our knowledge, there are no studies examining such work-related factors in relation to stress reactivity. Consequently, the present study will examine this.

Research into psychological stress and wellbeing has suggested that future health and wellbeing can depend on the extent of one's physiological responses to stressful situations (Obrist, 1981). Physiological reactivity to acute psychological stress is related to an increased risk of cardiovascular disease (Obrist, 1981) and predicts conditions such as hypertension (Carroll et al. 2012b; Carroll et al. 2011; Carroll et al. 2001) carotid arteriosclerosis (Everson et al. 1997) and even cardiovascular disease mortality (Carroll et al. 2012a). Additionally, elevated cortisol (a stress hormone) secretion in response to acute mental stress is associated with the development of hypertension (Hamer and Steptoe 2012). However, negative health outcomes including depression, obesity and addiction are also related to blunted reactivity (Heaney et al. 2011; Phillips 2011). Thus, how older manual workers respond physiologically to psychological stress is key to understanding the potential risk of damage that may later affect health and wellbeing across working life and into retirement.

Recent research has begun to explore whether perceived high levels of psychological resilience might buffer against the effects of stress (de Paula Couto et al. 2011; Galatzer-Levy et al. 2014). In adults over 55 years old, high resilience was associated with good physical and mental health (Schure et al. 2013); those with low resilience had high levels of depression. Further, adults with a mean age 68 years with high levels of resilience had more positive wellbeing (de Paula Couto et al. 2011). In younger adults, policemen aged 27-32 years who were resilient displayed a significant cortisol increase (healthy) in response to acute psychological stress, while those less resilient showed a blunted (unhealthy) response (Galatzer-Levy et al. 2014). Recently, a review of 29 studies evidenced the relationship between work-related stress and elevated BP, and suggested a stronger association of increased BP and job strain in those aged 50 years and over (Landsbergis 2013). Additional evidence suggests that those who experience high job strain (high demand, low control) are at risk of sustained cardiovascular dysfunction over time (Clays et al. 2007; Steptoe 2001; Steptoe 2004). There has been scant research into stress reactivity and the association with job-related factors in older workers. Of the available studies, one found that men aged 55-65 years with high job strain had pronounced cardiovascular responses to mental stress (Steptoe et al. 1993). A further study found cardiovascular reactivity was positively associated with job strain in a group of workers with a mean age 51.9 years, and was higher among those over 50 (Clays et al., 2007). Equally, work-related stress has also been associated with higher cortisol reactivity (Hausser et al. 2011; Karhula et al. 2016; Steptoe et al. 2000). However, current evidence suggests that the relationship between work and stress reactivity is complex (Rudolph et al. 2016) and the majority of studies have not measured or found consistent results for both cardiovascular and cortisol responses to acute stress, or have not measured resilience. Therefore, further research is needed to understand how resilience and work-related factors may relate to the stress response within older workers.

There is evidence to suggest that social support plays a role in promoting resilience to psychological stress; those who are married or cohabiting have been shown to have higher levels of resilience than those who live alone (Guinn et al. 2009). Additionally, in occupations such as the police force where there are high levels of psychological stress, employees with greater levels of support from colleagues have higher resilience (de Terte et al. 2014). Although social support can reduce reactivity to stress ((Phillips et al., 2006), the impact of marital status on the response to stress is unclear (Zhao et al., 2003), and will be examined in the present study.

It is clear from the above evidence that the research into the relationships between resilience and work-related factors and physiological responses to acute psychological stress in this age group is limited. Further, those aged 45-54 years old have been found to be less resilient than those younger or older (Bonanno et al. 2007). Given that high levels of psychological stress and extremes of reactivity to acute psychological stress are a risk factor for cardiovascular pathology, and that after age 50 years, the risk of physiological health problems such as hypertension increases (McEniery et al. 2007), it is worthwhile attempting to understand the relationships between these factors among older workers if they are to remain healthy and employed for longer. Consequently, the objectives of this study were to identify the relationship between the physiological response to acute psychological stress and perceived psychological resilience to stress and work-related variables in older manual workers aged 50+ years. It was hypothesised that those who exhibited maladaptive (exaggerated or blunted) response to acute psychological stress would have low levels of perceived stress resilience, and display lower levels of positive work-related factors such as work engagement.

3.2. Methods

3.2.1. *Participants and Design*

Participants were 200 manual workers aged 50+ years (mean = 57.1, standard deviation (SD) = 5.62 years) who were recruited in 2015 via posters displayed in 20 organisations and industries including the welfare sector i.e. health professionals, education (teachers), service (fire and rescue and police officers) from around the UK. Other industries included retail, construction and farming. A purposive sample of thirty-one participants willing to undertake further testing were invited to complete a questionnaire to measure perceived levels of resilience and work-related factors, and to attend a testing session to measure cardiovascular and cortisol reactions to an acute psychological stress task. Previous correlational reactivity studies have revealed significant associations with similar sample sizes, e.g., (Almela et al., 2011, Domes, 2002, Hogan et al., 2012), so we attempted to recruit a similar number. Participants were given gift vouchers for completing the stress testing session. Written informed consent was given and the University of Birmingham ethics committee approved the study.

3.2.2. Measures

3.2.2.1 *Stress Resilience Questionnaire*

The ability to recover from stress was measured using the Brief Resilience Scale (Smith et al. 2008). This is a one-dimensional self-report questionnaire containing six items e.g. “I tend to bounce back after hard times” with a possible response of 1 (strongly disagree) to 5 (strongly agree). A mean of the 6 items is taken to represent level of resilience. The questionnaire has previously demonstrated high internal consistency of α = .80 - .91 (Smith et al., 2008) and .78 in the present study.

3.2.2.2. *Sickness Presenteeism Questionnaire*

The Work Limitations Questionnaire (WLQ) (Lerner et al., 2001) was used to assess sickness presenteeism. Previous research has evidenced the scale as being suitable for measuring presenteeism (Schultz and Edington 2007). The scale includes four dimensions (Time demands e.g., work required hours, Physical demands e.g., repeat motions, Mental demands e.g., concentrate on work, and Interpersonal demands e.g., speak on the phone). The 25 item self-report instrument is a valid and reliable (internal consistency $\alpha = .90$) method of measuring the degree to which chronic health problems interfere with the ability to perform job roles (Lerner et al. 2001). A 4-week WLQ is considered to be cost effective and more efficient when periods of time need to be matched across other instruments within a study (Lerner et al., 2001). This study therefore asked participants to respond with regard to the past 4 weeks. The scale had an internal consistency of .90.

3.2.2.3 *Work Engagement Questionnaire*

The Utrecht Work Engagement Scale (UWES – 9) (Schaufeli & Bakker 2006) was used to measure work engagement. The UWES -9 is a shortened version of the original 17-item UWES self-report questionnaire and measures three dimensions of work engagement; vigour, dedication and absorption. Responses were rated on a 7-point scale (1 = Never, 7 = Always) with higher scores indicating higher levels of work engagement. Evidence of the validity and internal consistency ($\alpha = .92$) of the UWES-9 has been reported (Schaufeli, Bakker & Salanova, 2006). In the present study the internal consistency was .90.

2.2.4 *Health Behaviours*

Smoking and alcohol consumption were measured using a single item question. Responses for smoking were statements rated as ‘Previously’, ‘Currently’, ‘Never’. Alcohol consumption measured as ‘Often’, ‘Sometimes’, ‘Rarely’ or ‘Never’.

3.2.2.5. *Psychological Stress Task Evaluation*

Participants rated to what extent they found the task to be difficult, stressful, and engaging as well as how they thought they had performed. Responses were made on a 0 (not at all) to 6 (extremely) Likert-type scales.

3.2.2.6. *Acute Psychological Stress Task*

Participants undertook the 10 min Paced Auditory Serial Addition Test (PASAT) (Gronwall 1977). The PASAT has been shown previously to reliably perturb both the cardiovascular system and salivary cortisol (Phillips et al. 2006; Phillips et al. 2009; Ring et al. 2002). Participants were presented with a series of single digit numbers by compact disc and required in each case to add the present number to the number previously presented and call out the answer. However, they had to retain each previous number presented in order to add it to the next number presented, thus the task also involves working memory. The intervals between the numbers were 4.5s for the first 2 min and shortened by .5s every subsequent 2 min. An experimenter sitting directly adjacent to the participants obtrusively scored participants' answers. The task also involved elements of competition and social evaluation. A leader board was displayed in the room with the top five scores previously reached and the participants were instructed to attempt to beat the displayed scores. Participants started with 1000 points and five points were deducted for every wrong answer. Participants were also instructed to watch themselves live on a laptop screen directly in front of them throughout the task; they were informed that the test was recorded and would be assessed by “body language experts”. In reality, no such assessment or recording was made. They were told that they would hear a brief burst of loud aversive noise if they hesitated or made an error. If they did not make any errors within each block of 10 numbers, they received the noise at a point during the last five numbers of every block in order to standardise the number of noise bursts.

3.2.2.7. *Cardiovascular And Salivary Cortisol Measurements*

During the testing session, systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were measured discontinuously every two minutes from the participant's dominant arm using a standard brachial artery cuff and an Omron blood pressure monitor (Intelli Sense ™, Japan). Four stimulated saliva samples were obtained using salivettes (Sarstedt Ltd., Leicester, UK). Samples were obtained at 10 minutes into baseline. The remaining samples were taken within 1 min of the end of the task at the start of recovery and then 10 and 20 min following the stress task. Participants placed the salivette dental swab into their mouths and gently chewed for 60 secs to collect saliva. The swab was returned to the salivette tube and stored in the fridge until the end of the testing session. Salivettes were then centrifuged at 4000 rpm for 5 min and the saliva was pipetted into eppendorfs which were stored at − 20 °C until assay. Salivary cortisol samples were analysed all in the same day in duplicate by ELISA (IBL International, Germany). This assay is based on the competition principle and microplate separation. An unknown amount of cortisol present in the sample and a fixed amount of cortisol conjugated with horseradish peroxidase compete for the binding sites of antibodies coated on to wells. After two hours the microplate is washed to stop the competition reaction. After addition of a substrate solution the concentration of cortisol is inversely proportional to the optical density measured at 450 nm. The mean intra-assay coefficient of variation was 15% and the inter-assay coefficient was 7%.

3.2.3 *Procedure*

Prior to testing of the participants willing to complete further stress testing, a screening questionnaire pertaining to the participants' general health was administered. Those who had a history of cardiovascular or metabolic disease, taking prescription medication (contraception allowed) or using corticosteroid medication e.g. daily brown inhaler use, or had current illness or infection were excluded. Thirty-one participants who met the inclusion criteria i.e. not taking prescription medication or had previous medical conditions listed above and who were free from illness or infection, were invited back for testing. Prior to testing, participants were not allowed to exercise nor consume alcohol 12 hours beforehand or to consume caffeine or nicotine two hours beforehand or to eat for one hour before. Questionnaire completion, and cardiovascular and salivary cortisol measurements were carried out in a quiet room at the participant's home or a quiet place of their choice. The testing session consisted of four periods: 10 min adaptation, 10 min baseline, 10 min stress task and 20 min recovery. During the formal 10-min baseline, cardiovascular measurements were made at 2, 4, 6 and 8 minutes. Cardiovascular measurements were made at 2, 4, 6, and 8 min during the acute stress task and every two minutes during the recovery period. A 4-item questionnaire was administered immediately following the stress task exposure. At the end of the testing session, participants were debriefed and thanked.

3.2.4 *Data Analysis*

Data analysis was conducted using IBM SPSS version 22. Firstly, repeated measures ANOVAs were conducted to ensure the stress task perturbed the cardiovascular system and cortisol, as would be expected. Next, univariate regressions were performed to explore potential associations between the main psychosocial variables and reactivity. Finally, multivariate regressions were used with models in which all of the significant psychosocial variables were entered together, along with significant demographic variables in order to examine the prediction of reactivity from these variables together. Effects sizes are presented throughout as eta-squared or change in R-squared, as appropriate.

3.3. Results

3.3.1 Descriptive Statistics

The mean (SD) age of the sub-group of 31 participants was 55.0 (3.78) years including 13 (42%) women. Descriptive statistics for all participants are shown in Table 1.

Table 3.1: *Descriptive statistics. Means and standard deviations for all variables.*

Variable	Mean/N	(SD)/%
Age	54.9	(3.78)
Male	18	58
Female	13	42
Married	17.0	54.8
Drinks Alcohol:		
Often	10	32

Sometimes	14	45
Rarely	7	23
Smokes :		
Currently	5	16
Previously	8	25
Never	18	58
Resilience (BRS) (1-5)	3.9	(0.57)
Work Engagement (UWES, 1-6)	4.8	(0.93)
PASAT Score (1-1000)	582.6	(210.59)
PASAT Difficulty (0-6)	4.0	(1.36)
PASAT Stressfulness (0-6)	3.6	(1.35)
PASAT Performance (0-6)	2.7	(1.27)
PASAT Engaging (0-6)	4.2	(1.40)
Systolic Blood Pressure Baseline (mmHg)	120.2	(15.17)
Diastolic Blood Pressure Baseline (mmHg)	77.4	(10.30)
Heart Rate Baseline (mmHg)	66.3	(11.73)

Cortisol Baseline (nmol/dl)	0.1	(0.07)

(N = number of participants, % = percentage of participants)

3.3.2. Cardiovascular and Cortisol Reactivity to the Stress Task

From baseline to recovery, the PASAT evoked significant main effects of time for both cardiovascular and cortisol: for SBP, $F(3,90) = 81.2$, $p < .001$, $\eta^2 = .730$; DBP, $F(3,90) = 44.1$, $p < .001$, $\eta^2 = .595$; HR, $F(3,90) = 54.5$, $p < .001$, $\eta^2 = .645$ and cortisol, $F(3,87) = 7.1$, $p < .001$, $\eta^2 = .197$. These are illustrated in Figures 1 and 2. The mean (SD) reactivity for the group was: for SBP, 22.0 (10.22) mmHg, DBP, 11.4 (5.84) mmHg, HR, 8.5 (7.27) bpm, and cortisol, 0.04 (0.11) nmol/dl. Generally, all cardiovascular measurements increased with the stress task and subsequently recovered towards baseline after 20 minutes. Levels of cortisol meanwhile, increased with the stress task, then continued into the first 10 minutes of recovery and declined during the final 10 minutes.

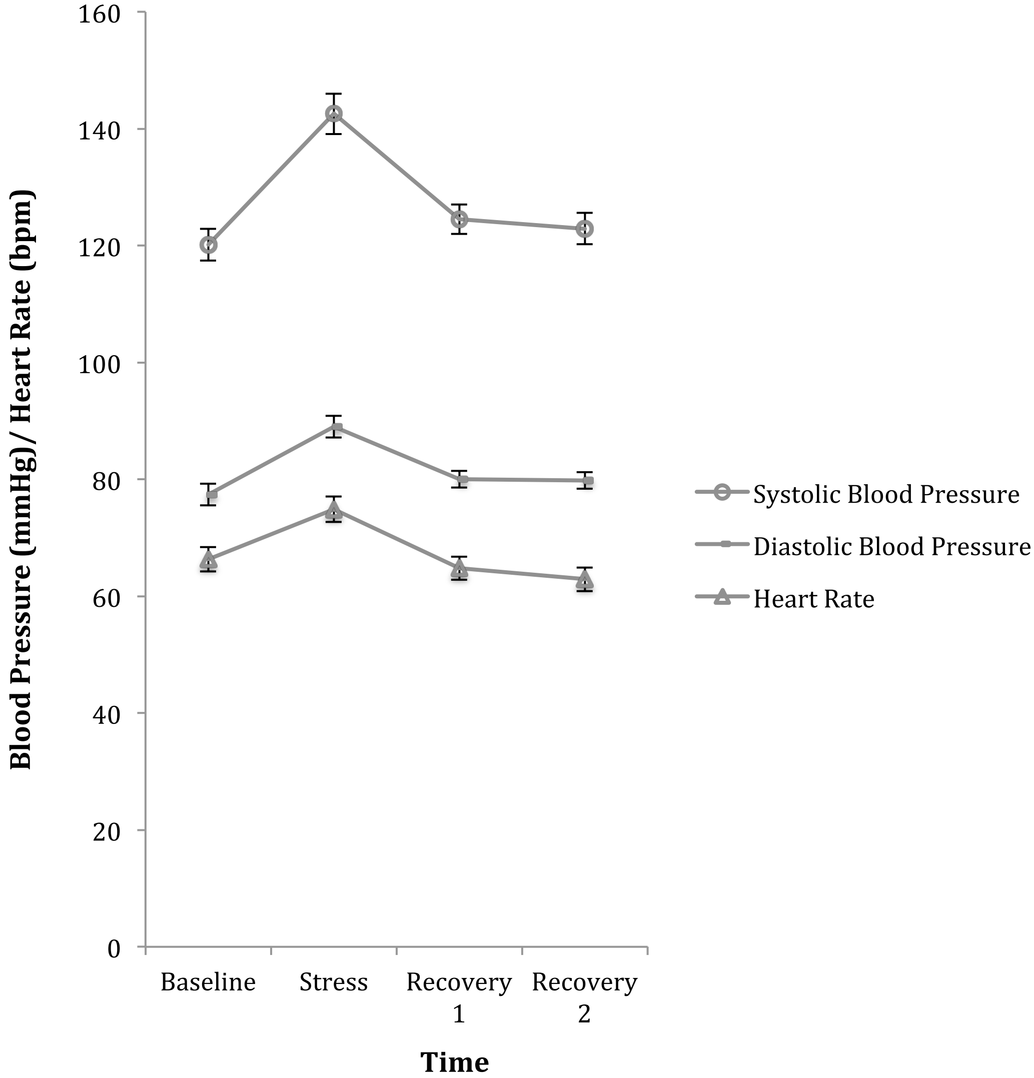

Figure 3.1. Cardiovascular change over time. Error bars represent ± 1 Standard Error of the mean.

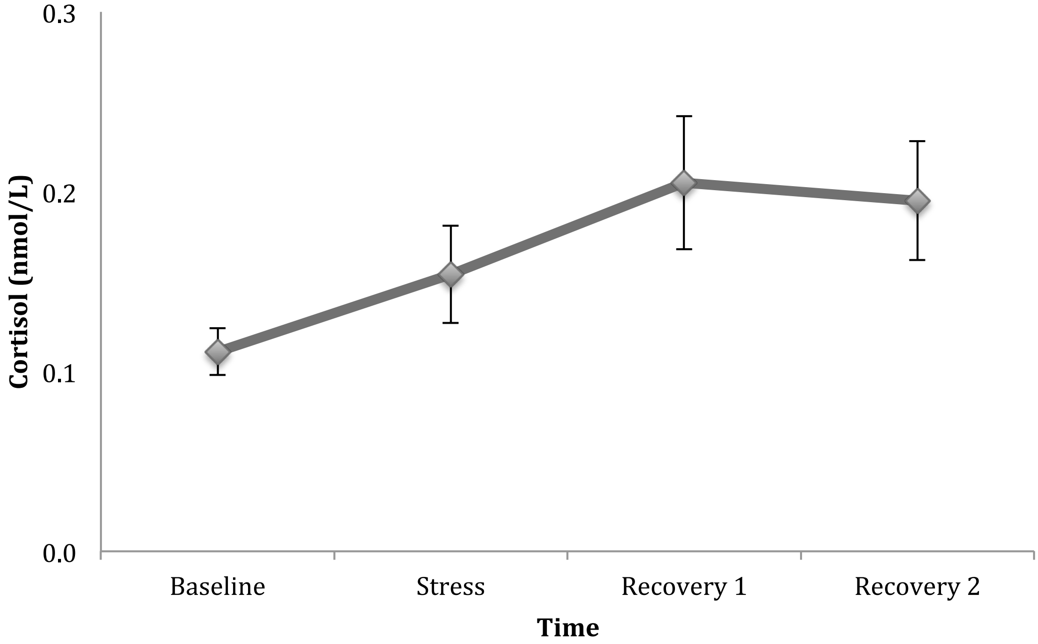

Figure 3.2. Cortisol change over time. Error bars represent ± 1 Standard Error of the mean.

