Behavioural and biological relationships between leisure-time physical activity and health outcomes during shift- and night-work

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Abstract

Shift-work is increasingly common in society and is associated with a number of health inequalities. The health effects of shift-work can include a reduction in quality and quantity of sleep, insomnia, chronic fatigue, anxiety and depression, decreased vigilance, metabolic syndrome, adverse cardiovascular (especially blood pressure), gastrointestinal effects and reproductive effects in women. Shift-work is also associated with disturbances to a workers domestic and social life. Physical activity is known to either prevent or alleviate these health inequalities in those with 'normal diurnal' lifestyles such as day-workers. However, shift-work generally decreases opportunities for physical activity. Moreover, the favourable affects of physical activity on such health inequalities have not been confirmed in shift-workers. The studies in the present thesis are designed to examine the associations between shift-work and physical activity covering a wide range of physiological and psycho-social variables in shift-workers.

The first descriptive study was designed to provide the first detailed and multi-research-strategy examination of LTPA and its correlates in shift-workers. One hundred and sixty one shift-workers participated in the initial cross-sectional study. A cohort of ten of these participants also volunteered for further diary- and interview-based studies. Participants completed the SSI together with a LTPA questionnaire. Gender, job type, age and shift-work experience were explored as correlates of LTPA. The cohort also completed a 7-day diary and wore an accelerometer for assessment of activity counts during work, leisure, and bed-time when working each shift-type (days, nights and rest). Participants also completed a semi-structured email-administered interview. The total energy expenditure per week in LTPA of male shift-workers was found to be twice that of women. Midwives recorded the lowest LTPA. Firefighters reported the most LTPA. The time spent out of bed during night shift days was 4-h higher compared with rest days. Data from this study indicated that LTPA is generally low amongst shift-workers, the majority of whom are overweight or obese. Job-type and gender are much more influential on LTPA than age or experience. Shift-workers spend more of their time on rest days in bed.

The second descriptive study was designed to explore the relationships between coping strategies adopted by shift-workers and their leisure-time energy expenditure. The importance of coping strategies has been highlighted in previous research. Ninety-five participants completed an adapted version of the completed the SSI together with a LTPA questionnaire. Predictors of age, time spent in shift-work, gender, marital status and the various shift-work coping indices were explored with step-wise multiple regression. Leisure-time energy expenditure over a 14-day period was entered as the outcome variable. Gender ($p < 0.023$) and time spent in shift-work ($p < 0.051$) were found to be predictors of energy expenditure, with the most experienced, male shift-workers expending the most energy during leisure-time. Overall 'disengagement' coping scores from the SSI were positively related to leisure-time energy expenditure ($p < 0.054$). In males, disengagement of sleep problems ($p > 0.086$) was found to be negatively correlated to energy expenditure, whereas disengagement of domestic-related problems was found to be positively related to energy expenditure ($p < 0.001$). These relations were not found in female shift-workers ($p > 0.762$). These data indicated that experienced male shift-workers participate in the most leisure-time physical activity. These people 'disengage' more from their domestic-related problems, but less from their sleep-related problems.

The next laboratory-based study was designed to examine the acute effects of evening exercise and meal frequency on psychophysiological and performance-related variables during a subsequent period of simulated night-work. Nine healthy participants, completed at least two crossover trials beginning at 18:00 h. Between 19:00-20:00 h, participants either rested or exercised at 50%VO_{2peak} and then remained awake throughout the night, completing various tasks until 05:15 h. Six participants completed a total of four trials in which they exercised or rested while either one standardized (60 kJ/kg) meal at 22:00 h or two smaller (30 kJ/kg) meals at 22:00 and 02:00 h were eaten. Core Body Temperature (T_c), wrist activity, mood, sleepiness, arousal, self-chosen work-rate, and reaction time were all measured throughout the simulated night-shift. Following exercise, T_c was significantly lower throughout the night-shift compared with no prior exercise (95% CI = 0.00 to 1.01°C), even though wrist activity was higher and sleepiness was lower after exercise. Self-chosen work-rate was significantly higher (95% CI = 20 to 43 W) and reaction time faster during the night-shift that followed exercise. Reaction time and alertness were worst when only 1 meal was ingested during the night-shift (p <0.04). These data indicate that a single bout of evening exercise can improve sleepiness as well as mental and physical performance during a subsequent simulated night-shift.

The second laboratory-based study was designed to investigate the acute effects of exercise on BP monitored during simulated night-work. Nine normotensive participants, completed at least two crossover trials beginning at 18:00 h. Between 19:00-20:00 h, participants either rested or exercised at 50%VO_{2peak} and then remained awake throughout the night, completing a variety of tasks until 05:15 h. Six participants completed a total of four trials in which they exercised or rested while either one standardized (60 kJ/kg) meal at 22:00 h or two smaller (30 kJ/kg) meals at 22:00 and 02:00 h were eaten. Systolic and diastolic BP, mean arterial pressure (MAP), heart rate and wrist activity were recorded every 30 min. Following exercise, MAP was significantly (p <0.0005) lower throughout the night-shift compared with no prior exercise (95% confidence limits for reduction: 4 to 7 mmHg). The post-exercise reductions in systolic BP and MAP were not moderated by diet, but the reduction in diastolic BP was slightly greater when only one meal was eaten (p <0.0005). BP was lower even though wrist activity and heart rate were significantly higher following exercise (p<0.0005). These data indicate that prior exercise lowers BP throughout a subsequent 8-hour night-shift in healthy individuals within the normotensive range. Therefore, regular low-intensity exercise might moderate the well-known association between shift-work participation and raised BP.

The final field-based intervention study was designed to determine using a 12-week randomised controlled trial, the effect of physical activity and dietary centred motivational interviewing (MI) upon blood pressure, stress and quality of life. Forty-four participants were involved in the trial. Twenty-one participants were assigned to the intervention group and received MI. Systolic and diastolic BP, mean arterial pressure (MAP), perceived stress (PSS) and quality of life (QOL) were all monitored. Thirty participants completed the trial. No significant differences between experimental groups were present with respect to SBP, DBP, MAP or HR (p>0.26, p>0.24; p>0.48 and p>0.86) respectively). PSS scores were significantly lower at study week 13 in the intervention group (p<0.05; 95% CI =7.7-20.6). Over the course of the study, the intervention group also had a significantly positive increase in QOL scores (p<0.05; 95% CI =78.1-87.1). There were no significant differences between groups in relation to physical activity. In this population, a 12-week MI intervention which focused upon increasing physical activity level and improving dietary habits significantly reduced workers perceived stress and increased the perception of quality of life, but not blood pressure or LTPA. MI focussing upon lifestyle factors may be a useful strategy for tackling stress, perceived quality of life and potentially CVD in shift-workers.

The findings from the studies in this thesis indicate that many of the short-term health benefits of exercise are apparent in contexts of shift- and night –work. The relatively small final intervention study demonstrates the potential utility of an individualised lifestyle intervention based on motivational interviewing for shift-workers.

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3. Fullick, S., Morris, C., Jones, H and Atkinson, G. (2009). Prior exercise lowers blood pressure during simulated night-work with different meal schedules. *American Journal of Hypertension*, 22(8):835-841.

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6. Fullick, S., Morris, C., Jones, H and Atkinson, G. (2009). Prior exercise lowers blood pressure during simulated night-work with different meal schedules. Presented at the 14th European College of Sport and Exercise Science Annual Conference, Oslo, Norway.