3.3.2.1. Resilience and Reactivity.

There were no significant associations between resilience and reactivity, for SBP, β = .01, *p* = .94, ΔR^2 <.001; DBP, β = .10, *p* = .59, ΔR^2 =.010, HR, β = -. 33, *p* = .08, ΔR^2 =.109, or cortisol, β = -. 08, *p* = .68, ΔR^2 =.006, reactivity.

3.3.2.2. Work Engagement and Reactivity

There was a significant negative association between work engagement and SBP reactivity, β = -.50, *p* = .02, ΔR^2 = .248. Further, there was a significant negative association between work engagement and HR reactivity, β = -.63, *p* = .001, ΔR^2 =.393, such that those who reported higher levels of work engagement exhibited lower SBP and

HR reactivity. There were no significant relationships between work engagement and DBP or cortisol reactivity.

3.3.2.3. *Sickness Presenteeism and Reactivity.*

A significant positive association was found between sickness presenteeism and HR reactivity, $\beta = .45$, $p = .03$, $\Delta R^2 = .200$, such that those with higher sickness presenteeism had HR reactivity. There were no significant associations between presenteeism and reactivity.

3.3.2.4. Socio-demographics and Reactivity

In regression analyses, age was not significantly associated with reactivity, and there were no significant gender differences in stress reactivity (all $p > .05$). However, marital status significantly predicted cortisol reactivity, $F(1,28) = 13.65$, $p = .001$, $\eta^2 = .304$. ANOVA indicated a significant difference between those who were married/cohabiting and those who were single/divorced/widowed for cortisol reactivity, $F(1,28) = 7.04$, $p = .013$, $\eta^2 = .201$, such that those living alone exhibited higher cortisol reactivity than those living with a spouse. Participants who were married or living with a partner showed a healthy cortisol response (0.02 nmol/dl) to the acute stressor whereas those living alone showed a somewhat exaggerated cortisol response (0.13 nmol/dl). There were no significant group differences across different levels of alcohol intake and reactivity. For smoking there was a significant effect for SBP reactivity, $F(2,27) = 4.58$, $p = .02$, $\eta^2 = .253$, such that those individuals who were previous smokers showed significantly higher reactivity than never smoker ($p = .05$) and current smokers ($p = .04$). There were no other associations or group differences for socio-demographics and reactivity.

3.3.2.5. Stress Task Performance, Ratings and Reactivity

Stress task performance and ratings of stressfulness did not significantly relate to reactivity (all $p > .05$). This suggests that the associations observed above were not due to task performance or perception differences in those with higher or lower work engagement or presenteeism.

3.3.3 Associations between Resilience and Work Variables

Resilience did not relate significantly to sickness presenteeism or work engagement. However, sickness presenteeism was significantly predicted by work engagement, $\beta = -.53$, $p = .007$, $\Delta R^2 = .284$, such that those with higher work engagement showed less presenteeism. There were no other significant associations between any of the questionnaire variables or with any of the socio-demographic variables.

3.3.4. Multivariate predictions of reactivity

Finally, in order to assess the impact of significantly related variables and socio-demographic variables, a series of regressions were run. For SBP reactivity, work engagement remained a significant predictor following adjustment for smoking, $\beta = .50$, $p = .02$, $\Delta R^2 = .244$. For HR reactivity, when work engagement and sickness presenteeism were entered together into the model, only work engagement remained a significant predictor, $\beta = -.63$, $p = .01$, $\Delta R^2 = .281$; sickness presenteeism was no longer related to HR reactivity, $\beta = .002$, $p = .99$, $\Delta R^2 = .112$. Consequently, we tested formally whether work engagement significantly mediated the association between presenteeism and HR reactivity using the PROCESS bootstrapping method (Hayes, 2013) such that there was a significant indirect effect of presenteeism on HR reactivity mediated through work engagement, *ab* = 7.31, 95% CI [1.82 – 15.26], with the mediator accounting for about 75% of the total effect (P_M = .74). This result suggests that if an individual displays signs of high levels of presenteeism and high HR reactivity in response to stress, increasing the individual's level of work engagement may protect against/ buffer the effects of exaggerated HR reactivity, and also has the capacity to reduce presenteeism.

3.4. Discussion

The present study sought to explore the relationship between perceived psychological resilience, work-related factors and physiological reactivity to acute psychological stress in a group of older manual workers. The findings revealed that both work-related factors were associated with HR reactivity; such that higher HR reactivity was displayed in those who reported low levels of work engagement and higher presenteeism. Low levels of work engagement were also associated with higher SBP reactivity. Interestingly, previous smokers exhibited significantly higher levels of SBP reactivity than current smokers or non-smokers, although adjustment for smoking did not alter the association between work engagement and SBP reactivity. Further, marital status was linked to cortisol reactivity, such that those who lived alone demonstrated an exaggerated response to acute stress.

With respect to work related factors, previous research has suggested that those with high levels of work engagement display high levels of psychological wellbeing (Koyuncu et al. 2006). Therefore, it is possible that high levels of work engagement promote psychological wellbeing and in turn buffer the physiological effects of high work demands (Leijten et al. 2015). This may explain why those with higher levels of work engagement did not display exaggerated HR reactivity. Of note, it has been previously demonstrated that work engagement predicts presenteeism, the higher the engagement, the lower the presenteeism levels (Admasachew and Dawson 2011). This was also the case in the present study. Further, in support of Leijten et al. (2015), work engagement mediated the effect of presenteeism on HR reactivity. Importantly, individuals with higher presenteeism and lower work engagement increase their risk of developing cardiovascular disease if their exaggerated physiological responses to acute stress persist over time (McEniery et al. 2007; Trieber 2003). The findings further existing research into negative health outcomes associated with presenteeism (Callen et al. 2013; Cancelliere et al. 2011; Leineweber et al. 2011) as well as those linking job-related stress to cardiovascular reactivity. Such that the link between reactivity and presenteeism underlines an added concern, in that high presenteeism may also exacerbate high reactivity previously associated with high job strain (Flynn and James 2009) and decreased work engagement. Given the mediating effect of work engagement mentioned above, it may be that work engagement is the key factor in determining a healthy rather than exaggerated level of HR reactivity. Further, the findings for HR reactivity add to the evidence linking job strain to BP reactivity (Flynn and James 2009; Steptoe 2001; Steptoe 2004). Participants in the present study who reported low levels of work engagement demonstrated significantly higher SBP reactivity than those with higher work engagement. This is also in accordance with previous research linking job strain to elevated ambulatory BP (Landsbergis et al., 2013, Clays et al., 2007, Flynn and James, 2009).

Interestingly, there was no link between resilience and work-related factors, or reactivity. This is in line with a previous study, which found no relationship between resilience factors and HR reactivity, although it was implied that resilience buffered against acute stress (Corina and Adriana 2013). Given this, it is necessary to bear in mind that other lifestyle factors such as physical activity may contribute to individual resilience. In a model of psychological resilience, de Terte et al., (2014) imply that healthy lifestyle practices, such as not smoking, suitable alcohol intake and social support, might help to promote psychological resilience. A good proportion of the present participants were non-smokers, married and moderate drinkers, however, we found no relationships between resilience and lifestyle factors or social support.

Contrary to previous research (Galatzer-Levy et al. 2014), the present study found no relationship between psychological resilience and cortisol reactivity. However, participants living alone displayed an exaggerated cortisol response to the stressor relative to married participants, indicating a risk of immune suppression and future hypertension (Fan et al. 2009; Hamer and Steptoe 2012). This finding lends some support to the buffering effect of social support for the impact of stress on health, as, in the present study, married participants mounted a healthy cortisol response to the acute stressor, indicating good physiological health (Phillips et al. 2005). Interestingly, marital status was not associated with resilience in the present study, however, it is evident from the findings and from previous research, that support of this nature has a bearing on how an individual responds to psychological stress (Bonanno et al. 2007; Corina and Adriana 2013). For example, men tested in the presence of a supportive spouse/partner showed lower cardiovascular reactivity to acute stress (Phillips et al. 2006); and individuals who perceive themselves generally to have good social support reveal lower resting cardiovascular function (Hughes and Howard 2009) and faster habituation to recurrent acute stress (Howard and Hughes 2012).

The present study is not without limitations. First, it is important to note that this study was correlational so no direction of causality can be assumed, however, it seems unlikely that one's habitual physiological response to acute stress might influence resilience and work engagement when participants seem to be unconscious of whether they are high or low physiological responders (Tucker 2007). Second, the associations found were not consistent across all cardiovascular measures and cortisol, however, the consistency of associations with HR reactivity would suggest that the present results are not simply due to random chance. Indeed, it has been shown that HR reactivity is also important as a predictor of future hypertension as well as BP reactivity (Moseley and Linden 2006; Treiber et al. 2003). Third, the present sample size was small, however, it is comparable with other correlational studies of reactivity, particularly among older adults (Almela et al. 2011; Domes 2002; Hogan et al. 2012). Additionally, it is possible that existing unknown comorbidities may have confounded the reactivity data, however, the participants who declared existing CVD were excluded from the study at screening. Further, the sample may be unusual in that all were aged 50+ years, un-medicated, without history of cardiovascular or metabolic disease. Thus, the sample might be representative of the 'healthy worker effect' (Shah, 2009) and potential selection bias. However, employees with long-term sickness absence would not be available for recruitment, and the levels of presenteeism identified in the study highlight the need to promote the health and longevity of older employees. Further, the study has several strengths. First, participants were all manual workers and aged >50 years, a population that has been previously under-researched. With the increasing age of the workforce, research into this population is becoming more important. Further, rather than explore stress in this age group in association with work and health, the investigation into resilience in the present study offers an original contribution to resilience literature by extending the research into older manual workers. This study also considers the repercussions resilience may have for sickness presenteeism, thereby extending current knowledge on sickness presenteeism in this age group.

3.4.1. Conclusion

The present study suggests that there may be a relationship between work engagement, and presenteesism and HR reactivity in older manual workers. Given that HR reactivity was associated with lower work engagement and higher presenteeism, it is possible that exaggerated reactivity could be a consequence of these negative factors and a pathway through which they relate to increased disease risk and ill health. This indicates the need for further research into ways to promote work engagement and decrease presenteeism, thereby potentially protecting cardiovascular health in this group of workers. Exaggerated cardiac reactivity on top of ageing, less social support and poorer lifestyle behaviours, may contribute to the risk of negative health and poorer wellbeing. Additionally, implications from the present study, give rise to the consideration of the impact of job strain on stress reactivity. However, further research is needed to gain a broader understanding of the role of stress reactivity in the links between resilience, work-related factors and future health.

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Declaration of Interest

The authors declare that they have no conflicts of interest.

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CHAPTER FOUR

4.0. UNDIAGNOSED OBSTRUCTIVE SLEEP APNEA AND PHYSICAL ACTIVITY IN OLDER MANUAL WORKERS.

The second study in this thesis highlighted a potential mechanism by which the maladaptive response to work stress in older manual workers may increase risk of CVD development. In light of the increased mortality risk associated with CVD worldwide, and the growing population of older workers, it is necessary to consider other health behaviours that may also contribute to the development of CVD.

Alongside negative lifestyle choices such as smoking and excess alcohol consumption, a lack of regular daily PA has long been recognized as a potential risk factor in obesity and CVD. More recently, inadequate duration and low quality of sleep have also gained recognition in this respect, in particular sleep loss associated with OSA that also increases the risk of CVD. Thus, OSA and PA formed the basis for research into the final two studies in this thesis. To this end, the third study examined the undiagnosed levels of OSA in older manual workers and therefore, their increased risk for CVD development. This study focused on the likely triggers for OSA development specifically the lack of regular PA and obesity, both of which are common risk factors for CVD.

Undiagnosed Obstructive Sleep Apnoea and Physical Activity in Older Manual Workers.

4.1. Abstract

Cardiovascular disease (CVD) is a negative health outcome of Obstructive Sleep Apnoea (OSA). Risk factors associated with OSA development include low physical activity (PA), high body mass index (BMI), and increasing age (>50 years) and weight loss is usually recommended as treatment. This cross-sectional study examined the association between PA, BMI and OSA severity in manual workers. Fifty-five participants, (23 females) mean age 55.2, were examined for OSA and completed a PA and anthropometric assessment. On average, OSA severity was mild, PA levels were moderate and 32% of the sample was classified as obese. PA was negatively associated with OSA severity, but BMI strongly independently predicted OSA severity, with no evidence of mediation. As both PA and BMI were significantly associated with OSA in older manual workers, increasing PA should also be a focus of treatment for OSA.

Keywords: Sleep disordered breathing; exercise; aging workforce; increased BMI; sleep apnoea.

4.2. Introduction.

Sleep is essential for life and integral to health and wellbeing (Roehrs, 2000). However, during the ageing process sleep patterns become disrupted, which leads to sleep deprivation (Stanley, 2005). Inadequate sleep has adverse effects on the body, including the production of higher cortisol (stress hormone) levels, which causes wear and tear physiologically, and further contributes to wakefulness (Stanley, 2005).

Although it is uncertain whether age-related sleep changes predict the onset of sleep complaints, a common condition responsible for age-related sleep disturbance, is a respiratory sleep disorder called obstructive sleep apnoea (OSA) (Al Lawati et al., 2009, Banno and Kryger, 2005). OSA is caused by upper airway collapse resulting in repeated incidence of airflow cessation (apnoea) or airflow reduction (hypopnoea), and consequently leads to arousals from sleep, alongside increased sympathetic nervous system activation, hypoventilation and hypoxemia (Al Lawati et al., 2009). The severity of OSA is measured as the number of respiratory interruptions that coincide with a decrease in oxygen saturation (apnoea-hypopnoea index) (AHI). The AHI indicates the number of apnoea and hypopnoea episodes detected in one hour of sleep (Laitinen et al., 2003)

It is estimated that 1.5 million adults in the UK have OSA, although only approximately 330,000 are actually diagnosed and treated (Rejon-Parrilla et al., 2014), thus, many adults may unknowingly have undiagnosed OSA. Recently, Webber et al. (2011) illustrated the incidence of undiagnosed OSA in a group of male rescue workers (n = 13,330) with a mean age of 44.2 years and found that only 13.9% who were deemed at risk for OSA were actually diagnosed. Owing to an increasingly older population (Government Office for Science, 2016) and rising obesity levels (NHS, 2013), the prevalence of OSA is likely to worsen over time (Rejon-Parrilla et al., 2014). This is of enormous concern as OSA has serious implications for health, increasing the risk of conditions such as cardiovascular disease (CVD) (Floras, 2014), type-2 diabetes (Pamidi and Tasali, 2012), and hypertension (Zhang and Si, 2012). Thus, early diagnosis is essential if health and wellbeing are to be preserved over the course of working life.

As many companies now need to retain older workers, it is important to bear in mind the impact of ageing-related diseases on health and wellbeing and ability to work, particularly in respect to OSA (Billett et al., 2011). Laitinen et al. (2003) suggest that moderate to severe OSA is highly prevalent in males and that the incidence of OSA peaks around the age of 50-59 years. Age-related physiological changes that are believed to contribute to the development of OSA include tissue and systemic alterations. For instance, one suggested mechanism of OSA, a greater stiffness of the soft palate found in middle-aged sleep apnoea patients, is thought to be caused by the pharyngeal fatty infiltration brought about by ageing (Veldi et al., 2004). Growing older also triggers significant changes within the cardiovascular system, which predispose an individual to CVD and as such adds additional CVD risk to that presented by OSA (McEniery et al., 2007). In addition to the above naturally occurring changes, poor health behaviours such as excessive alcohol consumption, smoking, obesity and lack of physical activity (PA) may amplify the likelihood of developing OSA (Koyama et al., 2012, Simpson et al., 2015). Thus, the physiological effects of growing older together with poor health behaviours are likely co-contributors to the development of OSA.

The health implications of OSA have enormous impact on quality of life and the ability to function effectively at work. For example, certain features of OSA such as excessive daytime sleepiness and morning headaches may present their own problems during the course of the working day (Banno and Kryger, 2005), such that work efficiency may be compromised and could result in sickness presenteeism (attending work whilst ill) (Guertler et al., 2015). Sleep loss owing to OSA becomes a real problem in the workplace in terms of production and even health and safety (Gaultney and Collins-McNeil, 2009). This is particularly true of older workers in manual occupations, where non-health related outcomes of OSA such as difficulty in staying awake, may lead to an increased risk of workplace injury (Heaton et al., 2010). Occupations that involve driving carry a high risk of road traffic accidents where OSA is concerned (Lemos et al., 2008). Road traffic accidents relating to OSA are costly to industry and to lives and have been evidenced to warrant that American commercial drivers in Philadelphia are screened before being deemed fit for work (Gurubhagavatula et al., 2008).

OSA-related sleepiness might be even more of a problem in older manual workers, who are already likely to experience age-related fatigue (Kiss et al., 2008). As a result of daytime sleepiness, adults aged over 50 years old with OSA are unlikely to practice good health behaviours such as regular PA, a lack of which has been shown to be associated with moderate to severe OSA (Simpson et al., 2015, Peppard and Young, 2004). Chennaoui et al. (2015) suggest that OSA limits exercise, however, Butner et al. (2013) disagree and conclude that capacity to exercise is more likely related to age and body weight. Either way, previous research suggests that the severity of OSA increases with age and weight, and that regular PA may alleviate age-related worsening of cardiorespiratory function, promote weight loss, and potentially reduce the severity of OSA (Butner et al., 2013, Vanhecke et al., 2008). Recent evidence highlights the potential of PA in reducing the severity of OSA (Aiello et al., 2016), however, there is limited evidence regarding the association between OSA and PA in those older than 50 years. The available literature generally suggests that low levels of daily PA is associated with increased severity of OSA independent of BMI in those who are older than 50 years old (Verwimp et al., 2013, Peppard and Young, 2004, Stanley, 2005, Simpson et al., 2015). Further, research is sparse in respect of PA and the occurrence of undiagnosed OSA in older manual workers.

It is also important to bear in mind that the ability to perform manual work competently without negative effect to health requires cardiorespiratory fitness, which may be achieved through regular leisure-time PA (Leino-Arjas et al., 2004). As such, strenuous workloads that regularly exceed a worker's ability due to lack of fitness will increase the risk of long-term sickness absence and the development of CVD. On the contrary, increased leisure-time PA may decrease these risks (Holtermann et al., 2012b, Holtermann et al., 2012a). Notably, manual workers are reported to have lower levels of leisure time PA than those of white-collar workers (e.g. managers) (Gram et al., 2016, Leino-Arjas et al., 2004). There is also evidence to suggest that increased BMI is common among manual workers (Fransen et al., 2006). Thus, together with high physical workload, low levels of PA and high BMI, manual workers are at increased risk of OSA and CVD development.

Consequently, the aim of the present study was to explore whether PA is associated with undiagnosed OSA as measured by an AHI score of ≥ 5, in a sample of manual workers aged over 50 years old (Ejaz et al., 2011). It was hypothesized that those with an undiagnosed presence of OSA would report low levels of PA, independent of BMI.

4.3. Method

4.3.1. Participants and Design

Participants were recruited by the researcher through advertising in an original population of 225 manual workers (healthcare, teaching and craft/labourers) aged over 50 years old (mean = 57.11, standard deviation (SD) = 5.62 years) who were recruited in 2015 as part of a study on presenteeism in manual workers from various industries (Thogersen-Ntoumani et al., 2017). Those who already had a diagnosis of and were receiving treatment for OSA, or were under current investigations for OSA, or had a history of cardiorespiratory conditions were excluded. Participants who met the inclusion criteria i.e. had no previous diagnosis of OSA, who had no history of cardiorespiratory conditions, were otherwise healthy and were not receiving treatment for OSA were included and invited for testing. Fifty-five participants (healthcare, teaching and craft/labourers) willing to undertake further investigation were invited to complete a questionnaire to measure daily levels of physical activity, and to wear a home sleep screening device overnight to identify the presence of obstructive sleep apnea. Participants were told that the ApneaLink would indicate the degree of OSA but was not an official diagnosis. Results of the screening were given to the participants in confidence via a telephone call or in person. Participants were encouraged to see their GP if our screening was suggesting that OSA was present. The University of Birmingham STEM ethics committee approved the study and written informed consent was given by all participants.

4.3.2. Measures

Physical Activity Questionnaire. The Baecke Questionnaire (Baecke et al., 1982) was used to measure habitual levels of physical activity. The Baecke Questionnaire measures physical activity across three contexts: sport/exercise, occupational (referred to as work), and leisure-time physical activity in the past month, and provides total and domain-specific scores. The questionnaire includes a rating of amount (hours per week, months per year) and type (swimming, jogging etc.) of activity. It has been tested in a group of workers over one month with a test-retest reliability of 0.71 (Philippaerts and Lefevre, 1998). Congruent validity and concurrent validity have been supported across three levels of professional status (manual workers, clerks and managers (Philippaerts & Lefevre, 1998). More recently, (Hertogh et al., 2008) reported in a validation study that the scale can correctly classify low (0-8) and high (>15) activity, but is less accurate in identifying moderate (9-15) activity. The Cronbach's alpha for internal consistency in the present study was 0.75.

Sleep Testing. To assess the presence of OSA, participants wore an ApneaLink^{TM} (ResMed, Sydney, Australia) for one night. ApneaLink^{TM} is a home sleep monitoring device and has been widely used in research as a tool for detecting sleep-related breathing conditions. The device is a two-channel monitor that provides ventilatory data via nasal flow, and oxygen saturation via pulse oximetry, which are analyzed to give an apnea/hypopnea index (AHI) score indicating OSA (ResMED, 2006). A minimum wear-time of at least two hours, but ideally four hours, is required for a valid evaluation (Erman et al., 2007). The device has 100% sensitivity and is 87.5% specific in identifying apnea, together with a 95% success and compliance rate (Patel et al., 2007).
It thus, provides a reliable and cost effective method of screening and diagnosing obstructive sleep apnoea (OSA).

Participants wore the device at home and were scored for OSA based on an apnoea/hypopnoea index (AHI). As per the ApneaLink^{TM} default settings, apnoea was defined as a reduction in flow by 20% of normal for at least 10 seconds and hypopnoea as a reduction in flow by 70% of normal for at least 10 seconds (Crowley et al., 2013). Pulse oximetry data became indicative for the presence of OSA when during apnoeas and hypopnoeas saturation dropped by more than 5% below normal. The severity of OSA is defined by AHI as follows: an AHI of 5-15 per hour was defined as mild OSA, AHI of 15-30 per hour as moderate OSA and AHI > 30 per hour as severe OSA (AASM Task Force, 1999).

Anthropometric Measures. Prior to testing, height and weight were measured to calculate body mass index (BMI) (kg/m^2). Salter Ultra Slim Glass Analyser scales (Model no.9141, HoMedics Group Ltd., Kent, UK) was used to measure weight, body fat percentage (through bioelectrical impedance) and BMI (kg/m^2). A Bosch PLR 30c Laser Measure (Robert Bosch GmbH, Germany) was used to measure height.

4.3.3. Procedures

A participant information sheet with details on the use of the ApneaLink^{TM} device was provided alongside a demonstration on how to wear it. Participants were shown by the researcher how to operate the device and given a paper illustration for reference. Participants were required to wear the device on a “normal/regular” night and to go to sleep at their habitual bedtime. Wear time was required overnight for one night and the device was collected the following day. All participants wore the ApneaLink^{TM} for the minimum required time of four hours (Erman et al., 2007). ApneaLink^{TM} software produced a computer generated summary report with automatic scoring for interpretation of AHI score and presence of OSA. Graphical readouts from the ApneaLink^{TM} were checked by trained researchers, to ensure that they reflected the AHI score given.

4.3.4. Data Analysis

Data analysis was conducted using IBM Statistical Package for the Social Sciences (SPSS) version 22. Firstly, correlations and ANOVAs were performed to explore potential associations between OSA severity, PA, socio-demographic variables and BMI. Further exploration of the associations between OSA, PA and BMI was carried out using linear regression analysis. Change in R-squared is reported as the effect size from the regression analyses. Mediation analyses were conducted using the PROCESS macro (Hayes, 2013) based on simple linear regression modelling.

4.4. Results

4.4.1. Descriptive Statistics

Descriptive statistics for all participants are shown in Table 4.1. The mean (SD) age of the participants was 55.2 (4.21) years, and the sample included slightly more males (58.2%) than females. The mean AHI score was 8.9 (11.75) indicating undiagnosed levels of mild OSA. Mean Physical Activity (PA) levels were reported as moderate, and 32% of the sample was classified as obese with a BMI $\geq$ 30 kg/m^2. PA levels were further broken down to reveal high levels of work PA (heavy lifting and walking), moderate leisure PA and lower levels of sport and exercise (e.g. running, swimming, cycling) (Table 1). To clarify, work PA included heavy lifting and walking. OSA severity groups were grouped as follows: 'No OSA' = 25, 'Mild OSA' = 19, 'Moderate OSA' = 7, 'Severe OSA' = 4. Of those with mild OSA, 14 participants had a lower BMI than the group mean of 28.50 kg/m^2. Further, the lowest BMI for those with mild OSA was 21 kg/m^2. There were no significant gender differences for OSA severity or PA. Age was also unrelated to OSA severity and PA.

Table 4.1. Descriptive statistics of the sample (n = 55).

Variable	**Mean/N**	**SD /%**
Age*	55.2	4.21
Female	23	42
Male	32	58
AHI Score (OSA)*	8.9	11.75
No OSA	24	45
Mild OSA	19	35
Moderate	7	13
Severe OSA	4	7
Physical Activity (PA)*	3.9	0.89
Low	3	5
Moderate	43	78
High	4	7
Work PA*	5.8	1.64
Leisure PA*	3.4	0.85
Sport PA*	2.8	0.85
BMI *	28.5	8.05
Normal Weight	14	25
Overweight	23	42
Obese	17	32

* Denotes mean score.

4.4.2. OSA severity and physical activity. Correlation revealed that PA was significantly and negatively associated with OSA severity, $r(54) = -0.29$, $p = 0.04$, such that those who engaged in less physical activity had greater OSA severity. A follow-up ANOVA between the four OSA severity groups (no, mild, moderate, severe) revealed no significant overall main effect of group, $F(3,53) = 1.98$, $p = 0.13$, however, pairwise post-hoc comparisons demonstrated significantly lower levels of PA in those with moderate OSA compared to those without OSA, $p = 0.037$ (Figure 4.1). There were no other significant group differences for PA.

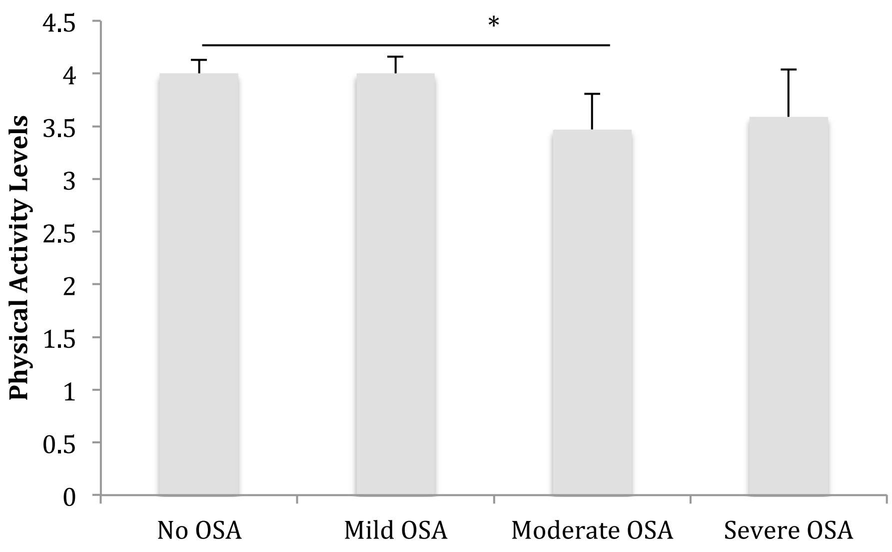

Figure 4.1. Levels of PA (as per BAECKE (1982) in OSA severity.
* Denotes significant difference between groups $p < .05$.

4.4.3. OSA severity, physical activity and BMI. The correlation between OSA severity and BMI was significant, $r(54) = 0.51$, $p < 0.001$, such that those with higher BMI had higher OSA severity. BMI, as would be expected, was also significantly different between the OSA severity groups, $F(3,50) = 7.7$, $p < 0.001$, $\eta^2 = 0.316$. Post-hoc analysis demonstrated significant differences between the OSA severity groups for BMI (Figure 4.2). Further, BMI and PA were significantly positively associated, $r(54) = 0.29$, $p = 0.03$. Interestingly, when BMI was added into a regression model predicting OSA severity from PA, the significant negative association between PA and OSA severity ($\beta = -0.29$, $p = 0.04$, $\Delta R^2 = 0.08$) became non-significant, $\beta = -0.15$, $p = 0.23$, $\Delta R^2 = 0.193$ (Figure 4.3). The PROCESS macro was performed within SPSS to explore whether BMI was mediating the association between PA and OSA severity, however, showed there was no indication of a significant indirect effect, 95% CI [- 0.4233, 0.0022], Effect - 0.1677, $p = 0.069$, suggesting no evidence of mediation.

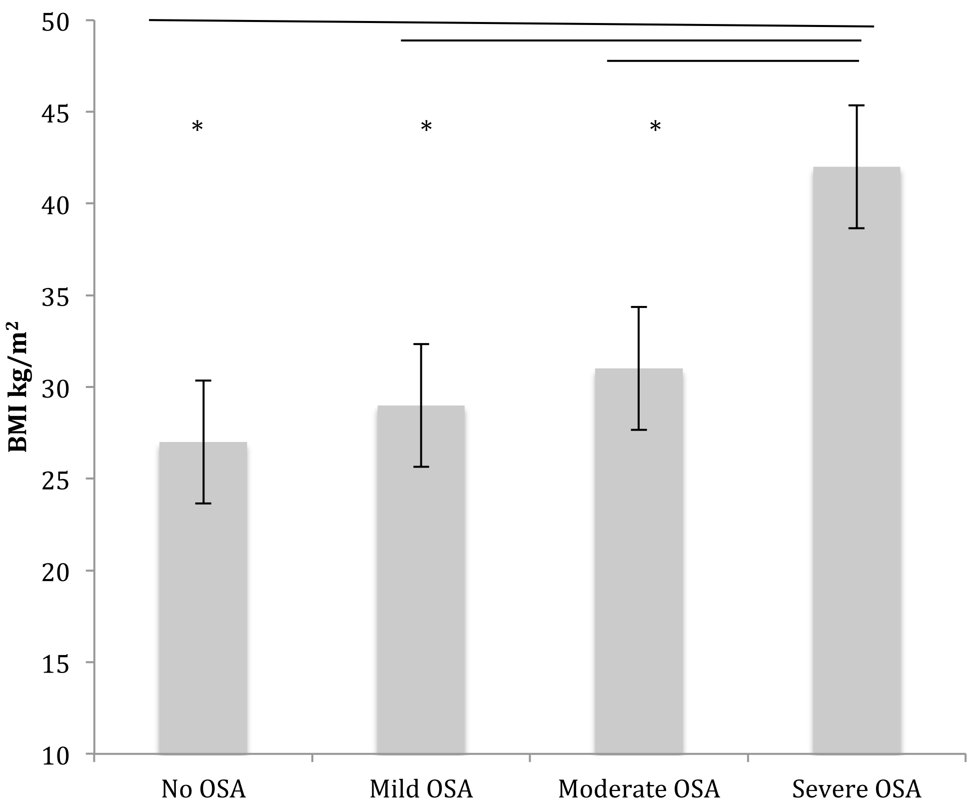

Figure 4.2. Body Mass Index (BMI) in OSA severity groups from the sample of manual workers (n = 55).

*Denotes significant difference between groups, p < .05

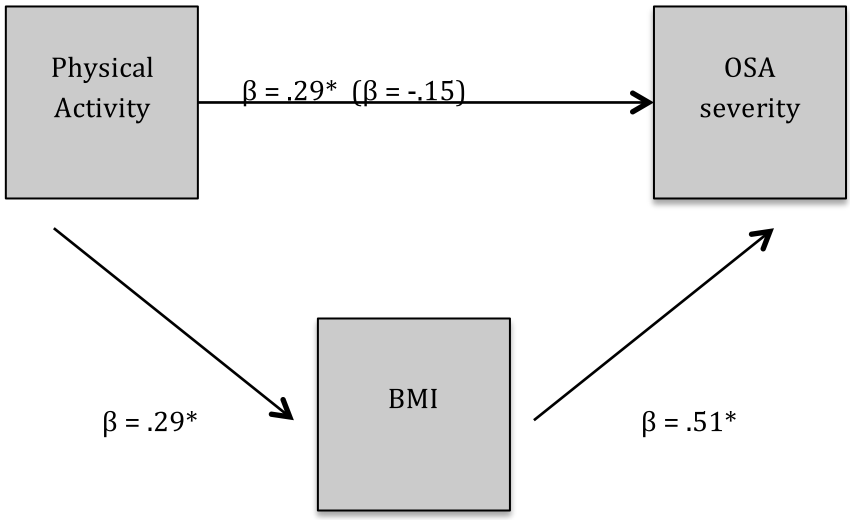

Figure 4.3. Relationship between Physical activity, OSA severity and BMI.

(β = -.15) denotes degree of change in association between physical activity and OSA severity when BMI is added to the relationship. * = p<.05

4.5. Discussion

The occupations of the participant sample of manual workers in the present study were healthcare and craft/labour. Previous evidence of the lack of leisure-time PA in manual workers, suggests that low levels of PA in the present study alongside raised BMI may increase the risk of OSA development (Leino-Arjas et al., 2004, Gram et al., 2016). The present study sought to explore the association of undiagnosed OSA, PA levels and BMI in a group of older manual workers. Preliminary results supported the hypothesis that undiagnosed levels of OSA were associated with low levels of PA. This is in keeping with previous studies, which found that lower levels of PA are associated with increased severity of OSA (Verwimp et al., 2013, Peppard and Young, 2004) and in contrast to Tan et al. (2015) who recently found that low levels of PA were not associated with OSA in individuals aged over 50 years old. However, the present study also showed BMI to be a stronger indictor of undiagnosed OSA than PA, implying that BMI may be a higher risk for OSA than low PA. That BMI was the stronger (and only significant) predictor in the model that included PA could be due to two possibilities. First, that there was reduced power to find effects given the moderate sample size and the correlation between these variables, or second that BMI is a multi-faceted variable, and contains variance not determined by PA, which may contribute through different (non-PA related) mechanisms to OSA severity. However, in observational research it is difficult to separate these aspects. The above finding corresponds with Webber et al. (2011) who found evidence of undiagnosed OSA in those with BMI >30 kg/m^2. Interestingly, the present study also found levels of currently undiagnosed mild OSA in those with a lower BMI than that classified as obese (>30 kg/m^2) suggesting that BMI may not be the sole trigger for the development of OSA.

Additionally, participants in the present study without OSA reported significantly higher levels of PA than those with moderate OSA. Arguably, there is evidence to suggest that BMI is a risk factor for OSA (Koyama et al., 2012) and previous research has shown that OSA severity increases with body weight (Butner et al., 2013). Additionally, it has been suggested that the only effective method of reducing OSA severity is through weight-loss (Young et al., 2002). Interestingly, the capacity to exercise is thought to be associated with age and weight and therefore, those who are older and have higher BMI may find it harder to exercise (Butner et al., 2013). In contrast, it is also logical that those who do not engage in much physical activity might also develop a higher BMI (Hankinson et al., 2010). The present study partially confirms the theory of Butner et al. (2013) in that BMI was found to be associated with levels of PA, although the direction of causality between these variables obviously cannot be inferred. It might be assumed that low PA may play a part in the development of OSA, but its role in the development or prevention of OSA is unclear. Previous evidence has demonstrated a lack of clarity in the ability of PA to reduce OSA severity in those aged over 50 years old with or without weight-loss (Sengul et al., 2011, Schobersberger, 2013). The question as to whether PA or BMI form the strongest risk factor of OSA severity is difficult to entangle given the expected and observed correlation between the two, and this is illustrated by a recent review, which explored the capacity of PA to reduce OSA independent of BMI (Aiello et al., 2016). The review authors concluded that current evidence is inconclusive and that the benefits of PA to health are worth considering it a modifiable risk factor (Aiello et al., 2016). Encouragingly, there is evidence that PA may well protect or reduce the severity of OSA independently of weight loss, although it is generally agreed that the mechanisms by which this occurs are unclear (Kline et al., 2011, Simpson et al., 2015, Verwimp et al., 2013, Peppard and Young, 2004).

Given the low adherence to the present gold standard treatment of OSA (continuous positive airway pressure), it is necessary to consider alternative or additional methods of management that may alleviate OSA and reduce CVD risk (Butner et al., 2013). Spencer et al. (2016) support this consideration, noting the benefit of PA to reduce risk factors associated with OSA development (including higher BMI) and reduce negative health conditions as a consequence of OSA. Thus, it is possible that PA is associated with the development of OSA and is at least a factor to be explored with regard to promoting weight-loss and improving overall health in the prevention and management of OSA (Katzmarzyk and Lear, 2012, Aiello et al., 2016).

It is possible that other health behaviours such as diet, smoking, and alcohol consumption that were not included in the present study may have had a bearing on the results. However, Franklin and Lindberg (2015) suggest that smoking is not an established risk factor of OSA and the role of alcohol is unclear. Thus, with the exception of BMI, there was little evidence to suggest that confounding variables were an important consideration in measuring the association of OSA and PA in the participant group.