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Abbreviations and Definitions

Definitions of key phases and abbreviations in order of appearance:

- **MRC** – Medical Research Council
- **RISES** – Research Institute for Sport and Exercise Sciences
- **SMR** – Standardised Morbidity Rate
- **EEG** – Electroencephologography
- **RR** – Relative Risk
- **CVD** – Cardiovascular Diseases
- **IHD** – Ischemic Heart Disease
- **BP** – Blood Pressure
- **DBP** – Diastolic Blood Pressure
- **BMI** – Body Mass Index
- **WHR** – Waist to Hip Ratio
- **SBP** – Systolic Blood Pressure
- **OR** – Odds Ratio
- **CI** – Confidence Interval
- **DLMO** – Dim Light Melatonin Onset
- **HSE** – Health and Safety Executive
- **ACSM** – American College Sports Medicine
- **VO_{2max}** – Maximal Oxygen Uptake
- **HR** – Heart Rate
- **RPE** – Rating of Perceived Exertion
- **ME** – Muscular Endurance Test
- **NS** – Not Significant
- **LTPA** – Leisure Time Physical Activity
- **SSI** – Standard Shift-work Index
- **CS** – Composite Morning Questionnaire

- **PS** – Preference Scale Questionnaire
- **VO_{2peak}** - Peak Rate of Oxygen Uptake
- **MAP** – Mean Arterial Pressure
- **POMS** – Profile of Mood States
- **SSS** – Stanford Sleepiness Scale
- T_c – Core Body Temperature
- **MI** – Motivational Interviewing
- **IPAQ** – International Physical Activity Questionnaire
- **METS** – Metabolic Equivalent of Tasks
- **PSS** – Perceived Stress Scale
- **QOL** – Quality of Life
- **PA** – Physical Activity
- **GHQ** – General Health Questionnaire

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Chapter 1

General Introduction

1.1 Introduction to the NPRI

The National Prevention Research Initiative (NPRI) is a focussed collaboration involving government departments, major medical charities and research councils that work together to encourage and support research into chronic disease prevention. Fundamentally the NPRI aims to develop and implement successful, cost-effective health interventions that reduce people's risk of developing major diseases by influencing their health behaviours.

The NPRI was founded in 2004 when the National Cancer Research Institute brought the consortium together. An initial budget of over £11 million funded Phase 1 and 2. Phase 3, announced in June 2008, will be supported by a further commitment of up to £12 million over five years. The Medical Research Council (MRC) manages the Initiative on behalf of its 16 Funding Partners.

On the 19th of January, 2006, the Advisory Board of the National Prevention Research Initiative approved the award of a grant to the Research Institute for Sport and Exercise Sciences (RISES) within Liverpool John Moores University. The award was made by the MRC on behalf of the eleven NPRI Funding Partners for a project entitled "Shift-work and Health: optimal timing of meals and physical activity. Funding was provided for two research students, Chris Morris and Sarah Fullick, to begin working collaboratively on the project on the 1st June, 2006. Some of the research work from the project is presented in this thesis, which concentrates on the impact of physical activity on short-term coping strategies for shift-work and longer-term health outcomes such as blood pressure. Chris Morris's PhD thesis focuses specifically on outcomes relevant to eating habits and appetite regulation during shift-work. Although, participants involved in the project have been included in both theses and some measurement aspects are common (e.g. the maximal oxygen uptake of the participants), all formulation and examination of research questions was separate and distinct.

1.2 Statement of the Problem

For many years, shift-work has been required to provide emergency cover and essential services at all hours of the day and night, as well as for maintaining long-term industrial processes. Nevertheless, shift-work is no longer restricted to these types of occupations, but is increasingly found in modern 'call centres', where employees deliver financial and retail services around the clock to meet the demands of a '24-hour' society. It is not surprising, therefore, that approximately 25% of the European workforce is now involved in a shift-work schedule that includes some time spent working at night (Harrington, 2001; Rajaratnam and Arendt, 2001; Costa, 2003; Smith *et al.*, 1999). Many employees can also be found working 'unusual hours'; outside of the 'normal' 9am-5pm period, but not necessarily involving night work, *e.g.* the permanent early morning shifts worked by postal delivery personnel or the shorter morning and evening 'split-shifts' worked by public transport staff or office cleaners (Taylor *et al.*, 1997). The last few decades have seen a growth in the shift-worker population (approximately 12.5% in Great Britain in 1954 to approximately 20% in 2001) and given that people within our modern society demand 24-h access and activities, shift-work is undoubtedly on the increase (Pati *et al.*, 2003; Harrington, 2001).

Shift-work schedules differ markedly in terms of organization, timing and duration of each shift as well as the speed of shift rotation. Whilst there might be benefits that result from working 'unusual hours' and shifts, such as increased wages, shift-work, and in particular night work, has been found to be associated with greater health problems in comparison to "normal" day work (Harrington, 2001; Waterhouse *et al.*, 1992). The health effects of shift-work can include a reduction in quality and quantity of sleep, insomnia, chronic fatigue, anxiety and depression, metabolic syndrome, adverse cardiovascular and gastrointestinal effects and reproductive effects in women. Boggild and Knutsson (1999) estimated that shift-workers are 40% more likely to develop cardiovascular disease than day workers. Suwazono *et al.*, (2008) found shift-work to be a more significant risk factor for increased BP during the study period than age or body mass index. Links between shift-work and increased risk of obesity (Lasfargues *et al.*, 1996; Karlsson *et al.*, 2001; Di Lorenzo *et al.*, 2003) and cancer (Scott *et al.*, 2001; Schernhammer *et al.*, 2003) have also been suggested. In addition, negative effects on vigilance, alertness and cognitive efficiency have been recorded in people whose circadian rhythms are disrupted, such as night or shift-workers (Rouch et al., 2005).

The exact reasons for the detrimental effects of shift-work on health are complicated. Most reviewers agree that the health inequalities associated with shift-work are both biological and behavioural in nature (Harrington, 2001; Costa, 2004; Knutsson, 2004; Waterhouse *et al.*, 1992). Harrington (2001) identified improvements in recreational facilities as a factor, which could potentially ameliorate shift-work problems in the short-term. Furthermore Harrington (2001) and Harma *et al.*, (1988a; 1988b; 1996) postulated that physical fitness and activity may help workers reduce the problems associated with shift-work. Whilst there have been a number of researchers who have highlighted the problems associated with shift-work and have sought to develop recreational/leisure/physical activity recommendations to help alleviate such problems, few have addressed the implementation of practical coping strategies within an 'actual' working environment. In light of this gap in knowledge, it is appropriate to adopt an interdisciplinary approach to the study of the problems associated with shift-work in terms of the value and feasibility of leisure-time physical activity during shift and night work. Such an approach is a fundamental characteristic of the present thesis.

1.3 Aim

The aims of this thesis are (i) to describe the levels and characteristics of leisure-time physical activity in shift-workers and (ii) examine the potential benefits on shift-worker health and job-related factors of leisure-time physical activity using laboratory-based and filed-based intervention studies.

1.4 Objectives

The above aims will be achieved through the following objectives:

1. To describe, using a combination of quantitative and qualitative research strategies, the problems associated with leisure-time physical activity in shift-workers and their families.

2. To examine the different coping strategies utilised by shift-workers and how these relate to leisure-time physical activity.

3. To examine the acute effects of evening exercise on vigilance and performance-related outcomes during a subsequent simulated period of night work.

4. To examine the acute effects of evening exercise on blood pressure during a subsequent simulated period of night work.

5. To examine the effectiveness of a 3-month lifestyle intervention on health outcomes during actual shift-work.

Chapter 2

Review of Literature

Aspects of this work have been published in the 2008 edition of Sports Med

2.1 Introduction to the review of literature

The aim of this chapter is to summarise the literature regarding shift-work, health and physical activity. First the reader is introduced to the prevalence and nature of shift-work in society. The epidemiology of shift-work and health is then analysed, with particular reference to the health outcomes considered in the present thesis. Focus is then directed towards the possible causes of impaired health during shift-work. Therefore, the reader is introduced to the study of chronobiology and human circadian rhythms followed by coverage of the chronobiology of circadian rhythm disturbances during shift-work. The impact of lifestyle factors on this research topic is then analysed, including coverage of the effects of physical activity on human circadian rhythms under 'normal' diurnal living and during shift-work. Finally, a synopsis of the content of this chapter is provided for the reader as a lead-in to the various study chapters.