The present study is not without limitations. First, there is the obvious issue of reverse causation, making it difficult to infer whether low PA predicts OSA or vice versa, similarly with the link between BMI and PA, however, given that PA engagement is self-selected, only PA intervention randomized trials could start to shed light on the potential causal direction of effects, which is a future direction for this research. Second, the sample size is relatively small, making it possible that the association between PA and OSA severity was attenuated by BMI due to low power and reduced degrees of freedom. Indeed, the lack of evidence of mediation suggests this, and in fact makes it probable that both PA and BMI are independent contributors to OSA severity, although this would need to be confirmed in a larger study. If so, our mediation analysis might also suggest that PA may offer protection against OSA development even in those with a high BMI, although again this would need to be explored in a further study. Third, the majority of the participants demonstrated moderate levels of PA and mostly none or mild levels of OSA severity. Thus, it is possible that there were not sufficient participants with moderate to severe OSA in the group to provide a clearer outcome of the association between PA and OSA. However, a strength of the study is that all participants were in manual occupations and all were older than 50 years old, which is a neglected group; given the growing age of the workforce, older workers' health is becoming of paramount importance (Billett et al., 2011). Fourth, self-report measures of PA are limited due to risk of over-reporting and recall bias. However, the instrument used to assess PA in the present study is validated to be one of the best methods of self-report PA measures and provides detailed information on three areas of PA. Future research may benefit from using objective measures of PA.

Evidence in respect of the association between undiagnosed OSA severity and PA is limited. Only a few studies have used participants aged over 50 years old and of those, OSA has already been diagnosed or the sample size is very small (Redolfi, 2015, Simpson et al., 2015, Verwimp et al., 2013). Findings from the present study add to current research into OSA and PA and extend it by examining the presence of undiagnosed OSA and levels of PA in older manual workers. The results highlight the potential existence of OSA that may reside in those without a formal OSA diagnosis in older manual workers and its potential for further development if left untreated. Further, it emphasizes the role of PA and BMI in undiagnosed OSA in this participant group. Findings from the present study support previous research illustrating the high incidence of undiagnosed OSA in manual workers and in the UK (Webber et al., 2011, Rejon-Parrilla et al., 2014).

4.6. Conclusion

It is clear from the results that undiagnosed OSA exists in the group of older manual workers examined in the present study. Indeed, low levels of PA were found to be associated with increased severity of OSA. It should also be noted that BMI in the present study was a stronger indicator of OSA severity than PA and therefore future intervention guidance may prove confusing. However, given the negative health outcomes associated with OSA and the benefits that regular PA offers to physical health and mental wellbeing, as well as a method of reducing weight and thereby BMI, it is worthwhile considering low PA as a risk factor for OSA in older workers. Further, the outcome of the present study warrants the consideration of PA as a cost effective management treatment of OSA through aiding weight loss and promoting healthy cardiovascular function in this age group.

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CHAPTER FIVE

5.0. ACTIVITY TO REDUCE OBSTRUCTIVE SLEEP APNOEA IN OLDER WORKERS.

The presence of undiagnosed OSA and its association with low levels of PA and high BMI that were present in older manual workers form the basis for the final study in this thesis. The third study highlighted the pathway to CVD through which low levels of daily PA and high BMI in older workers are key triggers in the development of OSA, and potentially in turn CVD.

Although, it is the current gold standard treatment and is generally successful in offsetting the risk of CVD, adherence to continuous positive airway pressure (CPAP) for OSA, is poor. Given the associations between OSA, BMI and PA derived from study 3, the final study in this thesis investigated the ability of a 12-week PA intervention to reduce OSA severity either alongside a reduction or independently of BMI.

Activity to Reduce Obstructive Sleep Apnoea (AROSA): A pilot intervention

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5.1. Abstract

Obstructive Sleep Apnoea (OSA) is a recognized risk factor for the development of cardiovascular disease. Continuous Positive Airway Pressure, although effective as a treatment, has poor patient adherence. This pilot study investigated the ability of daily physical activity (PA) to reduce OSA in manual workers independent of weight-loss and BMI. Ten participants, (8 males) mean age 57.3, (6.01) with an apnoea/hypopnea index (AHI) of $\geq$15 were assigned to a 12-week daily PA intervention. Baseline scores of self-reported PA (IPAQ) were positively and significantly related to baseline AHI score $r(10) = 0.68$, $p = 0.03$. Results post intervention, demonstrated a significant difference in duration of activity from baseline (M = 109.0 min, SD = 61.64) to end of intervention (M = 227.0 min, SD = 140.0); $t(9) = -2.79$, $p = 0.02$. A significant difference was also found in RPE between baseline (M = 10.5, SD = 2.0) to end of intervention (M = 14.0, SD = 1.50); $t(9) = -6.53$, $p = 0.00$. No significant differences were found for BMI, bodyweight or body fat percentage during this time. A paired samples t-test demonstrated a significant reduction in OSA severity (AHI), from baseline (M = 23.0, SD = 7.02) to end of intervention (M = 16.0, SD = 7.09); $t(9) = 2.22$, $p = 0.05$. The reduction of OSA severity was independent of BMI, bodyweight and fat percentage. Conclusion: Findings from this pilot study suggest that general daily, unstructured PA may offer a cost-effect pathway to reduce OSA and improve cardiovascular health.

Keywords: ***physical activity; obstructive sleep apnoea; cardiovascular disease; sleep disorders; ageing workers.***

5.2. Introduction

Obstructive Sleep Apnoea (OSA) is a respiratory sleep disorder characterized by recurrent and repetitive cessation of airflow (apnoea), or reduction of airflow (hypopnoea), during sleep owing to obstruction caused by upper airway collapse (Al Lawati et al., 2009). The severity of OSA ranges from mild to severe and is defined by sleep related obstructive breathing events per hour as measured by the Apnoea Hypopnoea Index (AHI); such that Mild is classified as 5 to 15 events/hour, Moderate as 15 to 30 events/hour and Severe as at least 30 events/hour (AASM Task Force, 1999). It is estimated that 3% to 7% of the UK adult population suffer from OSA, whilst a large majority of sufferers (85%) remain undiagnosed (Punjabi, 2008, Rejon-Parrilla et al., 2014). Additionally, it is estimated that 9% of middle-aged men and 4% of middle-aged women of the overall population are reported to suffer from moderate to severe OSA (Al Lawati et al., 2009).

Since OSA is associated with many negative health outcomes including increased risk of cardiovascular disease (CVD) (Floras, 2014), Type-2 Diabetes (Pamidi and Tasali, 2012) and hypertension (Zhang and Si, 2012), it has serious implications for health and wellbeing across the lifespan. Of particular concern is the health and wellbeing of older workers aged 50 years and over. With the ever-growing ageing population, the original age of retirement (men aged 65years and women aged 60 years) has now been phased out and older workers are being encouraged to continue working for as long as possible in order to sustain the UK economy (Government Office for Science, 2016). Thus, the health and wellbeing of this group is of paramount importance if they are to remain efficient within the workforce.

The ageing process predisposes an individual to health problems and chronic diseases (Ilmarinen, 2012). As such, it is important to understand the additional risks that ageing poses on the cardiovascular system in respect of OSA. Ageing is associated with structural changes within the cardiovascular system, most notably the gradual dilation and hardening of the arteries, a process known as arteriosclerosis (McEniery et al., 2007). Meanwhile, the intermittent hypoxia that occurs in those with OSA causes oxidative stress, metabolic derangement and endothelial damage within the vascular system (Sawatari et al., 2016, Kendzerska et al., 2014). Thus, together with the cardiovascular effects of ageing, OSA is a likely pathway to exacerbating the risk for future CVD in older workers.

One of the main risk factors for the development of OSA is obesity (Rejon-Parrilla et al., 2014). Excess bodyweight that increases the circumference of the neck region predisposes the individual to upper airway obstruction when sleeping (Young, 2004). It is also possible that overweight individuals may not exercise regularly and as a result have poor cardiovascular health and airway tone (Butner et al., 2013). Although recent research supports the theory that obesity is the main indicator for OSA (Tan et al., 2015), there is evidence to suggest that a lack of regular physical activity (PA) (five days of 30 minute moderate to vigorous intensity) increases the potential for OSA development (Simpson et al., 2015, Verwimp et al., 2013, Peppard and Young, 2004).

Currently, the gold standard treatment for OSA is continuous positive airway pressure (CPAP), which has demonstrated success in treating OSA when worn consistently over a period of time (four hours per night for 70% of nights (Sawyer et al., 2011) However, due to noise issues, discomfort with the mask and the general intrusion of the machine during sleep time, overall adherence to treatment is often poor (Cvengros et al., 2016, Tyrrell et al., 2006, Yetkin et al., 2008). Indeed, it has been suggested that approximately 20% of patients reject the treatment and a further 30% terminate its use within a year (Engleman and Wild, 2003).

Recent research has begun to explore the ability of PA to reduce OSA either alone, or in conjunction with other lifestyle changes (i.e. diet) in place of treatments such as CPAP (Thomasouli et al., 2013, Gozal, 2015, Dobrosielski et al., 2015). Indeed, changes in lifestyle behaviours including diet and exercise have been shown to be successful in reducing OSA (Thomasouli et al., 2013). Interestingly, several studies have highlighted the potential of PA to reduce OSA severity or even prevent its development independent of weight loss (Aiello et al., 2016, Iftikhar et al., 2014, Giebelhaus, 2000, Kline et al., 2011, Sengul et al., 2011). However, given the risk to cardiovascular health presented by OSA, the need for further research is growing (Aiello et al., 2016, Araghi et al., 2013). From the current evidence that PA can reduce OSA, the levels (i.e. amount, intensity, duration) of PA and mechanisms are unclear. For instance, although most of the above studies utilized supervised interventions, the review of Aiello et al. (2016) also included two studies with unsupervised interventions and crossed an age range of 32 to 54 years old. Additionally, the varied methods in which interventions were directed such as PA duration, frequency of days and type of exercise e.g. aerobic or resistance training or a combination of the two, render the current evidence inconclusive. The above-mentioned studies have largely explored the use of supervised PA interventions ranging from eight weeks to 12 weeks and from a frequency of two days to seven days per week and with varying durations. However, it is believed that more regular movement throughout the 24-hour daily period such as frequent walking is more beneficial to health as opposed to one moderate to vigorous session (Chaput et al., 2014). Indeed, Redolfi (2015) suggests that daily walking is a marker of musculovenous pump activation. The author demonstrated that regular walking encourages a reduction in rostral fluid shift from the legs at

night, which reduced the fluid accumulation, and subsequently around the pharyngx. Interestingly, this was found to reduce OSA independently of weight loss. Earlier research has also proposed that PA reduces OSA by strengthening and increasing fatigue resistance of the ventilatory and upper airway dilator muscles (Vincent et al., 2002). Additional research has demonstrated that regular aerobic exercise increases exercise capacity and improves breathing abnormalities during sleep (Yamamoto et al., 2007). Kline et al. (2011) similarly demonstrated an increase in global respiratory strength following a 12 week supervised PA intervention. It is also implied that walking and activities of daily living are easier to work into day to day life than structured exercise sessions and thus, are likely more sustainable over time (Chaput et al., 2014).

The current guidelines for daily PA advise 30 minutes of moderate to vigorous activity five days per week to preserve health (American College of Sports Medicine, 2011). Further, it has also been suggested that mild to moderate PA is a safe way to manage OSA in those aged 50 years and older (Giebelhaus, 2000). Notably, older workers with high occupational activity (e.g. repetitive awkward movements, heavy lifting, etc.) but low levels of leisure PA are reported to be at increased risk of long-term sickness absence (Leino-Arjas et al., 2004, Holtermann et al., 2012b, Krause et al., 2007). With this in mind, the aim of the present study was to determine whether a 12-week unsupervised physical activity intervention would reduce the severity of OSA independent of weight-loss or body mass index (BMI) in older manual workers.

5.3. Methods

5.3.1. *Participants*

Participants were recruited from a range of occupations e.g. construction, prison service via posters and leaflets. Those who were employed for at least three months before the start of the study, had no previous diagnosis or treatment for obstructive sleep apnoea (OSA) and were willing to be screened for suitability for a 12-week physical activity (PA) intervention were eligible for the study and invited to wear an ApneaLink™ device for one night to assess for presence and severity of OSA. Exclusion criteria included those younger than 50 or older than 69 years old, unemployed or in employment less than three months at commencement of study, had history of chest pain during exercise or heart trouble, or with a diagnosis of and currently undergoing treatment for OSA.

5.3.1.2. Intervention Selection

Following screening, ten participants (mean age 57.3 (6.02) years, 8 males), with an AHI score greater than 15, were recruited in the intervention.

5.3.1.3. Study Design

This intervention study was designed to test the effectiveness of a 12-week physical activity intervention to reduce the severity of previously undiagnosed moderate to severe OSA as measured through AHI score. Written informed consent was given and the University of Birmingham STEM ethics committee approved the study.

5.3.2. Measures

5.3.2.1. *Subjective Physical Activity*

The short form International Physical Activity Questionnaire (IPAQ) was used to measure habitual levels of physical activity over the last seven days. The IPAQ short form has been tested in 12 countries and has been shown to produce good repeatable (75%) and reliable data in middle aged employed samples (Craig et al., 2003) with median internal consistencies of $\alpha = .80$. Concurrent validity and criterion validity have been supported; the scale can correctly classify low, moderate and high intensity activity (Craig et al., 2003). The Cronbach's alpha for internal consistency in the present study was $\alpha = .77$.

5.3.2.2. *Percentage Increase in Daily Physical Activity*

Borg's Rating of Perceived Exertion (RPE) scale was used to assess physical activity intensity as perceived by participants. Borg's RPE is an affordable and reliable method of measuring subjective perceived effort during exercise and has been demonstrated as a valid measure of intensity relating to heart rate (Scherr et al., 2013).

5.3.2.3. *Anthropometric Measures*

Height and weight were measured before the intervention commenced to calculate body mass index (BMI) (kg/m^2). Electronic scales with bioelectrical impedance analysis (Salter Ultra Slim Glass Analyser scales, model 9141, HoMedics Group Ltd., Kent, UK) were used to measure weight, body fat percentage (through bioelectrical impedance). A Bosch PLR 30c Laser Measure (Robert Bosch GmbH, Germany) was used to measure height.

5.3.2.4. Obstructive Sleep Apnoea (OSA)

Participants were scored for OSA using an ApneaLink™ device. The device has been shown to be a cost effective, reliable and valid method of detecting the presence and risk of OSA in patients aged $\geq$50 years (Clark et al., 2009). It has a sensitivity for AHI > 10 of 92-100% and a specificity of 87 – 96.7% for participant compliance (Clark et al., 2009, Crowley et al., 2013, Patel et al., 2007). OSA presence and severity was basedon AHI (Punjabi, 2008). Apnoea was defined as a reduction in flow to less than 20% of normal and hypopnea as a reduction in flow to 20-50% of normal. Pulse oximetry data became indicative for the presence of OSA when during apnoeas and hyponeas saturation dropped by more than 5% below normal. In respect of AHI, OSA severity was defined as follows: AHI of 5-15 per hour assessed as mild OSA, AHI of 15-30 per hour as moderate OSA and AHI > 30 per hour as severe OSA (AASM Task Force, 1999, Chowdhuri et al., 2016).

5.3.2.5. *Objective Physical Activity*

GT3X accelerometers (ActiGraph, Pensacola, FL, USA) were used to validate subjective reports of PA and intensity. The GTX3 has demonstrated high intra and inter-instrument reliability with an intra-class correlation coefficiency for activity counts of 0.97 (Santos-Lozano et al., 2012). The accelerometer was worn as a belt on the right hip and collected motion data as suggested by (Cain and Geremia, 2011). Activity counts were produced as a result of the summed acceleration measured in the duration of collection over seven days and represented a measure of activity over time. Cut-points of $\leq$ 1951, 1952 – 5724, $\geq$ 5725 for light, moderate and vigorous intensity respectively, were used to determine levels of low, moderate and vigorous intensity physical activity (Freedson et al., 1998, Cain and Geremia, 2011).

5.3.3. *Procedure*

Overnight screening indicated eligible participants with an AHI of $\geq$ 15 who were then invited to take part in the intervention. Prior to the intervention, a screening questionnaire pertaining to the participants' general health was administered and baseline anthropometric measurements were recorded. All participants (n = 10) were invited to complete a questionnaire to measure current daily physical activity levels.

Over the following 12 weeks, participants increased the frequency, duration and intensity of their current PA levels (e.g. taking the stairs instead of the lift) (Table 1). Borg's Rating of Perceived Exertion (RPE) was used to gauge appropriate % increase in intensity ranging from a score of 9 to a score of 16. A score of 9 to 11 level of increase in intensity was deemed suitable for less trained individuals or where OSA may reduce aerobic capacity; this was advised at the start of the intervention and then increased upwards as required (Scherr et al., 2013, Ucok et al., 2009). The group was asked to report their total daily amount of PA and intensity (RPE) as two numbers to the mobile phone of the researcher via text message. Levels of PA were monitored by GTX3 accelerometers at three time points for 7 days (during weeks 1,6, and 12) to validate self-reported PA. Participants were asked to wear the accelerometer on a belt on the right hip from the moment they got up until they went to bed. Removal of the accelerometer was instructed for showering, bathing and swimming. Total minimum wear time required was 12 hours for seven days (Cain and Geremia, 2011). At the end of each seven days the researcher collected and downloaded the recorded data from the accelerometer. The accelerometer data was then compared to the self-report PA scores. At the end of the 12 weeks, post intervention measurements including AHI were taken as described earlier and compared to those at baseline to assess effectiveness of the intervention.

Table 5.1. Structure of 12-Week Physical Activity Intervention

Weeks	Duration (Mins)	RPE	Frequency (days per week)
1-4	10-15	9	3
5-8	15-20	9-13	4
9-12	30	13	5

RPE = Rate of Perceived Exertion.

5.3.4. Data Analysis

Data analysis was performed using IBM SPSS Statistics software version 25. Bivariate correlations were used in the first instance to assess relationships between all of the variables at baseline. Paired samples t-tests were performed to assess change of PA levels over time in minutes and perceived exertion (RPE) from beginning to end of intervention. The same tests were also used to investigate change in OSA severity, PA, BMI and weight pre and post intervention. Significance was assumed where $p = \leq 0.05$. In order to test for potential confounding variables, a repeated measured ANOVA was performed.

5.4. Results

5.4.1. Descriptive Statistics

Descriptive statistics for all participants are shown in Table 2. Ten participants (8 males) completed the intervention. Participants were non-smokers with a mean age of 57.3 (6.01) years. Mean BMI, weight (kg), body fat percentage, and AHI at baseline were 33 (kg/m^2), 97 (kg), 46% and 23, respectively, indicating that participants were obese with moderate OSA. PA scores at baseline were reported as moderate, whilst alcohol intake was reported at six to ten units per week with a frequency of alcoholic drinks once or twice per week.