2.2 The prevalence and nature of shift-work in society

Shift-work allows for continuous services and production, 24 hours per day. More than 3.5 million people in the United Kingdom work mostly on shifts, representing 16% of the British work-force (McOrmond *et al.,* 2004). Women have experienced slightly more involvement in shift-work than men, showing an increase of 2 percent, and this may be related to the move from a manufacturing to a service-based, 24/7 economy (McOrmond *et al.,* 2004). The proportion of persons engaging in shift-work and the relative increases in shift-work in relation to the number of women involved in shift-work are similar in most other countries in the developed world. Shift-workers predominate in heavy industries and emergency services (Figure 2.1), but they are also increasingly found in finance, service and leisure industries. Interestingly, those individuals with degree-level qualifications are the least likely to be involved in shift-work (Harrington, 2001; Rajaratnam and Arendt, 2001; Costa, 2003; Smith *et al.,* 1999).

The data presented in Figure 2.1 indicate that, in 1993 and 2003, men were more likely to report undertaking shift-work "most of the time" than women (16% compared with 13%, respectively). The predominance of men in shift-work may be related to the higher proportion of men employed in manufacturing industries, which are most likely to employ shift-workers. However, in nursing and other health related occupations, which have a predominantly female workforce, there is also a strong tradition of shift-work.

Shift-work systems vary considerably both within and across different professions but they all are designed to allow for a number of teams to be on duty over a 24 hour period. This plethora of systems has arisen through different combinations of the number of hours worked, the number of days worked, the time of day in which the shifts commence, and the frequency and regularity of shift changes (Waterhouse *et al.*, 1992). Knauth (1997) suggested that the most effective type of shift system might in fact be a tailor-made system and should be a compromise between the employer's goals, the wishes of the employees, and ergonomic recommendations for the design of shift systems. Nonetheless, there are some common shift systems which, include the three shift-system, continental shifts, two shift-systems, split shifts, permanent mornings, permanent afternoons/evenings, permanent nights, weekend shifts or other type of shift-work. The most common type of shift system in the United Kingdom seems to be the two-shift system, with early/late double day shifts (McOrmond *et al.,* 2004). This system typically consists of two shifts of eight hours each alternated over weekly or longer intervals. Interestingly, women are more likely work the two-shift system than men (31% and 29% of all female and male shift-workers respectively in spring 2003) (McOrmond *et al.,* 2004). Each system has the capacity to rotate in both a forward or backward manner either slowly (changing every week or few weeks) or rapidly (changing every few days). There is much debate regarding the 'most suitable' shift system. Each of these systems is described in more detail below.

2.2.1 Three-shift system

The day is divided into three working periods: morning, afternoon and night shifts normally last no longer than 8-hours. This type of shift-work usually, but not always, involves one or more weeks of mornings, followed by one or more weeks of afternoons, followed by one or more weeks of nights. Therefore teams normally spend a week on each, with nights, afternoons, morning progression over the three-week cycle.

2.2.2 Continental three-shift system

This is a continuous three-shift system that rotates rapidly; for example, three mornings, then two afternoons, then two nights. Normally, to avoid impracticalities, a rapidly forward rotating shift pattern is adopted. Forward rotation (earlies/lates/nights) is recommended from a circadian perspective because the internal body clock naturally tends to run slow when studied in temporal isolation conditions (i.e. every 25 hrs) (Mirrors and Waterhouse, 1981). Therefore, it has been suggested that it is easier to delay sleep than it is to advance it. Nevertheless, some workers prefer a backward rotation (nights/lates/earlies) because it may afford more time to recover from sleep deficits and prepare for the next night shift (Knauth, 1997).

2.2.3 Two-shift system and Split shifts

The two-shift system normally consists of shifts, each lasting eight hours. For example, 06:00-14:00 and 14:00-22:00. These shifts are usually alternated weekly or over longer intervals. The 06:00-14:00 shift may often be referred to as 'earlies', 'mornings', 'AM', or '6-2', while the 14:00-22:00 shift may be called 'lates', 'afters', 'afternoons', 'back shift' or '2-10'. Split shifts are full shifts divided into two distinct parts with a gap of several hours in between. Split-shifts are used in industries where peak-demands occur at different times of the day, for example catering, passenger transport and service industries. Office cleaners often work split shifts, being on duty in the early morning and late afternoon.

2.2.4 Permanent morning, evening and night shifts

Permanent shifts were designed to allow a worker (or a team of workers) to work one specific shift (morning, evening/afternoon or night). Often the shift in which a worker is assigned is chosen by the worker themselves. If an employee works permanent morning shifts, the shift times are normally around 06:00 to 14:00. Nevertheless, the exact times are highly dependent on the type of work and the organisation in which the worker is employed by. Permanent morning shifts are only normally used if the morning shift is the only shift-worked or worked part-time during the morning within a specific organisation. If an employee works permanent evening shifts the shift times are normally around 15:00 to 00:00, although these times can again vary. Permanent evening shifts only are usually called twilight shifts. If a shift-worker works permanent night shifts the shift times are normally around 18:00 to 06:00.

2.2.5 Weekend shifts

Weekend shifts are used for work during Fridays, Saturdays, Sundays (06:00-18:00), when there is no other work since most other workers are on rest days. This model typically uses 12-hour shifts, with workers limited to working 12 hours per day both Saturday and Sunday, rotating between days and nights on alternate weeks. When used in conjunction with a three-shift, semi-continuous pattern, full 24/7 cover can be achieved. There are disadvantages in terms of unsociable hours of work. The effect of weekend and night shift premium upon the 24 hours worked each week increases the value of paid hours to an attractive level which equates roughly to a normal weekly wage. It should be noted that this is not an indefinite list of shift patterns and many shift schedules are arranged in a bespoke manner to meet the individual needs of each organisation.

2.3 The epidemiology of shift-work and health: problems and pitfalls

Shift-work, and especially night-work, has been associated with increased risk of insomnia, gastro-intestinal problems, higher body mass index, heart disease, metabolic syndrome, and cancer (Waterhouse *et al.*, 1992; Lasfargues *et al.*, 1996; Karlsson *et al.*, 2001; Di Lorenzo *et al.*, 2003; Scott *et al.*, *2001*). Disruption of circadian rhythms during shift-work is thought to be important in explaining these increased health problems. Nevertheless, differences between shift-workers and day-workers in lifestyle factors, including participation in physical activities, have been generally under-researched.

Shift-work research is interdisciplinary in nature, involving the mechanisms by which circadian rhythms are generated and synchronized plus an understanding of shift schedules in terms of their pathological, psychological, and sociological consequences on workers (Knutsson, 2004). A major issue has been to understand the possible ways in which shift-work can impact an individual's performance and health from both an acute and chronic perspective (Knutsson, 2003; Knutsson *et al.*, 2004). Shift-work research is closely related to the research of chronobiology, the area of science that studies biological rhythms. Nearly all body functions, from those of the cellular level to those of the entire body, are rhythmic in origin. In chronobiology and therefore shift-working research, experimental animal studies are popular. Field studies on shift-workers typically involve experimental and quasi-experimental designs, especially for assessing short-term effects, while epidemiological designs are often the only way to explore associations between shift-work and chronic disease (Knutsson 2004). A number of studies exploring the epidemiology of shift-work have employed a variety of experimental designs such as cross-sectional, longitudinal, prospective and retrospective designs.

Since the epidemiological study of shift-work is of a multi-disciplinary nature, research in this area can be fraught with methodological problems and issues. One such problem relates to how shift-work is actually defined (see section 2.2), as the term shift-work as been used differently in scientific literature, should a broad or narrow definition be employed? However, shift-work covers a wide variety of working time arrangements, including all working hours that are outside the normal daytime ones, therefore a narrow definition would not necessarily capture the 'whole picture' of shift-work .Nevertheless, if it is true that social stress associated with irregular and 'odd' working hours that is the major risk factor for chronic disease in shift-workers, then it will probably not matter if a broad definition of shift-work is used. On the other hand, if night-work is the major deleterious component of shift-work, a broad definition would lead to an underestimation of its health impact (Knutsson 2004; Knutsson, 2003; Knutsson *et al.,* 2004). Akerstedt *et al.,* (1987) and Alfredsson *et al.,* (1985) addressed the issue of the definition of shift-work in a Swedish cohort study of 958,096 participants who were studied for 1 yr, shift-work was either defined as 'not day-work' or 'night-work'. When shift-work was defined as "not day-work" the Standardized Morbidity Ratio (SMR) for myocardial infarction was 115 (95% confidence interval or 95% CI: 104–126). When the definition was 'night-shift', the SMR increased to 148 (95% CI: 112–191). The results of this study suggest that night-work hours/rotation is probably an important factor that can affect the assessment of the association between shift-work and health in particular coronary heart disease. Night-work is probably also a concept which is too broad, since different kinds of night-work may result in different kinds or risks. Because of the discrepancy in shift-work definitions, it is often difficult to compare results of different studies. Therefore, a more clear definition of shift-work in epidemiological research is vital to allow for comparable and accurate research to be conducted.

Further discrepancies relating to the definitions, understanding and study of key variables often measured in shift-working research such as sleep, sleepiness, fatigue and their potential link to the deterioration of performance, increased risk of accidents and other issues relating to shift-work are apparent (Folkard and Lomardi 2004). Sleep can be measured objectively via electroencephalography (EEG). However, sleepiness is more difficult to measure, and it is usually assessed by self-reports (e.g., Ingre *et al.,* 2004). One issue with the self-assessment of sleepiness is bias due to the temporary stimulating effect of the self-assessment procedure. Each time the subject performs the self-assessment there is a temporary awakening effect caused by actually doing the task. This effect is probably more pronounced when the subject is approaching superficial sleep, therefore leading to an underestimation of sleepiness. More objective methods to detect severe sleepiness using video camera techniques, where eye and eye lid movements can be observed, are promising. However, such methods are not always conducive to field-based studies (Knutsson 2004). Fatigue is a conception often used interchangeably with sleepiness. Yet, there is a difference between sleepiness and fatigue (Pigeon *et al.,* 2003). Sleepiness can and is usually defined as difficulties in staying awake even when wakefulness is required, and after a night's good sleep sleepiness will disappear. Conversely, fatigue is an uncomfortable feeling often described as lack of energy and is not relieved by a period of sleep (Shen *et al.,* 2006). The majority of studies that rely on self-report methods fail to distinguish between fatigue and sleepiness. Therefore, it is not clear as to whether both factors are predictors of accidents. Lack of distinction between the two concepts may lead to improper preventive measures (Knutsson 2004).

Length of time working shifts (dose exposure) is also an area of concern when studying shift-work. A dose–response relationship is regarded as an indicator of causal relationship and it has been suggested that time spent working shifts (i.e. dose of shift-work) is related to long-term health effects (Baker *et al.*, 2004; Bohle and Tiley, 1998; Oginska *et al.*, 1993; Bonnefond *et al.*, 2006). Knutsson *et al.*, (1986) conducted a study on Swedish mill workers, where a clear dose– response relationship between years of shift-work and coronary heart disease were found and reported. After 2–4 yrs of shift-work the relative risk was 1.5; after 6–10 yrs it increased to 2.0; after 11–15 yrs it increased to 2.2; and after 16–20 yrs it rose to 2.8. Kawachi *et al.*, (1996) also reported that there was a slight but insignificantly increased risk up to 5 yrs of shift-work in nurses. Five years of shift-work or more were associated with a substantial increase in the relative risk of coronary heart disease. The relative risk (RR) for 6–9 yrs of shift-work was 1.78 (95% CI: 1.19–2.67), for 10–14 yrs RR=2.01 (95% CI: 1.29–3.14), and for 15 yrs or more RR=1.69 (95% CI: 1.15–2.48). The data from the aforementioned studies suggested that the risk of coronary heart disease is somewhat modest up to 5 yrs of experiencing shift-work, but if done for more than 5 yrs the risk increases to a considerably higher level. However, a problem of using "years of shift-work/ length of time working shifts" as a measure of exposure dose is the choice of reference category. Shift-work jobs are often different from day-work jobs. A person who transfers from shift to day-work will often experience a change in the work environment, which, invariably can affect the dose-response relationship and often means the comparison of 'day-workers' and 'shift-workers' is somewhat problematic.

Another concern faced by researchers wanting to study shift-work is the bias of the 'healthy worker effect.' The 'healthy worker effect' simply refers to a selection process that leads to a workforce of shift-workers that is healthier than day-workers (Costa, 1997). This simple but significant selection process starts with the individual's own judgment of his/her ability to endure the working conditions and therefore the submission of an application for a specified vocation that requires shift-work. If the application process is successful then the selection continues in terms of a survivor effect, i.e., the less 'healthy' and those less able to 'cope/tolerate' with shift-work are likely to quit a particular job or leave the workplace. This phenomenon can occur whether or not the cause of health problems is occupational or otherwise. The 'healthy worker effect' has typically been dealt with by subdivision of the population into day-workers, current shift-workers, and ex-shift- workers. Nevertheless, this does not seem to attend to several key factors that influence the interpretation of findings. Firstly, the subdivisions do not take into account the pre-employment selection made by the individuals themselves. If, for example, the results do not show differences in health between the three groups, there is still the possibility of a detrimental effect of shift-work. Secondly, it obscures the fact that some workers may have left shift-work not only because of its negative health impact, they might have left shift-work because of other occupation-related diseases or diseases not caused by occupational exposure. More health problems in the ex-shift-workers group do not necessarily mean they are caused by illnesses due to shift-work (Knutsson, 2004).

Such issues should be taken into account when studying shift-workers. Shift-work research would be more easy to interpret if the term 'shift-work' were defined in a more clear and explicit fashion. Those researching shift-work should also take into account the interchangeability of terms and key variables, the selection process and the dose-response issues relating to time spent in shift-work. Shift-work has a multitude of issues and problems, as such any research being conducted within this field should be considered and of a multi-factorial nature in order to gain a holistic picture of shift-work and the health of the shift-worker.

2.3.1 Shift-work, sleep, chronic fatigue, vigilance and performance

Sleep loss is obviously one of the most important immediate consequences of shift-work, especially during those systems that require an individual to work at night (Rajaratnam and Arendt, 2001). The normal daily sequence of 'sleep, work, leisure,' often has to be changed to 'sleep, leisure, work,' when the workers are on afternoon, evening or night-shifts, and the sleep length (in general decreased) can vary considerably among the different shifts and rest days according to the imposed or selected retiring and rising times (Costa, 1997). A significant reduction of sleep-time can occur during a period of morning shifts (due to an early start which is not generally accompanied by an earlier bed time), leading to less time spent in the final part of the night sleep. On night-shifts, diurnal sleep is reduced and perturbed not only due to unfavourable environmental conditions (for example peripheral day-time noise and light), domestic conditions (child care, meal-times and so on). But also for circadian reasons (it is more difficult to fall asleep and the sleep length is shorter when rest starts during the rising phase of the body temperature rhythm, sleep is also more interrupted and altered in its ultradian stage sequencing, therefore losing part of its restorative properties) (Tepas and Carvalhais, 1990). Disturbances in sleep can cause 'shift-lag syndrome' and can in the long run mediate 'chronic fatigue' (Costa, 1997) (persistent and severe and sleep loss) psychoneurotic syndromes such as anxiety and depression. These complaints may be treated with hyponotic or psychotropic drugs and this can induce a dangerous vicious circle due to habituation effects (Costa, 1997; Pati *et al.*, 2001).