Table 5.2. Descriptive statistics of the sample (n = 10)

Variable	Mean/N	SD/%
Age	57.3	6.01
Males	8	80%
BMI (kg/m^2)	33	7.23
Weight (kg)	97	17.69
Bodyfat (%)	46.1	15.30
AHI Score (OSA)	23	6.99
Physical Activity (PA)	2	0.47

5.4.2. OSA and Physical Activity Levels

Bivariate correlations were used in the first instance to assess relationships between all of the variables at baseline. Baseline self-reported PA (IPAQ) was positively and significantly related to baseline AHI score $r(10) = 0.68$, $p = 0.03$.

5.4.3. Physical Activity Duration (minutes) and Intensity (RPE)

A paired samples t-test revealed there was a significant difference in minutes per week of activity from baseline (M = 109.0, SD = 61.64) to the end of the intervention (M = 227.0, SD = 140.0); $t(9) = -2.79$, $p = 0.02$, such that PA duration had increased from baseline to end of intervention. A significant difference was also found in RPE between baseline (M = 10.5, SD = 2.0) to end of intervention (M = 14.0, SD = 1.50); $t(9) = -6.53$, $p < 0.01$, such that RPE increased from baseline to end of intervention. Time spent in light PA was confirmed by accelerometer in week one with an average count per week of 1515 indicating light PA as defined by Freedson et al. (1998). Additionally, week 12 was validated by accelerometry with an average count of 2060 indicating moderate PA (Freedson et al. 1998).

5.4.4. BMI, Weight and Body Fat

Paired-samples t-test also demonstrated that there were no significant differences in BMI, bodyweight or body fat percentage between baseline and end of intervention. Further, analysis given below demonstrate the potential interaction of these variables on OSA reduction.

5.4.5. OSA and Physical Activity Intervention

A paired samples t-test was also used to assess the effect of the PA intervention on OSA severity. There was a significant reduction in OSA severity (AHI), from baseline (M = 23.0, SD = 7.02) to end of intervention (M = 16.0, SD = 7.09); $t(9) = 2.22$, $p = 0.05$. In order to assess any confounding effects of BMI, bodyweight and body fat on the reduction of OSA severity, repeated measures ANOVA tests were performed, examining each potential confounding variable in turn. Results demonstrated that reduction of OSA severity was independent of BMI, bodyweight and fat percentage, such that the addition of covariates did not change the significance of the effect of PA on OSA severity.

5.5. Discussion

The present study investigated the ability of a 12-week PA intervention to reduce the severity of OSA. To our knowledge, the present study is the first to investigate the ability of a 12-week, unstructured daily PA intervention by manipulating duration and intensity of PA, for the reduction of OSA. Our findings confirm that a 12-week unsupervised PA intervention is effective in reducing OSA severity independent of BMI and weight-loss. This is in support of previous evidence which demonstrates that exercise is effective in reducing OSA severity in those with moderate to severe sleep apnoea independent of anthropometric changes (de Andrade and Pedrosa, 2016, Iftikhar et al., 2014, Kline et al., 2011), and in contrast to other research, which states exercise alone is not sufficient to reduce OSA severity (Iftikhar et al., 2017). Previously, weight-loss has been deemed a necessary addition to regular aerobic and or resistance exercise in the reduction of OSA severity. For example, (Gozal, 2015) suggests that even minor weight loss combined with PA is a favourable way to reduce OSA. Thomasouli et al. (2013) add support to this in their review of the impact of diet and lifestyle management strategies for OSA. However, the review only included six studies, which covered interventions ranging from two to 18 months, and so it is difficult to generalize these findings in terms of efficacy of interventions. A recent meta-analysis, which compared the effects of diet and exercise training to CPAP, suggested that exercise training could be used as an adjunctive to CPAP and thus, not an alternative (Iftikhar et al., 2017). Therefore, it seems that the role of PA as a sole intervention for the management of OSA is inconclusive (Aiello et al., 2016) Nonetheless, it would appear that in support of the present study, general consensus is that regular exercise/PA is necessary for the benefit of cardiovascular health and cannot be ruled out as a potential way in which, OSA could be potentially managed or even be prevented without the use of low calorie diets or surgical intervention (Aiello et al., 2016).

Previously, there have been many suggestions as to the mechanisms by which PA helps to reduce OSA, such as upper airway adaption and rostral fluid shift (Redolfi, 2015, Vincent et al., 2002). Although, the present study did not investigate the mechanism by which PA reduced OSA severity in its participants, it adds to existing literature into the ability of exercise to reduce OSA severity independent of BMI change and weight-loss and supports the suggestions above of (Aiello et al., 2016). The present study also furthers current evidence, by investigating the effects of PA on OSA in older manual workers who are an underserved population in this area of research. Indeed, older manual workers have been previously demonstrated to have low levels of leisure time PA, thus, together with their increasing age, older manual workers are likely candidates for OSA development (Fleg and Strait, 2012, Leino-Arjas et al., 2004, Ejaz et al., 2011). Previous research into exercise as an intervention for OSA management, has largely used structured/planned supervised exercise, and although indications are positive in this effect, it is unknown as to whether participants are likely to adhere to such structure beyond intervention end (Thomasouli et al., 2013, Sengul et al., 2011, Kline et al., 2011, Giebelhaus, 2000). Thus, more longitudinal studies are necessary in this respect to determine this outcome. Additionally, findings from the present study demonstrate the potential of daily-unstructured PA to reduce OSA severity. This is encouraging, since daily general PA such as walking, using the stairs instead of lifts, may be easier to incorporate into daily life and therefore, more sustainable in the long-term, as opposed to structured exercise which requires planning. Indeed, Chaput et al. (2014) suggests that PA spread over a 24-hour period may be more beneficial to health than single bouts of planned exercise.

The present study also offers support to the recommendations of daily levels of PA to preserve health and prevent disease and demonstrates that the recommended daily activity levels for adults may be sufficient to reduce or potentially prevent OSA and its development. Further, the contribution of regular daily PA, may offer an alternative means of OSA management, especially for those who find they cannot tolerate treatments such as CPAP and also help to offset the risk of CVD in OSA sufferers (Aiello et al., 2016, Eckel et al., 2014). It has also previously been suggested that regular PA may improve inflammatory profiles associated with OSA and CVD such as activation of the peripheral nervous system and others that predispose an individual to vascular damage (Alves Eda et al., 2013). Although CPAP is still the recommended gold standard treatment for OSA management, it does not promote the participation of regular physical activity, which has far reaching benefits for health and wellbeing (Mendelson et al., 2018).

5.5.1. Limitations

It must be noted that the present study is not without limitations. Firstly, the sample size was small and thus, findings from the present study cannot be generalized to other groups. However, the present study is a pilot study and thus, may serve as a platform to guide similar interventions in this age group. Secondly, the daily PA duration and intensity across the 12 weeks were self–reported and so may be prone to recall bias and over-reporting. However, the PA levels were validated at three time points across the intervention with accelerometers and as such validate the reported levels of PA. The present study demonstrated a significant increase in activity levels and change in OSA severity post-intervention independent of change in BMI and weight-loss. Further, the changes demonstrated in OSA severity (which cannot be manipulated or influenced) suggest that intervention PA adherence was good. A lack of control group is also a limitation of the present study. However, the ethical issue of finding presence of OSA within control group participants and not providing the opportunity for those individuals to participate in the intervention is questionable. The strengths of the present study should also be noted. To our knowledge, this is the first pilot study that has used unstructured general PA to reduce OSA. Additionally, all of the participants were older workers, aged 50 years and over who were not undergoing any treatment for OSA.

5.5.2. Conclusion

The present study demonstrated that a 12-week PA intervention using general daily PA has the ability to significantly reduce OSA in this participant group independent of weight-loss and BMI. This suggests that incorporating more general activity during daily life may prove a feasible route to the management of OSA, and should therefore, be given strong consideration as a primary cost-effective method of treatment.

5.6. References

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CHAPTER SIX

6.0. DISCUSSION

6.1. Summary Of Main Findings

The present thesis consists of four empirical studies contributing to four chapters. In study one, a person-centred approach was used to explore typologies of older manual workers based on presenteeism, stress resilience and PA. The study also explored the difference between profiles in socio-demographic characteristics (age, gender, education, job role) as a means of identifying profiles at risk of ill-being. It was hypothesized that one profile would exhibit high levels of sport, low levels of presenteeism and high levels of resilience and that another profile would exhibit characteristics the reverse of this. A second hypothesis indicated that profiles would differ on perceived health and work-related affect. In confirmation of the second hypothesis, results demonstrated that profiles differed on work-related affect and health perceptions. Further, the first hypothesis was partially confirmed in that one profile displayed high levels of PA, low levels of presenteeism but low levels of resilience. Findings from this study support previous research that indicates high levels of PA are associated with low levels of presenteeism (Cancelliere et al., 2011, Schultz and Edington, 2007).

Given that the role of stress resilience was unclear in study one and that work related stress is associated with presenteeism, study two explored the relationship between perceived psychological resilience and work-related factors (presenteeism and work engagement) and the physiological response to acute psychological stress, in older manual workers in the UK. In study two it was hypothesized that those with a maladaptive response to acute psychological stress would have low perceived stress resilience and low positive work-related factors. Results demonstrated that perceived psychological resilience was not associated with work-related factors or reactivity. Workers with higher positive work-related factors (high work engagement, low presenteeism) had lower cardiovascular reactivity. In contrast, workers with high presenteeism had high heart rate reactivity. In light of these findings and the increased risk to cardiovascular health that ageing presents, the risk of poor sleep quality and thus, the breathing sleep disorder of OSA, that also predisposes an individual to CVD was explored next.

Study three investigated the association of PA levels, BMI and undiagnosed OSA (AHI $\geq$ 5) in a group of older manual workers. It was hypothesized that those with a presence of undiagnosed OSA would report low levels of PA independent of BMI. The preliminary results indicated that undiagnosed OSA was associated with low levels of PA, however, BMI proved to be the stronger indicator, implying that PA may be a modifiable risk factor in the development of OSA. Further, mild OSA was found in those with a BMI lower than that classified as obese (>30kg/m^2), suggesting that BMI may not be the sole trigger for OSA development.

As a result of the findings of study three, study four investigated the ability of a 12-week PA intervention to attenuate untreated moderate to severe OSA. It was hypothesized that a gradual percentage increase in intensity and duration in general daily PA over 12 weeks, would reduce the severity of OSA independent of BMI or weight change. Results indicated that the PA intervention significantly reduced OSA independent of BMI and weight change and thus, offers a potential means of OSA management.

6.2. Stress Resilience, Presenteeism and Physical Activity.

Chapters two and three of this thesis explored the role of stress resilience in relation to work, health and wellbeing in older manual workers. The study in chapter two used a novel person-centred approach to provide understanding of the health and wellbeing profiles of older manual workers. The study aimed to identify individuals who might be at the highest risk of ill-health and used this information to inform potential areas of research for the rest of this thesis. Health and wellbeing profiles in this study were based on resilience, presenteeism, and different domains of PA. All four profiles differed on aspects of self-rated health and wellbeing. In line with previous research, the lowest levels of presenteeism were found in the group with the highest levels of sport/exercise participation (Cancelliere et al., 2011, Schultz and Edington, 2007). Conversely, those with the highest levels of presenteeism in the form of stress or anxiety showed only moderate levels of PA implying that higher levels of PA may be necessary to improve health and wellbeing (Gerber et al., 2013, Gerber et al., 2014a). Additionally, stress resilience was not found to discriminate between the profiles and thus, did not serve as a particularly meaningful resource in the protection against presenteeism in this sample. This may have been due to heterogenous needs of individuals in the sample, which may be hidden in a larger group of participants (Bal and Jansen, 2015). Chapter two adds to current literature on presenteeism which, to date, is limited in terms of whether resilience has an important role in presenteeism; although recent research, has demonstrated early signs of decreasing presenteeism via resilience training (Johnson et al., 2015).

Additionally, findings from chapter two imply that increasing PA in older manual workers may be a possible route for intervention and promotion of health and wellbeing in older manual workers. Notably, the results of chapter two demonstrate the usefulness of latent profile analysis to identify individuals who may be at risk of negative wellbeing and poor health which helps inform further research into variables such as resilience and stress. Consequently, the explorative nature of chapter two provides the basis for more detailed examination in the chapters beyond. Chapter two also emphasized the effect of ageing in older manual workers, such as loss of physical strength and cardiorespiratory fitness and how poor lifestyle behaviours impact on health and wellbeing in the workplace (Ilmarinen, 2001, Savinainen et al., 2004). Chapter three expanded the investigation into resilience and presenteeism and included another relevant work-related variable - work engagement. Together the three variables were examined in relation to stress reactivity.

6.3. Resilience, Reactivity and the Risk to Work Related and Cardiovascular Health.

Since there is considerable evidence linking job strain (work stress) to increased risk of cardiovascular disease (CVD) (Flynn and James, 2009, Steptoe and Willemsen, 2004, Steptoe, 2001, Clays et al., 2007, Landsbergis et al., 2013), chapter three examined perceived stress resilience, presenteeism, and work engagement and the physiological response to acute psychological stress as a potential mechanism linking work-related factors and CVD. Similar to the results in chapter two, the results for chapter three also demonstrated no significant association between resilience and presenteeism or work engagement. However, there was a significant association between presenteeism, work engagement and stress reactivity. The manual workers with higher presenteeism and lower work engagement in this study displayed increased levels of heart rate reactivity and blood pressure reactivity in response to acute psychological stress, demonstrating the physiological effect of psychological stress associated with work in this participant sample. This outcome also supports previous evidence indicating the association between higher work engagement and lower presenteeism (Admasachew and Dawson, 2011). Importantly, individuals with higher levels of presenteeism and lower work engagement increase their risk of ill-health if these exaggerated physiological responses to acute stress exposures persist over time (McEniery et al., 2007, Treiber et al., 2003). The physiological response to psychological stress highlights the way in which work-related stress, specifically low work engagement and high presenteeism may be a pathway to CVD risk in manual workers (Tsutsumi et al., 2011). The findings also extend the existing research into negative health outcomes associated with presenteeism as well as those linking work-related stress to cardiovascular reactivity (Callen et al., 2013, Cancelliere et al., 2011, Leineweber et al., 2011). Although, in contrast to the study of Galatzer-Levy et al. (2014), results in chapter three showed no relationship between psychological resilience and cortisol (stress) reactivity, however, participants in chapter three, who lived alone displayed an exaggerated cortisol response to the stressor relative to married participants. This additional finding is important since it indicates a risk of immune suppression and future hypertension among more isolated adults (Fan et al., 2009, Hamer and Steptoe, 2012). It also lends support to the buffering effect of social support for the impact of stress on health, since married participants in chapter three mounted a healthy moderate cortisol response to the acute stressor, indicating an appropriate stress response (Phillips et al., 2005, Carroll, 2009). Interestingly, resilience was not associated with marital status in chapter three. However, it is evident from the findings and from previous research that spouse/marital support has a bearing on how an individual responds to psychological stress (Bonanno et al., 2007, Corina and Adriana, 2013, Phillips et al., 2006).

Together, chapters two and three demonstrated that the psychological and physiological effects of job-related stress, which, combined with age-related changes to the cardiovascular system, may further interact with poor health behaviours and lifestyle choices, such as low physical activity, and thus, increase the risk of CVD. As such, the outcomes from chapters two and three prompted the consideration of other potential lifestyle risk factors that may also play their part in the development of CVD in this age group. In addition to low physical activity, poor sleep has been linked to numerous health issues including the production of higher cortisol levels, which causes wear and tear physiologically (Stanley, 2005). OSA in particular is associated with an increased risk of CVD (Floras, 2014) and hypertension (Zhang and Si, 2012). Thus, to continue the investigation of health behaviours and CVD development in older manual workers, chapters four and five in this thesis were concerned with the relationship between undiagnosed OSA, body mass index (BMI) and the role of PA.

6.4. Obstructive Sleep Apnoea, Physical Activity and BMI.

The passing of age (from 30 years old and beyond) brings with it structural changes to the cardiovascular system and as such lends itself to potential risks for CVD development such as arterial stiffness and thickening (Fleg and Strait, 2012, McEniery et al., 2007). Additionally, a recognized risk factor for OSA development is advancing age; diagnosis of OSA is often in the mid fifties, although many people in the UK remain undiagnosed (Rejon-Parrilla et al., 2014). As such, chapter four investigated the presence of undiagnosed OSA in association with reported levels of daily PA and BMI in older manual workers. Findings from the study demonstrated that a lack of regular PA and a high BMI in older manual workers was associated with the increased risk for OSA development. The findings were in line with previous research and also provided evidence to suggest that low levels of PA are associated with increased severity of OSA (Peppard and Young, 2004, Verwimp et al., 2013, Gram et al., 2016, Leino-Arjas et al., 2004). Interestingly, the study of Tan et al. (2015) disagreed and suggested that obesity is a more likely cause for OSA. Webber et al. (2011), also found evidence of undiagnosed OSA in those with a high BMI (>30kg/m^2). The implication that obesity is a stronger cause for OSA than PA was highlighted in the study of chapter four which also found BMI to be the stronger predictor of OSA than PA. However, the sample size within the study was only moderate, thus resulting in reduced power to find effects and so may explain this outcome to a degree. Further, BMI is a multi-faceted variable, which may contribute through non-PA-related mechanisms to OSA severity. However, the findings in chapter four also found undiagnosed OSA occurrence in those with a lower BMI than those classified as obese. Additionally, although PA was a predictor of OSA, BMI was the stronger predictor. This in itself suggests that BMI may indeed not be the sole trigger for the development of OSA and, as such, lends support to the fact that it is difficult to separate the contribution of BMI and PA mechanisms to OSA severity. Further, participants in chapter four without OSA engaged in significantly higher levels of PA than those with moderate OSA. Interestingly, the capacity to exercise is thought to be associated with age and weight, in that those who are older and have a higher BMI may find it difficult to exercise (Butner et al., 2013). In contrast, it is also logical that those who do not engage in much PA might also develop a higher BMI (Hankinson et al., 2010). Although, it might be assumed that low PA levels may play a part in the development of OSA and its severity, its role is unclear. This has been highlighted in previous studies where a lack of clarity exists in the ability of PA to reduce OSA severity in those aged over 50 years irrelevant of weight-loss (Schobersberger, 2013, Sengul et al., 2011). As to whether PA or BMI form the strongest risk factor of OSA severity is difficult to determine given the observed relationship between the two. In their review, Aiello et al. (2016), concluded that current evidence of the ability of PA to reduce OSA independent of BMI is inconclusive and that the benefits of PA to health are worth considering it a modifiable risk factor in interventions. Encouragingly, there is evidence to suggest that PA may protect or reduce the severity of OSA independently of weight loss, although the mechanisms by which this occurs are also unclear (Kline et al., 2011, Kline et al., 2017, Verwimp et al., 2013, Peppard and Young, 2004, Simpson et al., 2015).

Given the low adherence to the present gold standard treatment of OSA (CPAP), it is necessary to consider alternative or additional methods of management such as PA that may alleviate OSA and reduce CVD risk (Butner et al., 2013). Spencer et al. (2016) support this consideration, noting the benefit of PA to reduce risk factors associated with OSA development (including higher BMI) and reduce health conditions such as CVD as a consequence of OSA. Given the uncertainty about PA being associated with the development of OSA, and that it is at least a factor to be explored with regard to promoting weight-loss and improving overall health in the prevention and management of OSA (Aiello et al., 2016, Katzmarzyk and Lear, 2012), the final study in chapter five of this thesis has emerged. Since the majority of participants in chapter four were found to have none or mild levels of OSA severity, it is possible that there were not sufficient participants with moderate to severe OSA in the group to provide a clearer understanding of the association between PA and OSA. Thus, chapter five explored the ability of PA to reduce moderate to severe OSA independent of BMI in a group of older workers through a 12-week PA intervention.

6.5. Physical Activity, OSA and Ageing Workers

The study in chapter five investigated the ability of a 12-week PA intervention to reduce the severity of OSA. The 12-week, unstructured daily PA intervention manipulated duration and intensity of PA, for the reduction of OSA. Findings confirmed that a 12-week unsupervised PA intervention is effective in reducing OSA severity independent of BMI and weight-loss. This was in support of previous evidence which demonstrates that exercise is effective in reducing OSA severity in those with moderate to severe sleep apnoea independent of anthropometric changes (de Andrade and Pedrosa, 2016, Iftikhar et al., 2014, Kline et al., 2011), and in contrast to other research, which states exercise alone is not sufficient to reduce OSA severity (Iftikhar et al., 2017). Previously, weight-loss has been deemed a necessary addition to regular aerobic and or resistance exercise in the reduction of OSA severity. For example, (Gozal, 2015) suggests that even minor weight loss combined with PA is a favourable way to reduce OSA. Thomasouli et al. (2013) add support to this in their review of the impact of diet and lifestyle management strategies for OSA. However, the review only included six studies, which covered interventions ranging from two to 18 months, and so it is difficult to generalize these findings in terms of efficacy of interventions. A recent meta-analysis, which compared the effects of diet and exercise training to CPAP, suggested that exercise training could be used as an adjunctive to CPAP and thus, not an alternative (Iftikhar et al., 2017). Therefore, it seems that the role of PA as a sole intervention for the management of OSA is inconclusive (Aiello et al., 2016) Nonetheless, it would appear that in support of the study in chapter 5, general consensus is that regular exercise/PA is necessary for the benefit of cardiovascular health and cannot be ruled out as a potential way in which, OSA could be managed or even prevented without the use of low calorie diets or surgical intervention (Aiello et al., 2016).

Previously, there have been many suggestions as to the mechanisms by which PA helps to reduce OSA, such as upper airway adaption and rostral fluid shift (Redolfi, 2015, Vincent et al., 2002). Although, chapter five did not investigate the mechanism by which PA reduced OSA severity in its participants, the study adds to existing literature into the ability of exercise to reduce OSA severity independent of BMI change and weight-loss and supports the suggestions above of (Aiello et al., 2016). The study also furthers current evidence, by investigating the effects of PA on OSA in older manual workers who are an underserved population in this area of research. Indeed, older manual workers have been previously demonstrated to have low levels of leisure time PA, thus, together with their increasing age, older manual workers are likely candidates for OSA development (Fleg and Strait, 2012, Leino-Arjas et al., 2004, Ejaz et al., 2011). Previous research into exercise as an intervention for OSA management, has largely used structured/planned supervised exercise, and although indications are positive in this effect, it is unknown as to whether participants are likely to adhere to such structure beyond intervention end (Thomasouli et al., 2013, Sengul et al., 2011, Kline et al., 2011, Giebelhaus, 2000). Thus, more longitudinal studies are necessary in this respect to determine this outcome. Additionally, findings from the final study in chapter five, demonstrate the potential of daily-unstructured PA to reduce OSA severity. This is encouraging, since daily general PA such as walking, using the stairs instead of lifts, may be easier to incorporate into daily life and therefore, more sustainable in the long-term, as opposed to structured exercise which requires planning. Indeed, Chaput et al. (2014) suggests that PA spread over a 24-hour period may be more beneficial to health than single bouts of planned exercise.

Chapter five also offers support to the recommendations of daily levels of PA to preserve health and prevent disease and demonstrates that the recommended daily activity levels for adults may be sufficient to reduce or potentially prevent OSA and its development. Further, the contribution of regular daily PA, may offer an alternative means of OSA management, especially for those who find they cannot tolerate treatments such as CPAP and also help to offset the risk of CVD in OSA sufferers (Aiello et al., 2016, Eckel et al., 2014). It has also previously been suggested that regular PA may improve inflammatory profiles associated with OSA and CVD such as activation of the peripheral nervous system and others that predispose an individual to vascular damage (Alves Eda et al., 2013). Although, CPAP is still the recommended gold standard treatment for OSA management, it does not promote the participation of regular physical activity, which has far reaching benefits for health and wellbeing (Mendelson et al., 2018).

Of note, the sample size in chapter five was small and thus, findings from the study cannot be generalized to other groups. However, the study is a pilot study and thus, may serve as a platform to guide similar interventions in this age group. The daily PA duration and intensity across the 12 weeks were self–reported and so may be prone to recall bias and over-reporting. However, the PA levels were validated at three time points across the intervention with accelerometers and as such validate the reported levels of PA. The study in chapter five also demonstrated a significant increase in activity levels and change in OSA severity post-intervention independent of change in BMI and weight-loss. Further, the changes demonstrated in OSA severity (which cannot be manipulated or influenced) suggest that intervention PA adherence was good. Other strengths of the study should also be noted. The study is the first pilot study that has used unstructured general PA to reduce OSA. Additionally, all of the participants were older workers, aged 50 years and over who were not undergoing any treatment for OSA.

6.6. Conclusions

General Discussion

This thesis has demonstrated that overlapping negative health behaviours combine to undermine positive health and wellbeing and thus, hamper the ability of an ageing worker to perform optimally. As such, it is logical to see that it is rarely sufficient to explore only isolated aspects of health and wellbeing, when considering the potential detrimental impact on health that may lead to the development of conditions such as cardiovascular disease (CVD). Of note, the World Health Organisation reported CVD as the leading cause of death worldwide, with heart disease and stroke accounting for 15 million deaths in 2015 (World Health Organisation, 2017). The studies in this thesis have demonstrated the potential pathways by which the health behaviours of an ageing worker, such as a lack of PA, work stress and sleep disorders combine to promote the development of CVD. However, before interventions can be formulated to address the relevant changes required to offset the risk of CVD in this group, it is necessary to first understand how the interplay of work and health affect the ageing worker. Moreover, given the dramatic changes in the distribution of active workers to pensioners (Crawford et al., 2010, Department for Work and Pensions, 2011), it is critical to understand more about factors that help retain older workers in the workforce. In this respect, the findings from the first study of this thesis add unique insight to previous literature by using a person-centred perspective to enhance understanding of health and well-being profiles of older (aged >50) manual workers. As such it would appear that the associations between presenteeism, stress resilience and PA in this group are more complex than have previously been depicted.

Given that many of the workers from the first study displayed presenteeism in the form of psychological stress, the second study of this thesis demonstrated that there is a strong association between work engagement, presenteeism and HR reactivity in older manual workers. It is evident from this second study and previous literature, that work stress has a negative effect on health and gives rise to higher levels of presenteeism and lower work engagement (Taloyan et al., 2012, Leineweber et al., 2011). Therefore, it is possible that exaggerated reactivity to work related stress could be a consequence of these negative factors and a pathway through which they relate to increased disease risk and ill health. This indicates the need for further research into ways to promote work engagement and decrease presenteeism, thereby potentially protecting cardiovascular health in this group of workers. Exaggerated cardiac reactivity on top of ageing, less social support and poorer lifestyle behaviours, may contribute to the risk of negative health outcomes and poorer wellbeing. Additionally, implications from the second study, give rise to the consideration of the impact of job strain on stress reactivity. However, further research is needed to gain a broader understanding of the role of stress reactivity in the links between resilience, work-related factors and future health.

Alongside work stress, other negative health behaviours such as insufficient duration and quality of sleep along with a lack of regular PA, add their part to the potential development of CVD. The positive benefits of regular PA and sufficient sleep are well established (Stanley, 2005, Black et al., 2015, Gerber et al., 2013, Aghayev et al., 2010, Hoevenaar-Blom et al., 2011). In contrast, the second half of this thesis demonstrated the impact that a lack of regular PA has on sleep disorders such as OSA, which further increases the risk of CVD development. As such, the relationship between PA and OSA development was investigated. Of particular interest and concern is the large number of sufferers (approximately 85%) who are unaware that they have OSA and so remain undiagnosed in the UK (Rejon-Parrilla et al., 2014). This report was reflected in the results of the third study of this thesis, which demonstrated that undiagnosed OSA exists in the group of older manual workers examined in the study. Indeed, low levels of PA were found to be associated with increased severity of OSA. Additionally, obesity is also a well-established risk factor for the development of OSA (Rejon-Parrilla et al., 2014). Indeed, study three of this thesis found that BMI was a stronger indicator of OSA severity than PA and therefore may prove confusing in respect to intervention guidance. However, given the negative health outcomes associated with OSA and the benefits that regular PA offers to physical health and mental wellbeing, as well as reducing weight and thereby BMI, it is worthwhile considering low PA as a risk factor for OSA in older workers alongside obesity. Further, the outcome of the study warrants the consideration of PA as a cost effective management treatment of OSA through aiding weight loss and promoting healthy cardiovascular function in this age group.

In light of this, the final study of this thesis demonstrated that regular, progressive PA in both intensity and duration across 12 weeks reduced the severity of OSA in a group of older workers. Although recent research has started to explore the use of PA as way to manage or reduce OSA, many studies have combined exercise with diet, or have involved the use of structured exercise (Aiello et al., 2016, Mendelson et al., 2018). Although much of the current literature is encouraging, the debate as to whether exercise alone is a sufficient way of managing OSA remains. However, the benefits of regular PA to health makes it a worthwhile addition to current treatment (CPAP) (Aiello et al., 2016). Despite being the gold standard treatment for OSA, and its success in the management of OSA and the reduction of CVD risk, the use of CPAP does not however, encourage the individual to cultivate positive health behaviour changes such as increasing PA. Lifestyle changes are necessary in order to offer long term impact on health and other comorbidities associated with OSA such as Type-2 diabetes and hypertension (Mendelson et al., 2018). Further, CPAP is often poorly tolerated and as a result terminated early on, resulting in the reinstatement of OSA and its symptoms (Engleman and Wild, 2003, Olsen et al., 2008). With its far-reaching positive benefits on future health, including reduction of stress, obesity, hypertension and improvement of cardiovascular health, promoting the practice of PA is a cost effective way to manage OSA and promote health and wellbeing (Eckel et al., 2014, Childs and de Wit, 2014). Although, structured/planned exercise has been shown to be of use in this instance, the final study of this thesis brings an original contribution to this area of research by implementing progressive, general daily PA (e.g. using the stairs instead of the lift) by way of management of OSA, that can be easily fitted into individuals' lifestyles at no additional cost. The final study in this thesis demonstrated that gradual increments of daily PA (e.g. using the stairs instead of the lift) built up to the current recommended guidelines of PA to preserve health, over 12 weeks significantly reduced OSA severity. As such, increasing general daily PA may be more sustainable overtime, as it does not require specific arrangements such as attending a gym or scheduled exercise classes, to perform. Indeed, previous research has recommended that physical movement should be encouraged over the 24-hour period to increase daily

PA (Chaput et al., 2014). Future research should explore the introduction of PA interventions through the use of mobile devices. It is possible that mobile devices such as apps and activity watches provide an individual with an awareness of how active they are and serve as a motivation tool to increase activity.

6.7. Limitations

There are several limitations in this thesis that warrant consideration. In study one, it was not possible for causal inferences to be made due to the cross-sectional nature of the study. Further, the stability of the profiles is unknown and as such it may be interesting to examine profile stability over time using Latent Transition Analysis (Henning et al., 2016). Self-report as opposed to objective PA is another limitation of study one due to the tendency for individuals to overestimate their PA levels using self-report methods (van Sluijs, 2007). However, study one had a number of strengths. Firstly, the use of Latent Profile Analysis provided a view of the interactional patterns of associations within different types of individuals. Specifically, how the three constructs of presenteeism, PA and resilience simultaneously interact within-persons to create unique patterns that impact other relevant outcomes linked to work and health. Further, it enabled the identification of older manual workers at risk of poor health and ill-being. Secondly, PA was differentiated into work, leisure and sport/exercise domains, presenteeism was assessed using multi-dimensional measure capturing four distinct components. This enabled a detailed understanding of associations between the variables. Finally, the study provided insight into heterogeneity in health and well-being characteristics among a group of older manual workers who are normally underserved in this type of research.

Due to the correlational nature of study two, it was also not possible to assume any direction of causality. However, it is unlikely that one's habitual physiological response to acute stress might influence resilience and work engagement when participants seem unconscious of whether they are high or low responders (Tucker, 2007). Secondly, the associations found were not consistent across all cardiovascular measures and cortisol, however, the consistency of associations with HR reactivity would suggest that the results were not due to random chance. Third, the sample size in study two was small, however, it is comparable with other correlational studies of reactivity, particularly among older adults (Almela et al., 2011, Domes, 2002, Hogan et al., 2012). Additionally, the sample may be unusual in that all were aged 50+ years, un-medicated, without history of cardiovascular or metabolic disease. Thus, the sample might be representative of the 'healthy worker effect' (Shah, 2009) and potential selection bias. However, employees with long-term sickness absence would not be available for recruitment, and the levels of presenteeism identified in the study highlight the need to promote the health and longevity of older employees. Study two also has several strengths. Firstly, participants were all manual workers and aged >50 years, a population that has been previously under-researched. With the increasing age of the workforce, research into this population is becoming more important. Further, rather than explore stress in this age group in association with work and health, the investigation into resilience in the present study offers an original contribution to resilience literature by extending the research into older manual workers. This study also considers the repercussions that resilience may have for sickness presenteeism, thereby extending current knowledge on sickness presenteeism in this age group.

The issue of reverse causation was a limitation of study three and thus, it was difficult to infer whether low PA predicted OSA or vice versa, similarly with the link between BMI and PA, however, given that PA engagement is self-selected, only PA intervention randomized trials could start to shed light on the potential causal direction of effects, which is a future direction for this research. The second limitation of study three was the relatively small sample size, making it possible that the association between PA and OSA severity was attenuated by BMI due to low power and reduced degrees of freedom.

Indeed, the lack of evidence of mediation suggests this, and in fact makes it probable that both PA and BMI are independent contributors to OSA severity, although this would need to be confirmed in a larger study. Third, the majority of the participants demonstrated moderate levels of PA and mostly none or mild levels of OSA severity. Thus, it is possible that there were not sufficient participants with moderate to severe OSA in the group to provide a clearer outcome of the association between PA and OSA. Finally, self-reported measures of PA were limited due to risk of over-reporting and recall bias. Nonetheless, study three has several strengths. All participants were in manual occupations and all were older than 50 years old, which is a neglected group; given the growing age of the workforce, older workers' health is becoming of paramount importance (Billet et al., 2011). Although self-report measures of PA were limited as mentioned above, the instrument used to assess PA in study three is validated to be one of the best methods of self-report PA measures and provides detailed information on three areas of PA. The findings of study three add to current research into OSA and PA and extend it by examining the presence of undiagnosed OSA and levels of PA in older manual workers. The results highlight the potential existence of OSA that may reside in those without a formal OSA diagnosis in older manual workers and its potential for further development if left untreated. Further, it emphasizes the role of PA and BMI in undiagnosed OSA in this participant group. Findings from the study support previous research illustrating the high incidence of undiagnosed OSA in manual workers and in the UK (Webber et al., 2011, Rejon-Parrilla et al., 2014).

Of note, the sample size in study four was small and thus, findings from the study cannot be generalized to other groups. However, the study is a pilot study and thus, may serve as a platform to guide similar interventions in this age group. The daily PA duration and intensity across the 12 weeks were self–reported and so may be prone to recall bias and over-reporting. However, the PA levels were validated at three time points across the intervention with accelerometers and as such validate the reported levels of PA. Study four in chapter five also demonstrated a significant increase in activity levels and change in OSA severity post-intervention independent of change in BMI and weight-loss. Further, the changes demonstrated in OSA severity (which cannot be manipulated or influenced) suggest that intervention PA adherence was good. Other strengths of the study should also be noted. The study is the first pilot study that has used unstructured general PA to reduce OSA. Additionally, all of the participants were older workers, aged 50 years and over who were not undergoing any treatment for OSA.

In summary, sleep is key to good overall health, wellbeing and function. The disturbance and lack of which predisposes an individual to many health risks, but in particular CVD. If sleep is insufficient/disrupted, an ageing worker will go to work tired, which means a potential inability to cope with the demands of the working day and as such may induce feelings of psychological stress. A lack of sleep and increased stress alone can lead to obesity and potentially CVD, and may be further compounded by a lack of desire to exercise (Butner et al., 2013, Mendelson et al., 2018, Muhsen et al., 2010). As is evident from this thesis and previously discussed literature, poor health behaviours along with the age-related physiological changes to the CV system, compound the risk of CVD in older workers. However, it is also evident that cultivating positive health behaviours such as increasing daily levels of PA, and ensuring good sleep hygiene (habits conducive to a sufficient sleep) and learning to manage stress, can greatly improve health and wellbeing. Additionally, regular PA can offset some of the age-related physiological effects such as loss of CV fitness and life-threatening conditions such as OSA thereby reducing the risk to CVD (Childs and de Wit, 2014, Aiello et al., 2016). Thus, through engaging in positive health behaviours, better health and wellbeing is possible during working life and beyond.

6.8. Future Directions

There are several routes forward from the findings of this thesis, which can be further explored. It is evident from this thesis that ageing together with poor lifestyle behaviours has the potential to lead to poor health and early mortality. However, it would seem that the integration of regular daily PA, sufficient sleep and resilience to stress are key to keeping an ageing worker healthy in work and across the lifespan.

The findings from study one suggest that it may be possible to identify profiles of older workers at risk from poor health and ill-being and use this information as a means of guiding appropriate interventions. To this end, it may be useful to develop profile-specific interventions in order to assess suitability of interventions for different profiles of workers. Results also indicated that high levels of PA in terms of sport/exercise might form the focus of PA interventions to reduce presenteeism and improve fitness according to the needs of specific groups. Additionally, on-site facilities such as showers, changing areas and flexible work times may make it easier to allow time for PA participation. It may also be beneficial to investigate multi-faceted interventions that target several different components. Additionally, objective PA measures may be more helpful in profiling older workers in future studies. It may also be interesting to explore predictors of profile stability over time at important life-events or transitions such as retirement using Latent Transitional Analysis. Lastly, future research should examine whether PA is a determinant or outcome of stress resilience in longitudinal studies. Further investigations are also required to establish what type (intensity and duration) and dose of PA would be of benefit in this age group. In respect to stress reactivity and resilience, future research into presenteeism in older workers is required to decrease presenteeism and increase work engagement. Presenteeism is still a fairly new area of research and older manual workers are underserved in this area. There is a growing need for interventions that address presenteeism and that consequently help protect CV health in this age group. Further research is also needed into stress reactivity in relation to resilience, work engagement, presenteeism so that interventions can be developed to build resilience to stress, improve work engagement and lower presenteeism in ageing workers.

This in turn may help to sustain healthy ageing workers within the workforce and consequently preserve good health into retirement and beyond.