In general, sleep loss and the subsequent fatigue experienced by shift-workers will also result in performance deficits, including increased variability in performance, slowed physical and mental reaction time, increased errors, decreased vigilance, impaired memory, and reduced motivation (Dinges *et al.*, 1991). To date there is no real consensus on the extent of impairment resulting from a given amount of sleep loss. Nonetheless, Williamson and Feyer (2000) found that depending on the task measured, after 17-19 hours of wakefulness, decrements in task performance have been found to be equivalent to, or worse than those seen at a blood alcohol concentration of 0.05%. Whilst the blood alcohol concentration limit for drivers in the UK is 0.08%, researchers have found that an individual's vision can be significantly and adversely affect by blood alcohol concentrations of 0.03% (Chamberlian and Soloman, 2002). Furthermore, 0.03%-0.05% blood alcohol concentrations interfere with voluntary eye movements and impair the eyes' ability to rapidly track a moving target and can influence overall cognitive performance (Chamberlian and Soloman, 2002). Gold *et al.,* (1992) established that sleep deprivation and misalignment of circadian phase as experienced during rotating shift-work are each associated with frequent lapses of attention and increased reaction time, leading to increased error rates on performance tasks. Rogers (2003) found that nearly two-thirds of nursing staff working long and irregular hours struggled to stay awake during their shifts, suffering episodes of drowsiness and diminished alertness. Such episodes of diminished vigilance during shift-work have been found to be related to increases in the number of errors made by nursing staff (Scott *et al.,* 2006). In general, performance efficiency appears to parallel the circadian rhythm of body temperature, but it can peak earlier or later according to the type of task, time spent awake, motivation and arousal (Folkard and Monk, 1985). By contrast, little is known about the long-term consequences of chronic sleep deprivation and chronic fatigue as can be the case during shift-work, on cognitive abilities (Rouch *et al.,* 2005; Harrington 2001).

Sleep loss, sleep related factors, chronic fatigue and oscillatory mechanisms of vigilance and performance have all been linked to 'human error' and accidents in the work-place. Generally, performance efficiency in the work-place appears to parallel the circadian rhythm of body temperature, but it can peak earlier or later depending on the type of task (physical, cognitive, memory load), time spent awake, arousal and motivation (Folkard and Monk, 1985). Vigilance and performance can be considerably affected by marked irregularity of the rest/activity patterns and by the prolonged physical and mental effort, this is seen for example in long-haul pilots) (Price and Holley, 1990). Nonetheless, there are contradictory findings from epidemiological studies on work accidents in industrial shift-workers. Some studies have reported an increased number of incidents occurring on night shifts, others have found more accidents occurring during the evening and day shifts when performance should be optimal. It is possible that these contradictions can be explained by the aforementioned circadian or ultradian rhythmic influences, other factors such as environmental conditions (i.e. lighting, noise), job content, changes in work-load, shift-length (i.e. 8-h or 12-h duty), supervision, time pressures and psychophysiological conditions. There both organisational as well as chronobiological aspects of shift-work, vigilance and performance must be considered (Costa, 1996; 1997)

2.3.2 Shift-work and cardiovascular problems

Cardiovascular diseases (CVD) are the leading cause of death and disability in most industrialized countries, in fact one-billion people worldwide are affected by CVD. Whilst advances in medication, operations and other tertiary preventions have alleviated the lethality of CVD the primary aim should still be prevention and therefore reduce the incidence of CVD (Beaglehole, 1990). The antecedents of CVD are multifactorial, and over the past decade it has become apparent that conditions in the work environment can contribute to the aetiology of CVD (Boggild and Knutsson, 1999). Workers who are exposed to a variety or chemicals, as well as those workers who engage in a sedentary work, monotonous work or work that is stressful, work environments in which there is excessive passive smoke and shift-work have all been identified as occupational risk factors for CVD (Kristensen, 1989; Boggild and Knutsson, 1999). Koller (1983) suggested a dose-response relationship between years of shift-work and CVD (figure 2.2).

Knutsson *et al.*, (1986) indicated that shift-work is associated with increased risk of ischemic heart disease (IHD), at least during the first two decades of shift-working. Knutsson (1989) found a higher risk of CVD among shift-workers compared to day-workers. Since this early indication of higher risk, several other researchers have confirmed these findings. Boggild and Knutsson (1999) estimated that shift-workers are 40% more likely to develop cardiovascular disease than day-workers; the possible causal mechanism in which shift-work might be related to CVD is shown in Figure 2.3. Knowledge of the potential links between CVD and shift-work are particularly valuable, as problems associated with shift-work can only be prevented or alleviated by manipulating these links, not by eliminating the primary exposure. Shift-work is often coupled with high job strain/stress which is also known to affect CVD. Whether the stress/strain is due to job content, rhythm disturbance, social implications or all of the aforementioned is still a matter of debate and an area that requires further research (Tobe and Kiss, 2005; Rau, 2006; Steptoe, 2005).

Ha and Park (2005) conducted a study in 134 male shift-workers (working in a manufacturing industry) and 226 female shift-workers (nurses), to examine the relationship between shift-work duration and metabolic risk factors of CVD. All 360 shift-workers had participated in shift-work for between 2 to 8 yrs (mean duration in shift-work 2.8 yrs), with the mean age of the male workers being 28.5 yrs and the mean age of female workers being 29.1 yrs of age (Figure 2.4).

Twenty percent of the male workers and 29% of the female workers were classified as having high job strain. Ha and Park (2005) indicated that there were significant increasing trends in blood pressure (BP) observed with increasing shift-work duration in the case of the male workers, but in the case of female nurses aged less than 30 yrs where a significant inverse association was observed in diastolic blood pressure (DBP). Furthermore, male workers (in particular those of 30 yrs old and above) showed a significant positive association between cholesterol level and shift-work duration, whilst, the female nurses of 30 yrs old or more showed an inverse relationship between the two factors. Ha and Park (2005) further indicated that 30% of male workers and only 2.4% of female workers could be classified as hypertensive, with body mass index (BMI) having no significant associations with shift-work duration, however, waist to hip ratio (WHR) in the nurses of 30 yrs or more had strong associations with shift-work duration. The exact mechanisms for the disparity between genders is not clear, nevertheless, the difference been job content and difference in numbers of male and female participants and the potential social-economic and demographic differences may explain such differences. There are several factors that may increase the risk of developing CVD. The major risk factors appear to be hypertension, high blood cholesterol, physical inactivity, digestive disturbance/habits and smoking (Pati *et al.*, 2001).

2.3.2.1 Shift-work and blood pressure

Twenty-four-hour patterns of heart rate and blood pressure are associated with the sleep-wake cycle and a number of other cyclic behavioural factors, as well as being mediated in part by endogenous (i.e. in the hypothalamus) circadian control (Smolensky *et al.*, 2007). A myriad of acute and chronic medical conditions and sleep disorders can also moderate blood pressure and ultimately cause hypertension (Smolensky *et al.*, 2007; Gangwisch *et al.*, 2007). Data from many previous studies have indicated an increased risk of hypertension among shift-workers (Akerstedt *et al.*, 1984; Suwazono *et al.*, 2008). Although some researchers have shown discrepancies in BP readings during night-work (Ha and Park, 2005) others have shown a clear rise in both systolic blood pressure (SBP) and DBP (Ohira *et al.*, 2000). Often these differences can be attributed to methodological flaws some of which have been discussed in section 2.3, others could potentially relate to inconsistencies in measuring equipment utilised in different studies and even potentially human error. Fialho *et al.*, 2006) measured the ambulatory BP of sixty-one medical residents working shifts in the emergency room and working a regular 'diurnal' shift. Fialho *et al.*, (2006) indicated that both mean 24-h SBP and DBP readings during sleep were higher during shift-work in the emergency room than during the typical day (117 v 113 mmHg, $p<0.05$; 73 v 69 mmHg respectively). Fialho *et al.*, (2006) therefore concluded that the undesirable changes in BP elicited by shift-work could be a risk factor for CVD. Suwazono *et al.*, (2008) conducted a longitudinal (14-years in length) cohort study in normotensive, male shift-workers to establish whether shift-work was an independent risk factor for an increase in BP. Shift-work was found to be a more significant risk factor of hypertension than BMI, smoking, drinking habits and habitual exercise (Figure 2.5). The exact mechanisms surrounding this increased risk are yet to be unravelled. Nevertheless, the following reasons have been forwarded; internal desychonization of circadian rhythms, lifestyle changes and a general increase in work-related stress.

Interestingly, exercise and physical activity are used as effective treatments of hypertension in those individuals living a 'normal diurnal' existence. For example, Hellenius *et al.,* (1993) reported that an exercise program can mediate reductions in BP that are similar in magnitude to those incurred by restricting dietary salt. There is little or no research on physical activity and the health implications relating to the reduction in blood pressure for shift-workers. Nonetheless, shift-workers are generally less active than day-workers, the exact reasons as to why this is the case is somewhat unclear. However, it has been speculated that sleep problems, domestic and social responsibilities are amongst a number of actual/perceived barriers in which shift-workers face when attempting to participate in physical activity (Atkinson *et al.,* 2008). The distinct absence of research data relating to the potential associations between physical activity, BP and shift-workers is surprising given that exercise clearly helps in the general management of hypertension (Harmer *et al.,* 2006).

2.3.2.2 Shift-work, blood pressure and internal desychonization of circadian rhythms

The external influence of sleep and activity on circadian rhythms is called *masking* (Baumgart *et al.,* 1989). In some but not all of the studies on night shift-work and blood pressure, a longer plateau of high SBP is described in the night-time (Yamasaki *et al.,* 1998). This is important in as much as previous studies have indicated that there might be associations with high BP and individuals with continuously or with an increased regulatory of higher values of BP (Izzedine *et al.,* 2005). Changes in sleep length and quality have also been found to potentially influence BP in shift-workers (Smolensky *et al.,* 2007). There is evidence that sleep deprivation, such as that experienced by shift-workers, have shown significant increases in blood pressure and sympathetic nervous system activity after sleep was restricted to 3.6 to 4.5 h (Gangwisch *et al.,* 2006). Since heart rate and BP are under the control of the autonomic nerve system (Quan *et al.,* 2006) it is therefore speculated that shift-work also changes the circadian fluctuations of the autonomic activity (Ito *et al.,* 2001). Rutenfranz *et al.,* (1988), found the level of catecholamines circulating in blood and in urine can indeed change (increase) as a result of shift-work. Such alterations in the circadian rhythm of autonomic regulation can have important implications on physical, psychological and medical problems relating to hypertension and shift-work (Ito *et al.,* 2001). Autonomic activity is also involved in the occurrence of hypertension by the modulation of vascular tone and blood coagulability Furthermore, long-term treatment with melatonin has been shown not only to promote sleep but also to reduce BP in hypertensive patients (Scheer *et al.,* 2004). However, the exact antecedents for the role shift-work seems to play as a factor affecting higher levels of BP are still somewhat unclear.

2.3.2.3 Lifestyle changes

Shift-work has been associated with a number of negative lifestyle changes and poorer health habits and thus increasing a person's vulnerability to illness such as hypertension (Steenland, 2000). Participating in shift-work has been shown to increase the consumption of cigarettes and alcohol, reduce physical activity levels, disturb eating patterns and increase the prevalence of being overweight and an individual exhibiting higher cholesterol levels (Kivimaki *et al.*, 2001). All of the aforementioned lifestyle changes have been found to alter blood pressure and are often linked to hypertension and CVD. Interesting a number of lifestyle behaviours that are negatively affected by shift-work are often employed as an intervention to prevent and/or treat/alleviate existing CVD (Messerli *et al.*, 2007) (Figure 2.6).

2.3.2.4 Interaction between blood pressure, work, family, friends and stress

Psychosocial factors may influence the development of early hypertension (Tobe *et al.*, 2005). The interaction between work and family life may lead to stress. Shift-workers have to sleep in the day time, may be unavailable for family and friends at weekends and during the evenings on weekdays, and may have problems in attending regular social arrangements

(Monk, 1988; Scott, 1990). Sleep is often compromised for both physiological and social reasons and may be compromised when shift-workers choose between family, friends and sleep; such 'stress and strain' has been reported to negatively influence BP (Tobe *et al.*, 2005). Several researchers have suggested two major sources of stressful experiences in shift-work:

1. Physiological disruption of circadian rhythms, leading to sleep problems and general fatigue.
2. Social conflicts, as working hours in evening and night impinge on family interactions.

The impact of psychological factors on the development of hypertension can be best understood in the context of the daily interactions of life at work and at home. Steptoe and Cropley (2003) have suggested that high job demands and low control at work have previously been related to elevated BP. Previous research has mainly focused on job strain, defined as low (i.e. lower than 20%) job latitude and high (i.e. the upper 20%) job demands which has been associated with hypertension and other CVD (Schnall *et al.,* 1990). Shift-work could potentially be perceived as demanding by workers since shift-work is known to cause circadian disrhythmia, which, is known to have a number of implications affecting most areas of an individual's life. What is more workers often perceive a lack of control regarding the work rosters and patterns. With this in mind shift-work could indeed have associations with increased stress levels (perceived or actual), which in turn could potentially negatively influence BP values. However, demands of the job and level of control alone are somewhat inconsistent in explaining elevated blood pressure values. McVicar (2003) indicated that home life, gender and an individual's ability to cope with either perceived or actual stressors has previously been related to elevated blood pressure. Individuals differ in the extent to which they respond to stress/challenge with increases in cardiovascular and neuroendocrine activity, these differences are related to genetic factors, social and psychologically influences (Steptoe, 1998). Since shift-work is known to impact holistically upon all aspects of an individual's lifestyle (for example family life, job performance, sleep loss and so on) and has previously been suggested to disturb social and domestic activities within a family home, often causing stress between family members (Lipovcan *et al.,* 2004). In recent years martial cohesion has also been associated to fluctuations in BP also (Baker *et al.,* 2000). Shift-work has been associated to disturbance of marital and home life, this coupled with the direct stress of shift-work (sleep disturbance) can cause what is termed 'double exposure' (Tobe *et al.*, 2005). 'Double exposure' is a term used to describe the interplay between domestic and work stressors. Therefore, it is plausible to suggest that the physiologic changes that result from recurrent stressors associated with work-home/life balance may predispose individuals to the onset of hypertension at an early age (Tobe *et al,* 2005).

2.3.3 Shift-work, tolerance and coping

Shift-workers' health and well-being are the consequence of more or less balanced interactions among all the factors which collectively represent one's "tolerance" to shift-work (Costa, 2004) (Figure 2.7).

There are several dimensions related to: a) individual characteristics, i.e. age, gender, biological temporal structure, physical fitness, personality traits (e.g. neuroticism), personal behaviours (i.e. morningness, sleep strategies, commitment); b) family and living situations (i.e. marital status, number and age of children and co-habiting persons, housing comfort, partner's job); c) social conditions (income level, participation in community activities, public services and social protection, labour market restrictions and discrimination; commuting; d) work organisation (i.e. job demands, working hours, shift schedules, health surveillance).

These factors can have different effects (e.g. physical health, mental health, social relations) according to the circumstances and ways of interaction (e.g. addition, enhancement, compensation), and the consequent result depends not only on the specific load of each factor, but mainly on how much and how long they interact and interfere with each other in relation to the peculiar conditions of each individual or group of shift-workers. They may also have significant implications on productivity, company strategies and social organisation, which in turn influence individual health and well-being (Costa 2004). A shift-workers ability or inability to shift-work is strongly related to their ability to cope with the multi-factorial implications shift-work has on an individual's life.

The extent to which individuals cope with shift-work is very heterogeneous (Lasfargues *et al.*, 1996; Karlsson *et al.*, 2001; Di Lorenzo *et al.*, 2003). As such, most researchers would agree that it is imperative to consider how individuals cope with working shifts, and how they deal with the possible health problems that they might experience. Whilst a number of reviews, booklets and guides on how to cope with irregular working hours have been produced (Monk and Folkard, 1992; Wedderbrun, 1991; Harrington, 2001; Costa, 2003), little attention has focused on how individuals actually cope with shift-work and how effective are the strategies they employ at sustaining health and well-being. A more systematic approach to exploring individual coping strategies may help us understand why some individuals seem to be more successful than others (Spelten *et al.,* 1993).