The findings from study one implied that increasing PA may well play a part in reducing presenteeism but the role of sleep in older workers is also a necessary consideration. It is likely, that several variables combine to result in presenteeism, exaggerated stress reactivity, and poor work engagement; thus a multi-disciplinary approach is required when considering appropriate interventions.

This thesis demonstrated the risk of CVD that older workers face due to ageing and poor lifestyle behaviours. It is possible that many older workers are aware that they do not do participate in sufficient PA, however, the implications of such may often be overlooked or go unnoticed. This was evident in study three which demonstrated that older manual workers who engaged in low levels of PA displayed higher levels of OSA that was currently undiagnosed and therefore, untreated. This illustrates how potential pathways such as untreated OSA that leads to CVD development go unnoticed. It is possible that older workers in manual occupations perceive that they get their exercise at work and so need not participate in leisure time PA. However, this thesis has demonstrated that a lack of PA does in fact leave the older manual worker vulnerable to increased risk of ill health and potentially CVD as a result of exaggerated stress reactivity and OSA development. Additionally, sleep loss also leads to weight gain and consequently obesity, which is another risk factor for OSA and CVD. It may be beneficial to screen older workers for OSA who display low levels of PA, exaggerated response to stress and report poor sleep quality in other occupations and in larger sample sizes. Alongside the findings of study four in this thesis, a general consensus is beginning to emerge that regular PA may help in the management of OSA and is of particular benefit to those who cannot tolerate CPAP. This aside, the intensity, duration and type of PA required is yet to be determined and so further studies should focus on dose response of PA in respect of OSA reduction. Although, assessing the effect of PA interventions in the management of OSA in sufficient numbers of participants may prove costly, more research is required if the burden of CVD is to lessen for the healthcare system. Given the health benefits available from regular PA such as reduced BMI, weight loss, increased CV fitness and improved sleep quality, to name a few, more research is needed to emphasise the importance of promoting this lifestyle behaviour alongside improvements in sleep hygiene to enhance positive health and wellbeing and reduce the risk of CVD. It is feasible that the help of mobile devices and apps that are able to monitor PA and sleep could be beneficial, thus future studies could explore interventions that might be delivered through mobile devices. This would serve as a way of motivating an individual's PA frequency and bring awareness of actual PA levels in relation to what is required to maintain health and wellbeing.

Finally, this thesis has presented the interplay of stress reactivity, resilience, sleep and PA in older manual workers and highlights the need for an understanding in the overlapping roles that these fundamental variables have on health and wellbeing in an ageing worker. It would seem that sleep is fundamental to a whole host of necessary functions of health and wellbeing and if lacking, along with persistent lack of PA, maladaptive response to stress, and age-related changes to the cardiovascular system, an older worker is at an increased risk of developing CVD.

It is obvious that ageing cannot be halted and that from this thesis and available literature it is difficult to determine which variable is most responsible for increasing CVD risk alongside age-related changes in older workers. Since sleep and PA are essential to health, wellbeing and functioning, and are modifiable, interventions that focus on improving sleep and increasing PA should warrant strong consideration if older workers are to be retained as part of a healthy and productive workforce and not a burden on the healthcare system.

6.9 **Implications for Theory**.

This thesis used the framework of Kooij (2015) as a guide to explore ways in which potential proactive health behaviours might act as resources by which successful ageing at work might be achieved in older manual workers. The findings from the studies in this thesis build on Kooij's framework of successful ageing at work in respect to helping employees to take an active role in maintaining health and, thereby, workability.

Results from this thesis imply that increasing PA in the older manual worker might prove a useful resource in improving cardiovascular health, reducing presenteeism and OSA and the potential health risks that they are associated with. Thus, increasing PA is possibly the best modifiable variable that may offer a multi-pronged attack for promoting and maintaining health and wellbeing in the older manual worker. However, given that health research into older manual workers is generally underserved at present, it might prove worthwhile to investigate the potential of regular PA as a means to build on the above framework. Specific outcomes of interest for further exploration should be the reduction of presenteeism and OSA in larger groups of older manual workers. Further, increasing the regularity of PA in this group would also be of interest in respect to sleep quality. For instance, it might be logical to assume that if OSA is reduced by increasing PA, it is possible that this might also lead to improved sleep quality and duration if the fragmented sleep brought about by OSA subsides following OSA reduction. Thus, employees who have sufficient sleep are more likely to be able to meet the demands of their workload and be more productive in their working role. Moreover, increasing PA might also offer OSA sufferers who are unable to use CPAP an alternative mode of management and, in turn, a resource to help them maintain successful ageing at work.

Increasing work engagement is a further outcome for consideration since findings in this thesis demonstrated that high levels of work engagement were associated with reduced presenteeism and more moderate CV reactivity. Ways in which work engagement might be increased therefore warrants exploration and may be a potential resource available to the older worker in motivating and sustaining a longer working life. Whether PA is associated with work engagement in this age group also remains unexplored and as such presents another area for further study. Additionally, the benefit of social support might also be worth exploring in respect to motivating and sustaining a successful working life. Given that PA appears to be the obvious modifiable variable as a resource, a regular workplace group exercise program may prove worthwhile.

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Appendix

I. Health and Wellbeing in Workers Aged 50+ Years (Survey)

Health and Wellbeing in Workers 50+

Thank you for taking part in this study!

Demographic Information

Sex (please tick): Male ☐/ Female ☐ **Postcode**: (main residence):……………..
…..

Date of Birth: ………………..

Your marital status (please tick the box closest to your situation)

Single ☐ Living with a partner ☐ Married ☐
Divorced ☐ In partnership, but not living together ☐ Widowed ☐

What is the highest qualification you hold (tick the box that applies to you)

O-levels or GCSEs ☐ A-levels ☐ NVQ ☐
College degree/diploma ☐ Bachelor's degree ☐
Postgraduate degree/diploma ☐
Other (please give details)……………
None of the above ☐

How old were you when you left school or full-time education ? ……………

Occupation: (Please tick the appropriate description of your occupation)
Construction ☐ Craft/Labourer ☐ Transportations/communications ☐ Security ☐
Farming ☐ Forestry ☐ Fisheries ☐ Unclassified ☐

Health
How would you rate your overall health in the last 12 months: (Please tick the appropriate answer)

Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor ☐

Do have a past history of any of the following: (please tick all that apply)

Heart disease	☐	Rheumatoid Arthritis	☐
Vascular disease (e.g., stroke)	☐	Osteoarthritis	☐
Asthma or chronic bronchitis	☐	Kidney diseases	☐
Liver disease	☐	Back/Neck/Shoulder Pain	☐

On average, how would you rate your overall sleep quality in the last 30 days

Excellent ☐ Very good☐ Good ☐ Fair ☐ Poor ☐

Lifestyle Behaviours
Please read the following questions carefully and tick the one that most applies to you.

Do you drink alcohol? Often☐ Sometimes☐ Rarely ☐ Never☐

Do you smoke ? Currently☐ Previously☐ Never☐

The next set of questions tells us how you generally **respond to stressful events.**

Instructions: Use the following scale and **tick** one number for each statement to indicate how much you disagree or agree with each of the statements.
1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

	1	2	3	4	5
I tend to bounce back quickly after hard times.	☐	☐	☐	☐	☐
I have a hard time making it through stress events.	☐	☐	☐	☐	☐
It does not take me long to recover from a stressful event.	☐	☐	☐	☐	☐
It is hard for me to snap back when something bad happens	☐	☐	☐	☐	☐
I usually come through difficult times with little trouble.	☐	☐	☐	☐	☐
I tend to take a long time to get over set-backs in my life.	☐	☐	☐	☐	☐

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?

Bed Time ___________

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?

Getting up time __________

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.)

Hours of sleep per night __________

For each of the remaining questions, tick the most appropriate response. Please answer all questions.

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

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
Cannot get to sleep within 30 minutes	☐	☐	☐	☐
Wake up in the middle of the night or early morning	☐	☐	☐	☐
Have to get up to use the bathroom	☐	☐	☐	☐
Cannot breathe comfortably	☐	☐	☐	☐
Cough or snore loudly	☐	☐	☐	☐
Feel too cold	☐	☐	☐	☐
Feel too hot	☐	☐	☐	☐
Had bad dreams	☐	☐	☐	☐
Have pain	☐	☐	☐	☐
Other reasons	☐	☐	☐	☐

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 a very slight problem ☐
Somewhat of a problem ☐ A very big problem ☐

10. Do you have a bed partner or room-mate?

No bed partner or room-mate ☐ Partner/room-mate 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 . . .

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
Loud Snoring	☐	☐	☐	☐
Long pauses between breaths while asleep		☐	☐	☐
Legs twitching or jerking while you sleep	☐	☐	☐	☐
Episodes of disorientation or confusion during sleep	☐	☐	☐	☐
Other restlessness while asleep.	☐	☐	☐	☐

The next scale asks about **personality traits** that may or may not apply to you. Please tick a box next to each statement to indicate the extent to which ***you agree or disagree with that statement.*** You should rate the extent to which the pair of traits applies to you, even if one characteristic applies more strongly than the other. ***I see myself as:***

1 = Disagree strongly **7 = Agree strongly**

	1	**2**	**3**	**4**	**5**	**6**	**7**
Extraverted, Enthusiastic.	☐	☐	☐	☐	☐	☐	☐
Critical, quarrelsome.	☐	☐	☐	☐	☐	☐	☐
Dependable, self-disciplined.	☐	☐	☐	☐	☐	☐	☐
Anxious, easily upset.	☐	☐	☐	☐	☐	☐	☐
Open to new experiences.	☐	☐	☐	☐	☐	☐	☐
Reserved, quiet.	☐	☐	☐	☐	☐	☐	☐
Sympathetic, warm.	☐	☐	☐	☐	☐	☐	☐
Disorganized, careless.	☐	☐	☐	☐	☐	☐	☐
Calm, emotionally stable.	☐	☐	☐	☐	☐	☐	☐
Conventional, uncreative.	☐	☐	☐	☐	☐	☐	☐

Physical Activity

The next few questions help us understand at what time of day you usually exercise/ engage in physical activity. Please read the questions carefully , then tick all the boxes that apply to your usual routine.

1. I usually engage in physical activity before work . ☐

2. I usually engage in physical activity after work. ☐

3. I usually engage in physical activity during work e.g. lunch time walk.☐

4. I usually engage in physical activity at the weekends only. ☐

5. I usually engage in physical activity in a combination of the above (please give an example below, e.g. I usually engage in Physical activity before work and at weekends)

☐ ……

The next set of statements tells us about your physical activity habits in the past month and is divided into three sections, please tick the box that is most appropriate to you.

Physical Demands at Work

At work I sit:	☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always
At work I stand:	☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always
At work I walk:	☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always
At work I lift heavy loads:	☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always
After working I am tired:	☐ Very often ☐ Often ☐ Sometimes ☐ Seldom ☐ Never
At work I sweat:	☐ Very often ☐ Often ☐ Sometimes ☐ Seldom ☐ Never
In comparison with other my own age, I think my work is physically:	☐ Much heavier ☐ Heavier ☐ As heavy ☐ Lighter ☐ Much lighter

Sport and Exercise Habits:

(NB. Sport refers to activities eg. Tennis, football, i.e. organised activity. Exercise refers to things e.g. Jogging, and other leisure time activities.)

Do you play sport OR do any exercise (other than walking)? ☐ No ☐ Yes	
• Which sport OR exercise do you do MOST frequently? • How many hours per week? • How many months per year?	____________ ☐ <1 ☐ 1-2 ☐ 2-3 ☐ 3-4 ☐ >4 ☐ <1 ☐ 1-3 ☐ 4-6 ☐ 7-9 ☐ >9
• If you do a SECOND sport OR exercise, whi one is it? • How many hours per week? • How many months per year?	____________ ☐ <1 ☐ 1-2 ☐ 2-3 ☐ 3-4 ☐ >4 ☐ <1 ☐ 1-3 ☐ 4-6 ☐ 7-9 ☐ >9
• If you do a THIRD sport OR exercise, which one is it? • How many hours per week? • How many months per year?	____________ ☐ <1 ☐ 1-2 ☐ 2-3 ☐ 3-4 ☐ >4 ☐ <1 ☐ 1-3 ☐ 4-6 ☐ 7-9 ☐ >9

Physical Activity Habits during Leisure Time:

In comparison with others my own age, I think my physical activity during LEISURE time is:	☐ Much more ☐ More ☐ The same ☐ Less ☐ Much less
During leisure time I sweat:	☐ Very often ☐ Often ☐ Sometimes ☐ Seldom ☐ Never
During leisure time I play sport OR do exercise:	☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Very often
During leisure time I watch TV	☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Very often
During leisure time I walk:	☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Very often
During leisure time I cycle:	☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Very often
How many minutes do you walk AND/OR cycle PER DAY from work, shopping etc.:	☐ <5 ☐ 5-15 ☐ 15-30 ☐ 30-45 ☐ >45

The next set of questions and statements apply if you have **aches or pains** such as back, shoulder or neck pain. Please read and answer questions carefully. Do not take too long to answer the questions, however it is important that you answer every question.

1. Where do you have a pain? Please tick all appropriate sites.

Neck ☐ Shoulder ☐ Leg ☐ Upper back ☐ Arm ☐ Lower back ☐

Other ☐ (please state)…………………………………………..

2. How many days have you missed from work because of your pain in the last 18 months? Please

tick one.

☐ 0 days ☐ 1-2 days ☐ 3-7 days ☐ 8-14 days ☐ 15-30 days ☐ 1 month

☐ 2 months ☐ 3-6 months ☐6-12 months ☐ over 1 year.

3. How long have you had your current pain problem? Please tick one.

☐ 0-1 week ☐ 1-2 weeks ☐ 3-4 weeks ☐ 4-5 weeks ☐6-8 weeks ☐ 9-11 weeks

☐ 3-6 months ☐ 6-9 months ☐ 9-12 months ☐ over 1 year.

4. Is your work heavy or monotonous? Please rate by ticking the best alterantive.

☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
0	1	2	3	4	5	6	7	8	9	10

Not at all Extremely

5. How would you rate the pain that you have had during the past week? Please tick one.

☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
0	1	2	3	4	5	6	7	8	9	10

No Pain Pain as bad as it could be.

6. In the past three months, on average, how bad was your pain on a 0-10 scale? Tick one.

☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
0	1	2	3	4	5	6	7	8	9	10

No Pain Pain as bad as it could be.

7. How often would you say that you have experience pain episodes, on average, during the past

three months? Tick one.

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

0 1 2 3 4 5 6 7 8 9 10

Never Always

8. Based on all things you do to cope or deal with your pain, on an average day, how able are you to decrease it? Please tick one box that is closest.

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

0 1 2 3 4 5 6 7 8 9 10

Can't decrease it at all Can decrease it completely

9. How tense or anxious have you felt in the past week? Tick one.

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

0 1 2 3 4 5 6 7 8 9 10

Absolutely calm and relaxed As tense & anxious as I have ever felt.

10. How much have been bothered by feeling depressed in the past week? Please tick one.

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

0 1 2 3 4 5 6 7 8 9 10

Not at all Extremely

11. In your view, how large is the risk that your current pain may become persistent. Tick one.

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

0 1 2 3 4 5 6 7 8 9 10

No risk Very large risk

12. In your estimation, what are the chances you will be able to work in the next six months? Tick one.

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

0 1 2 3 4 5 6 7 8 9 10

No chance Very large chance

13. If you take into consideration your work routines, management, salary, promotion possibilities and work mates, how satisfied are you with your job? Tick one.

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

0 1 2 3 4 5 6 7 8 9 10

Not satisfied at all Very satisfied

Here are some things that people have said about their pain. For each statement please tick a box from 0 to 10 to say how much physical activities, such as bending, lifting, walking, driving would affect your pain.

	Completely disagree										Completely agree
Physical activity makes my pain worse.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
An increase in pain is an indication that I should stop what I am doing until the pain decreases.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
I should not do my normal work with my pain.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10

Below is a list of five activities. Please tick the box that best describes your ability to participate in these activities.

	Can't do it because of pain										Can do it without pain
I can do light work for an hour.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
I can walk for an hour.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
I can do ordinary household chores	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
I can do the weekly shopping.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
I can sleep at night.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10

The following statements are about **how you feel at work**. Please read reach statement carefully. Tick the box that most resembles how you have most frequently felt about your job in the last 30 days.

	Never	**Almost Never** (A few times a year / less)	**Rarely** (Once a month or	**Sometimes** (A few times a month)	**Often**	**Very Often** (A few times a week)	**Always** (Every Day)
At my work I feel bursting with energy.	☐	☐	☐	☐	☐	☐	☐
At my job I feel strong and vigorous.	☐	☐	☐	☐	☐	☐	☐
When I get up in the morning, I feel like going to work	☐	☐	☐	☐	☐	☐	☐
I am enthusiastic about my job.	☐	☐	☐	☐	☐	☐	☐
My job inspires me.	☐	☐	☐	☐	☐	☐	☐
I am proud of the work I do.	☐	☐	☐	☐	☐	☐	☐
I feel happy when working intensely.	☐	☐	☐	☐	☐	☐	☐
I am immersed in my work.	☐	☐	☐	☐	☐	☐	☐
I get carried away when I am working.	☐	☐	☐	☐	☐	☐	☐

Below are a number of statements that describe **different emotions that a job can make a person feel.** Please tick the amount to which <u>any part of your job (e.g., the work, co-workers, supervisor, clients, pay) has made you feel</u> that emotion in the past <u>30</u> days.

Please tick **one** response for each item that best indicates how often you've experienced each emotion at work over the past 30 days.	Never	Rarely	Sometimes	Quite often	Extremely often
1. My job made me feel angry.	☐	☐	☐	☐	☐
2. My job made me feel anxious.	☐	☐	☐	☐	☐

3. My job made me feel at ease.	☐	☐	☐	☐	☐
4. My job made me feel bored.	☐	☐	☐	☐	☐
5. My job made me feel calm.	☐	☐	☐	☐	☐
6. My job made me feel content.	☐	☐	☐	☐	☐
7. My job made me feel depressed.	☐	☐	☐	☐	☐
8. My job made me feel discouraged.	☐	☐	☐	☐	☐
9. My job made me feel disgusted.	☐	☐	☐	☐	☐
10. My job made me feel ecstatic.	☐	☐	☐	☐	☐
11. My job made me feel energetic.	☐	☐	☐	☐	☐
12. My job made me feel enthusiastic.	☐	☐	☐	☐	☐
13. My job made me feel excited.	☐	☐	☐	☐	☐
14. My job made me feel fatigued.	☐	☐	☐	☐	☐
15. My job made me feel frightened.	☐	☐	☐	☐	☐
16. My job made me feel furious.	☐	☐	☐	☐	☐
17. My job made me feel gloomy.	☐	☐	☐	☐	☐
18. My job made me feel inspired.	☐	☐	☐	☐	☐
19. My job made me feel relaxed.	☐	☐	☐	☐	☐
20. My job made me feel satisfied.	☐	☐	☐	☐	☐

The next section asks you about **you in general**. Please rate each statement on a scale of 1-4 "not really true for me" to "really true for me". Tick only **ONE** of the four boxes in each row.