Coping refers to individuals' behavioural and cognitive efforts to manage situations that are viewed as taxing personal resources (Lazarus and Folkman, 1984; Carver *et al.,* 1989; Soderstrom *et al.,* 2000). Generally, researchers distinguish between two broad types of coping strategy: approach/engagement-oriented strategies (involving active attempts to confront and resolve the problem) and avoidance/disengagement strategies (reducing the associated emotional distress or evading the problem) (Klag and Bradley, 2004, Tobin *et al.,* 1989). Some study findings indicate that engaging or approaching problems is more beneficial and will prevent burnout as opposed to avoiding or disengaging from the problem (Ceslowitz, 1989; Chang *et al.,* 2006). Nevertheless, Lazarus (1992) suggested that there are no universally good or bad coping processes, merely those that might often be better or worse than others in a particular individual. Indeed, it has been suggested that individuals use both disengagement and engagement strategies to deal with shift-work-related problems, regardless of shift-schedule or job-type (Smith *et al.,* 1999). Since coping is a dynamic process, the strategies employed may also evolve with time and experience. For example Smith *et al.,* (1999) found that, regardless of the shift schedule, shift-working nurses with inflexible sleeping habits tended to avoid or disengage from the problems whilst permanent night-working nurses utilised both engagement and disengagement strategies when dealing with sleep and social/family disturbances. It should be noted that the vast majority of participants were female; coping is thought to show gender differences (Tamres and Helgeson, 2002).

2.3.4 Shift-work and cancer

The effect of shift-work on cancer, particularly breast cancer, has received increasing interest from the lay media since a panel of the International Agency for Research on Cancer declared in 2007 that "shift-work that involves circadian disruption is probably carcinogenic to humans" (Straif *et al.,* 2007, pp1065). This conclusion was based mainly on evidence from animal studies and limited evidence from human studies. The evidence is strongest for breast cancer, although the risk of prostate and colorectal cancer may also be increased by shift-work (Kolstad, 2008). Two recent meta-analyses have suggested that the risk of breast cancer is increased by about 50% in night-workers and by about 70% in flight personnel (Kolstad, 2008 and Wise, 2009). Schernhammer *et al.,* (2003) documented 602 incident cases of colorectal cancer among 78 586 women who were followed up from 1988 through 1998 (Table 2.1). Compared with women who never worked rotating night shifts, women who worked 1–14 years or 15 years or more on rotating night shifts had multivariate relative risks of colorectal cancer of 1.00 (95% confidence interval [CI] = 0.84 to 1.19) and 1.35 (95% CI = 1.03 to 1.77), respectively (p trend = .04). These data suggest that working a rotating night shift at least three nights per month for 15 or more years may increase the risk of colorectal cancer in women.

If this association is correct, shift-work could have its effect by several different mechanisms. There are several mechanisms in which have been proposed to cause such associations:

- Light at night suppresses the production of melatonin, which is purported to have direct and indirect anticancer effects (Stevens, 2009)
- Sleep disruption stimulates the hypothalmic-pituitary axis to release glucocorticoids, which results in depression of immune function (Bovbjerg, 2003)
- Phase shift, in which the peripheral rhythms of functions such as digestion are out of phase with central sleep and wake rhythms. This may result in changes in the control of cell and tissue proliferation (Haus and Smolensky 2006)
- Shift-work may result in changes in lifestyle factors such as smoking, diet, alcohol use, or exercise (Bøggild and Knutsson 1999)
- Decreased production of vitamin D resulting from being indoors and asleep during the hours of daylight (Kimlin and Tenkate 2007)

All of the proposed abovementioned mechanisms are biologically plausible and are supported by experimental evidence. However, the human evidence lags behind because of problems in accurately defining and assessing the relevant exposure and the difficulty in controlling for confounding factors, especially in cohort studies in one profession (Fritschi, 2009). However, in comparison to the other implications associated with shift-work, research into the link with cancer is still somewhat new and requires further attention.

2.4 Introduction to human circadian rhythms

Chronobiology is a field of biology that examines time-related phenomena in living organisms. The term chorno relates to 'time' and biology is related to 'life'. Chronobiologists are concerned with the fact that physiology process and functions are seldom constant over time but exhibit non-random variations that occur in regular time intervals. Such variations are known as biological rhythms. These cycles are important in many essential biological processes that occur in a "scheduled" fashion, such as eating, sleeping, mating, hibernating, migration, and cellular regeneration (Monk and Folkard, 1992).

2.4.1 Terminology and basis of circadian rhythms

The most important rhythm in chronobiology is the circadian rhythm, which refers to the 24-hour daily biological cycle (Minors and Waterhouse, 1981). The term circadian is a Latin word '*circa* which means 'around' or '*dia*' which means 'day'. Research data have indicated that the main physiological functions such as core body temperature, hormone production, heart rate, blood pressure, gastric activity, and the sleep/wake cycle, all have cycles or rhythms of approximately 25 hours. Normally our circadian rhythms are *synchronized* to one another by the internal biological clock (suprachiasmatic nuclei (SCN) found in the hypothalamus), and *entrained* (daily reset) to the 24 hour day/night cycle by external time cues, namely the variation in sunlight and the increase in environmental and family activity around us. External cues are termed zeitgebers (German for "time giver", synchronizer) and are any exogenous (external) cue that entrains the endogenous (internal) time-keeping system of organisms. The strongest zeitgeber, for both plants and animals, is the light/dark cycle. Other, non-photic, zeitgebers include temperature, social interactions, pharmacological manipulation, eating/drinking patterns and exercise. (Millar-Craig *et al.*, 1978; Minors and Waterhouse, 1981, 1984; Waterhouse *et al.*, 2005). There are several terms that are commonly encountered when looking at chronobiology. The term 'diurnal', in the context of his work, refers to following a 'normal lifestyle' of sleeping at night and activity (work) during the day. 'Nocturnal', conversely, refers to a lifestyle of activity (work) during the night, and sleeping during the day. The exogenous component of the circadian rhythms is controlled by external influences and this is commonly referred to as a 'masking effect' (Minors and Waterhouse, 1981; Waterhouse *et al., 2005*). The effect persists for a period not much longer than the stimulus is present. An example of this is the raising core body temperature by a hot bath. This alters the core body temperature for short period of time but it does not interfere with the endogenous body temperature rhythm in the long term (Vidacek *et al.,* 1995). Other terms that are used to describe a rhythm or oscillation are: cycle; period; amplitude; and acrophase. A cycle describes the repeating unit of a rhythm. It repeats itself indefinitely. The time required to complete one cycle of a rhythm is known as the period. It can be measured from peak to peak or trough to trough. The rhythms that have a period of around 24 hours are of most interest in this work. The Midline Estimating Statistic of a Rhythm (mensor) represents the value midway between the highest and lowest values of the cosine fitted curve (Halberg *et al.,* 1977). The amplitude of a rhythm is defined as 'one half the difference between the highest and lowest point of the mathematical model (half the peak trough distance of the fitted function)' (Haus and Touitou, 1992). To place a rhythm in a certain time continuum the acrophase must be known. The acrophase is the time at which the maximum value of the cosine curve occurs (Minors and Waterhouse, 1981; 1984). Finally, a 'phase advance' is when the entire rhythm shifts in phase towards an earlier time in the cycle (acrophase occurs earlier); and a 'phase delay' is when the entire rhythm shifts in phase towards a later time in the cycle (acrophase occurs later) (Minors and Waterhouse, 1981; 1984).