	Not really true for me. (1)	(2)	(3)	Really true for me. (4)
Some adults like the way they are leading their lives.	☐	☐	☐	☐
Other adults don't like the way they are leading their lives.	☐	☐	☐	☐
Some adults are very happy being the way they are.	☐	☐	☐	☐

Other adults would like to be different to the way they are.	☐	☐	☐	☐
Some adults question whether they are a worthwhile person.	☐	☐	☐	☐
Other adults feel like they are a worthwhile person.	☐	☐	☐	☐
Some adults are disappointed with themselves.	☐	☐	☐	☐
Other adults are pleased with themselves.	☐	☐	☐	☐
Some adults like the kind of person they are.	☐	☐	☐	☐
Other adults would like to be someone else.	☐	☐	☐	☐
Some adults are dissatisfied with themselves.	☐	☐	☐	☐
Other adults are satisfied with themselves.	☐	☐	☐	☐
Some adults are not satisfied with the way they do their work.	☐	☐	☐	☐
Other adults are satisfied with the way they do their work.	☐	☐	☐	☐
Some adults feel they are very good at their work.	☐	☐	☐	☐
Other adults worry about whether they can do their work.	☐	☐	☐	☐
Some adults are not very productive in their work.	☐	☐	☐	☐
Other adults are very productive in their work.	☐	☐	☐	☐
Some adults are proud of their work.	☐	☐	☐	☐
Other adults are not very proud of what they do.	☐	☐	☐	☐

The next set of questions asks about your intention to **continue working**. Please tick each statement that applies to you.

1. Do you think you are <u>able to</u> <u>continue working</u> in your current profession <u>until you are 65</u>?

Yes☐ No☐ Don't Know ☐

2. Would you like to <u>work until</u> age <u>65?</u> Yes ☐ No ☐ Don't Know ☐

If YES please state why (e.g. financial, social etc)

……………………………………………………………………

If NO please state reason (e.g. health, family)

………………………………………………………………….

3. Would you like to <u>work beyond age 65?</u> Yes ☐ No ☐ Don't Know ☐

If YES please state why (e.g. financial, social etc)

…………………………………………………..

If NO please state reason (health, family etc)

……………………………………………………………

The following questions tell us about **how you perform at work**. Please read each question carefully and tick the response that most resembles you.

How much time in the past 30 days were you able to do the following?

	None of the time	Hardly any of the time	Some of the time	Most of the time	All of the time
Work required hours.	☐	☐	☐	☐	☐
Get going at the beginning of the work day.	☐	☐	☐	☐	☐
Start on work soon after arriving.	☐	☐	☐	☐	☐
Work without breaks or rests.	☐	☐	☐	☐	☐
Stick to routine or schedule.	☐	☐	☐	☐	☐
Walk or move around work locations.	☐	☐	☐	☐	☐
Sit, stand, stay in 1 position.	☐	☐	☐	☐	☐
Repeat motions.	☐	☐	☐	☐	☐
Bend, twist or reach.	☐	☐	☐	☐	☐
Use handheld tools/equipment.	☐	☐	☐	☐	☐
Lift, carry, move objects.	☐	☐	☐	☐	☐
Keep mind on work.	☐	☐	☐	☐	☐
Think clearly.	☐	☐	☐	☐	☐

Work carefully.	☐	☐	☐	☐	☐
Concentrate on work.	☐	☐	☐	☐	☐
Lose train of thought.	☐	☐	☐	☐	☐
Easily read/use eyes.	☐	☐	☐	☐	☐
Speak in person/on the phone.	☐	☐	☐	☐	☐
Control temper.	☐	☐	☐	☐	☐
Help others to work.	☐	☐	☐	☐	☐
Handle workload.	☐	☐	☐	☐	☐
Work fast enough.	☐	☐	☐	☐	☐
Finish work on time.	☐	☐	☐	☐	☐
Work without mistakes.	☐	☐	☐	☐	☐
Do all you are capable of.					

I am happy to be contacted about a follow-up diary study ☐

My email address is: ……………………………………………………………………………………………
Alternatively (if you don't wish to be contacted via e-mail or do not have an e-mail address), you can enter your tel no here: ______________________________

II. Paced Auditory Serial Addition Test (PASAT)

10min PASAT

4	Answer		**6**	8			18			3
6	10		**6**	12			12		**9**	11
3	9			8			11		**2**	11
1	4			6			9		**9**	11
7	8			10		**3**	4		**1**	10
	10			9		**2**	5		**2**	13
	6			6		**5**	7			6
	5		**5**	8		**3**	8			9
	4		**1**	6		**5**	8			9
	6		**5**	6			12			11
4	8		**8**	13			11			16
9	13		**5**	13			10		**8**	17
5	14			14			12		**3**	11
7	12			13			10		**6**	9
1	8			12		**8**	12		**2**	8
	9			17		**5**	13		**1**	3
	16			16		**7**	12			7
	14		**7**	14		**8**	15			7
	15		**3**	10		**3**	11			7
	14		**4**	7			12			9
5	10		**8**	12			15			13
4	9		**3**	11			12		**4**	11
5	9			4			7		**2**	6
6	11			9			5		**9**	11
7	13			14		**3**	7		**8**	17
	10			13		**7**	10		**4**	12
3	6		**8**	15		**9**	16			11
	9		**8**	16		**9**	18			9
	14		**3**	11		**3**	12			5

	17		**7**	10			8			10
1	10		**7**	14			7			10
5	6		**9**	16			4		**7**	10
3	8			14			5		**8**	15
7	10			9			10		**8**	16
2	9			5		**4**	11		**2**	10
	11			2		**8**	12		**2**	4
	11			7		**1**	9			5
	10		**2**	8		**8**	9			9
	9		**4**	6		**8**	16			11
	10		**2**	6			13			9
8	17		**5**	7			11			5
7	15		**4**	9			13		**2**	3
1	8			7			9		**5**	7
6	7			9			6		**5**	10
4	10			13		**3**	7		**2**	7
	6			15		**7**	10		**9**	11
	6			10		**3**	10			16
	5		**3**	5		**7**	10			14
	8		**6**	9		**8**	15			9
	8		**1**	7			11			9
9	11		**5**	6			7			
2	11		**8**	13			9		**Total**	
2	4			17			6		10min	

Extreme Cardiac Reactivity Screening Protocol

Are you currently ill/infections?

YES NO

Have you smoked in the last 2 hours?

YES

NO

Have you consumed alcohol in the last 12 hours?

YES NO

Have you eaten in the last hour?

YES NO

Have you had Coffee/Caffeine in last 2 hours? YES NO

Have you exercised vigorously in last 4 hours? YES NO

Are you on any medications? ______________________________

If any of the above questions are answered YES please ask further questions and make note of what they ate, drank, exercised, or have ill, and when.

1. Explain purpose of blood pressure cuff and attach to participant ○
   *To measure blood pressure during testing session
2. Take BP measure to make sure cuff is properly attached to participant ○
3. Explain purpose of salivettes ○

Adaptation

Minute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Activity	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest
Task										

SBP =
DBP =
HR =

4. Explain the start of the study and tell them that there is no talking ○
5. Begin stopwatch ○

Baseline

Minute	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**6-7**	**7-8**	**9**	**10**
Activity	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest
Task		BP		BP		BP		BP		**Cort**

Min 2
SBP =
DBP =
HR =

Min 4
SBP =
DBP =
HR =

Min 6
SBP =
DBP =
HR =

Min 8
SBP =
DBP =
HR =

Tas

1. Read PASAT explanation ○

PASAT explanation

"The CD will read out a series of numbers between one and nine, at fixed intervals apart. You have to listen to the numbers and add them together. So if you hear a 4 then a 5, you say 9 out loud. However, you must remember the 5, the second number, in order to add it to the next number read out by the tape. So if the tape says, 4.....5 you say 9, but remember the 5, then if the tape says ...3...you say 8, but remember the 3 and so on. You are always adding the number you just heard to the last number you heard before that, never to the number you have said out loud. Is that OK? (Answer any questions)

1. Participant completes practice task ○
2. Finish reading task instructions ○

PASAT instructions

Your performance on this task is assessed, recorded and you are in direct competition with fellow participants. It is very important that you perform to the best of your ability. You will start the test with 1000 points. For every number you miss, 5 points will be deducted from your score. Your score can decline rapidly if you do not concentrate or if you perform badly. The experimenter will be judging your performance. Performance tables will be produced and displayed to compare you to other participants in the study.

During this task, you will also be filmed. Two independent body language experts will assess the videos in order to judge how much you blush, fidget or stammer during the task as a measure of your anxiety levels. You will also be able to see yourself live on the television during the task. You must watch the screen at all times.

The experimenter will sound a buzzer every time you:

- Give an incorrect answer
- Look away from the television screen
- Stutter, mumble or hesitate.

The numbers on the tape will get faster as the tape goes on; you must keep up with the numbers. If you miss a number, you must pick up the pattern again as soon as possible so that your score does not decline too much.

3. Emphasize need to 1. Say #s loud, 2. Continue if you stop, 3. Keep looking at laptop screen ○

4. Turn on laptop screen ○
5. Start stopwatch ○

Stress

Minute	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
Activity	Task	Task	Task	Task	Task	Task	Task	Task	Rest	Rest
Task		BP		BP		BP		BP		

Min 2	Min 4	Min 6	Min 8
SBP =	SBP =	SBP =	SBP =
DBP =	DBP=	DBP=	DBP=
HR =	HR =	HR =	HR =

6. Tell participant task is over and to relax ○
7. Turn off laptop screen ○

Recovery

Minute	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
Activity	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest
Task	Cort	BP		BP		BP		BP		

Min 2	Min 4	Min 6	Min 8
SBP =	SBP =	SBP =	SBP =
DBP =	DBP=	DBP=	DBP=
HR =	HR =	HR =	HR =

Minute	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11

Activity	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest
Task	**Cort**	BP		BP		BP		BP			**Cort**

Min 2 SBP = DBP = HR =	**Min 4** SBP = DBP= HR =	**Min 6** SBP = DBP= HR =	**Min 8** SBP = DBP= HR =

8. Remove blood pressure cuff ○
9. Have participant complete Post-PASAT Ratings ○

III. Psychological Stress Task Evaluation

POST-PASAT Questionnaire

Please circle what applies.

How difficult did you find the task?

Not at all difficult	0	1	2	3	4	5	6	Extremely difficult

How stressful did you find the task?

Not at all stressful	0	1	2	3	4	5	6	Extremely stressful

How well do you think you performed?

Not very Well	0	1	2	3	4	5	6	Very well

How engaging did you find the task?

Not at all engaging	0	1	2	3	4	5	6	Extremely engaging

IV. Brief Resilience Scale

Instructions: Use the following scale and **tick** one number for each statement to indicate how much you disagree or agree with each of the statements.

1 = Strongly Disagree 2 = Disagree 3 = Neutral

4 = Agree 5 = Strongly Agree

	1	2	3	4	5
I tend to bounce back quickly after hard times.	☐	☐	☐	☐	☐
I have a hard time making it through stress events.	☐	☐	☐	☐	☐
It does not take me long to recover from a stressful event.	☐	☐	☐	☐	☐
It is hard for me to snap back when something bad happens	☐	☐	☐	☐	☐
I usually come through difficult times with little trouble.	☐	☐	☐	☐	☐
I tend to take a long time to get over set-backs in my life.	☐	☐	☐	☐	☐

V. Work Limitations Questionnaire

How much time in the past 30 days were you able to do the following?

	None of the time	Hardly any of the time	Some of the time	Most of the time	All of the time
Work required hours.	☐	☐	☐	☐	☐
Get going at the beginning of the work day.	☐	☐	☐	☐	☐
Start on work soon after arriving.	☐	☐	☐	☐	☐
Work without breaks or rests.	☐	☐	☐	☐	☐
Stick to routine or schedule.	☐	☐	☐	☐	☐
Walk or move around work locations.	☐	☐	☐	☐	☐
Sit, stand, stay in 1 position.	☐	☐	☐	☐	☐
Repeat motions.	☐	☐	☐	☐	☐
Bend, twist or reach.	☐	☐	☐	☐	☐
Use handheld tools/equipment.	☐	☐	☐	☐	☐
Lift, carry, move objects.	☐	☐	☐	☐	☐
Keep mind on work.	☐	☐	☐	☐	☐
Think clearly.	☐	☐	☐	☐	☐
Work carefully.	☐	☐	☐	☐	☐
Concentrate on work.	☐	☐	☐	☐	☐
Lose train of thought.	☐	☐	☐	☐	☐
Easily read/use eyes.	☐	☐	☐	☐	☐
Speak in person/on the phone.	☐	☐	☐	☐	☐
Control temper.	☐	☐	☐	☐	☐
Help others to work.	☐	☐	☐	☐	☐
Handle workload.	☐	☐	☐	☐	☐
Work fast enough.	☐	☐	☐	☐	☐
Finish work on time.	☐	☐	☐	☐	☐
Work without mistakes.	☐	☐	☐	☐	☐
Do all you are capable of.	☐	☐	☐	☐	☐

VI. Utrecht Work Engagement Scale

	Never	**Almost Never** (A few times a year / less)	**Rarely** (Once a month or less)	**Sometimes** (A few times a month)	**Often**	**Very Often**(A few times a week)	**Always** (Every Day)
At my work I feel bursting with energy.	☐	☐	☐	☐	☐	☐	☐
At my job I feel strong and vigorous.	☐	☐	☐	☐	☐	☐	☐
When I get up in the morning, I feel like going to work	☐	☐	☐	☐	☐	☐	☐
I am enthusiastic about my job.	☐	☐	☐	☐	☐	☐	☐
My job inspires me.	☐	☐	☐	☐	☐	☐	☐
I am proud of the work I do.	☐	☐	☐	☐	☐	☐	☐
I feel happy when working intensely.	☐	☐	☐	☐	☐	☐	☐
I am immersed in my work.	☐	☐	☐	☐	☐	☐	☐
I get carried away when I am working.	☐	☐	☐	☐	☐	☐	☐

VII. Health Behaviours Questionnaire

AROSA Intervention Screening Questionnaire
For Health Behaviours

Participant ID:

Health Behaviours (Marmot et al., 1991)

1. Smoking

Please circle the appropriate answer

Over the last year, how many cigarettes, on average, did you smoke per day?	None	1-5	6-10	11-20	21+	40+

2. Alcohol Consumption

For the following question, please base your answers on the following:

1 unit = ½ pint of beer, 1 small glass of wine, 1 measure of spirit. Remember that home poured measures are likely to be larger. **1 bottle of wine = 6 glasses, 1 average bottle of spirits = 27 measures**

Please circle the appropriate answer for each question.

a) Over the last year, on average, how often have you taken an alcoholic drink?	Never	Special Occasions only	1-2 per month	1-2 per week	Almost daily	2 per day or more
b) Over the last year, on average, how many units did you drink per week?	None	1-5	6-10	11-20	20-40	41+

VIII. BAECKE Physical Activity Questionnaire

This question helps to us understand at what time of day you usually exercise/ engage in physical activity. (Physical activity refers to any body movements that require energy e.g. gardening, playing football etc.). Please read the questions carefully, then tick all the boxes that apply to your usual routine.

I usually engage in physical activity before work. ☐

I usually engage in physical activity after work. ☐

I usually engage in physical activity during work e.g. lunch time walk. ☐

I usually engage in physical activity at the weekends. ☐

The next set of statements tells us about your physical activity habits in the past month and is divided into three sections, please tick the box that is most appropriate to you.

Physical Demands at Work

At work I sit…	☐ Very often	☐ Often	☐ Sometimes	☐ Seldom	☐ Never
At work I stand…	☐ Very often	☐ Often	☐ Sometimes	☐ Seldom	☐ Never
At work I walk…	☐ Very often	☐ Often	☐ Sometimes	☐ Seldom	☐ Never
At work I lift heavy loads…	☐ Very often	☐ Often	☐ Sometimes	☐ Seldom	☐ Never
After working I am tired….	☐ Very often	☐ Often	☐ Sometimes	☐ Seldom	☐ Never
At work I sweat…	☐ Very often	☐ Often	☐ Sometimes	☐ Seldom	☐ Never

In comparison with others my own age, I think my work is physically…	□ Much heavier	□ Heavier	□ As heavy	□ Lighter	□ Much lighter

Sport and Exercise Habits

(NB. Sport refers to activities e.g. Tennis, football, i.e. organised activity. Exercise refers to things e.g. Jogging, and other leisure time activities. Active commuting refers to things where you are not driving or being driven to work e.g. walking or cycling) Please tick the appropriate box.

	Yes	No
Do you play sport?	☐	☐
Do you do any exercise (other than walking)?	☐	☐
Do you actively commute to work?	☐	☐

Which sport OR exercise do you do most frequently?

……….

How many hours per week?

<1 < ☐ 1-2 1 ☐ 2-3 ☐ 3-4 ☐ >4 ☐

How many months per year?

<1 < ☐ 1-3 1 ☐ 4-6 4 ☐ 7-9 7 ☐ >9 > ☐

When is this sport or exercise done?

Before work ☐ During work ☐ After work ☐

If you do a SECOND sport OR exercise, which one is it?

………

How many hours per week?

<1 < ☐ 1-2 ☐ 3-4 ☐ 5-6 3 ☐ >9 > ☐

How many months per year?

<1 < ☐ 1-3 1 ☐ 4-6 4 ☐ 7-9 7 ☐ >9 > ☐

When is this sport or exercise done?

Before work ☐ During work ☐ After work ☐

If you do a THIRD sport OR exercise, which one is it?

………

How many hours per week?

<1 < ☐ 1-2 1 ☐ 2-3 2 ☐ 3-4 3 ☐ >4 > ☐

How many months per year?

<1 <: ☐ 1-3 1 ☐ 4-6 4 ☐ 7-9 7 ☐ >9 >' ☐

When is this sport or exercise done?

Before work ☐ During work ☐ After work ☐

Physical Activity Habits during Leisure Time

In comparison with others my own age, I think my physical activity during LEISURE time is…	☐ Much more	☐ More	☐ The same	☐ Less	☐ Much less
During leisure time I sweat…	☐ Never	☐ Seldom	☐ Sometimes	☐ Often	☐ Very often
During leisure time I play spor OR do exercise…	☐ Never	☐ Seldom	☐ Sometimes	☐ Often	☐ Very often
During leisure time I watch TV…	☐ Never	☐ Seldom	☐ Sometimes	☐ Often	☐ Very often
During leisure time I walk…	☐ Never	☐ Seldom	☐ Sometimes	☐ Often	☐ Very often
During leisure time I cycle…	☐ Never	☐ Seldom	☐ Sometimes	☐ Often	☐ Very often
How many minutes do you walk AND/OR cycle PER DAY from work, shopping etc…	☐ <5	☐ 5-15	☐ 15-30	☐ 30-45	☐ >45

IX. International Physical Activity Questionnaire (Short Form)

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ days per week No vigorous physical activities ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ hours per day

   _____ minutes per day

   Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ days per week

No moderate physical activities ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ hours per day

_____ minutes per day

Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

    _____ days per week

    No walking ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

    _____ hours per day

    _____ minutes per day

    Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **weekday**?

    ____ hours per day

    _____ minutes per day

    Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

X. BORG Rate of Perceived Exertion

6	No exertion
7	
8	
9	
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	
20	Maximal exertion