2.5 The chronobiology of shift-work

Working shifts (specifically rotating shifts), normally means an individual has to adjust their natural sleep/wake cycle to suit whichever shift an individual is on (normally predisposed by the shift roster/system provided by the employer) . However, human circadian rhythms do not adjust instantaneously - in fact different rhythms change at different rates - and typically take a week or more to adjust to the new sleep/ wake cycle. Rotating onto night shifts can in the majority of cases cause the greatest disruption to our circadian rhythms as we attempt to remain active and alert during the night when our circadian rhythms are falling to their lowest and try to sleep during the day when our circadian rhythms are rising to their peaks (Minors and Waterhouse, 1981). How quickly a shift-workers circadian rhythms can adjust to a new sleep/wake cycle depends on internal factors such as the age, gender, physical health/lifestyle and *chronotype* ('Larks and Owls'), and external factors such as the shift pattern, work load, family and social circumstances. If an individual rotates onto another shift before their circadian rhythms have had time to adjust to one sleep/wake cycle, then their circadian rhythms may become in a perpetual state of internal desynchronisation, where they are never fully synchronised to one another. Although the effects of shift-work on an individual's circadian rhythms cannot be eliminated completely, there are steps that can be taken at both the organisational level and individual level to minimize these effects (Harrington, 2001). Physical activity/exercise is one such step that has been hypothesised to potentially alleviate a number of the problems associated with shift-work and circadian dysrrhythmia (Atkinson *et al.*, 2007). The purported positive effects physical activity has been suggested to have on human circadian rhythms has received some attention especially relating to shift-work.

2.6 The measurement of physical activity

It is now generally accepted that variations in sedentary behaviour and physical activity have significant influence on human health, including, as discussed in earlier sections, the health of shift-workers and/or people adopting irregular hours of work (Bouchard *et al.*, 1983; Harrington, 2001). Therefore, accurate measurements of physical activity, and of the factors influencing it, are crucial for underpinning the efforts to address physical inactivity (Bauman *et al.*, 2006). Many measurement methods for physical activity have been developed and employed by researchers. Some methods are more invasive than others (e.g. self-reports vs the ingestion of doubly labelled water) and others have been designed specifically for certain populations, e.g. children, adolescents, or the elderly (Melanson *et al.*, 1996). Given that no gold standard method of measurement has ever been suggested specifically for shift-workers, it is important to outline the various advantages and disadvantages of each of these methods.

Doubly labelled water is frequently referred to as the 'gold standard' method for measuring energy expenditure and physical activity (Dale *et al.*, 2002). By using 2 stable isotopes (2H2O and H218O), researchers can calculate the rate of carbon dioxide production in humans over days or weeks. Subjects drink a specified amount of these isotopes according to their body mass, after which the loss from the body is tracked by analysis (using a mass spectrometer) of isotopes in urine samples every few days. From these data, oxygen uptake and energy expenditure can be calculated. This technique has the advantage of obtaining objective data without interfering physically with any activities that are undertaken. Disadvantages include a relatively high cost and the inability to determine the type, intensity, frequency, or duration of any single bout of activity. This technique has been shown to agree well with methods of indirect calorimetry (Haskell and Kiernan 2000), which involves estimating energy expenditure and physical activity by measuring respiratory gases. Indirect calorimetry is a relatively precise method for the measurement of energy expenditure and physical activity assessment. However, the process is somewhat invasive, expensive and challenging in terms of assessing rapid changes in physical activity patterns over shorter time periods (Dale *et al.*, 2002).

Self-report techniques are generally the most common form of physical activity measurement. The term 'self-report' encapsulates a variety of assessment methods such as self-administered questionnaires, interview-administered questionnaires, diaries and reports by proxy. Self-report techniques are attractive to researchers since they are less costly in comparison to other instruments, easy and quick to distribute to and measure larger populations and less of a burden to the participant and can capture both quantitative and qualitative information. Nevertheless, there are a number of well reported limitations to such methods (Dale *et al.*, 2002). Since the self-report techniques are more subjective in nature, participants can either misinterpret the question(s) being asked of them or have difficulty in accurately recalling information or intentionally misinterpret or provide misleading information. Finally, the validity of the contact of each self-report measure is an additional area which can cause inconsistencies (Shepherd, 2002). Nonetheless, Sallis and Saelens (2000) maintained that self-report methods have adequate reliability, content validity, and relative criterion validity for children, adults and older adults, with interview based measures yielding a greater accuracy level in comparison to self-administered measures. Whilst such subjective methods for measurement of physical activity can provide useful information, objective methods are now being regarded as best-practice for quantification of the amount and intensity of physical activity and amount of sedentary behaviour (Reilly *et al.*, 2008).

Directly measuring physical activity by physiologic monitoring or motion sensors offers a potential advantage over self-reported data; by reducing bias from poor memory and over-reporting or under-reporting (Haskell and Kiernan 2000). Recent reviewers have concluded that accelerometry (motion sensing) provides an objective, practical, accurate and reliable means of quantifying the amount ("volume") and intensity of habitual physical activity and the amount of sedentary behaviour (Reilly *et al.*, 2008). The main advantages of accelerometry are:

- There is an objective indicator of bodily movement
- It can be employed in a field and laboratory based environment
- It provides indications of intensity, frequency and duration of activities
- It is non-invasive

It has the potential to provide data over a long period of time

Nevertheless, a relatively high unit financial cost might prohibit the use of the assessment of large populations with accelerometry. There could also be a source of error due to inconsistent monitor placement on participant (Dale *et al.*, 2002).

Heart rate monitoring can provide a continuous recording of a physiological outcome that potentially reflects both the duration and the intensity of physical activity. Heart rate is typically used to estimate physical activity as energy expenditure (oxygen uptake), based on the assumption of a linear association between heart rate and energy expenditure that can be calibrated for each individual. Heart rate measured during daily activities is thus used to predict energy expenditure. Again, a relatively high unit cost often prohibits the use of heart monitors to assess the physical activity of a large population. The units may also be uncomfortable for the participant if they are worn for long periods of time. They are potentially only useful for aerobic activities and there is some uncertainty on how best to use the heart rate data to predict energy expenditure or monitor physical activity patterns. However, heart rate monitors provide little burden to the participant, often can provide educational information as well as motivatory qualities, can collect data easily and quickly, valid in both field and laboratory settings and describe intensity, duration and frequency well in adults (Reilly *et al.,* 2008).

Pedometers were the original motion sensor for measuring physical activity, were designed to count steps and therefore provide a potentially useful measure of distance walked or run. However, the high variability among pedometers and the lack of a stable calibration mechanism make them unsuitable for estimating physical activity in either laboratory or field research (Dale *et al.*, 2002). Nonetheless, pedometers have often been utilised as a motivational tool, allowing for goals to be set either per population or per individual based upon step account. However, there is in fact little empirical evidence to support the claim of pedometers as motivational tools. Marshall and Ferney, (2003) have shown that having access to pedometer feedback can result in significantly increased walking compared to those who wore a sealed pedometer. Rooney *et al*, (2003) has also suggested that the mere presence of a pedometer may increase walking. A study from Mutrie *et al*, (2004) attempted to establish whether using a pedometer for feedback combined with a goal setting programme provided additional motivation over use of only a goal setting programme. Both groups significantly increased their walking over 4-weeks regardless of whether the pedometer was open for feedback or sealed. Further, Mutrie *et al*, (2004) also established that the increase in step-counts was only evident in the short-term and after 52-weeks walking levels had returned to baseline. Contrasting to these studies Eastep *et al*, (2004) found no increase in walking levels either in those who wore a pedometer open for feedback, or a sealed pedometer. The usefulness of pedometers as either a tool to measure physical activity or as a motivational aid is still a matter of debate and requires further research.

Direct observations employ the overt behavioural aspects of physical activity. Although it is a time-intensive technique, in relation to both training an observer and collating data, it has an enormous advantage of being able to accurately describe what took place in within a specific time-frame. Both quantitative and qualitative data can be collected during this process (Dale *et al.*, 2002). Moreover, when exploring the measure of physical activity, the implementation of dual measurement techniques (for example questionnaire and accelerometer) can be considered with an aim of achieving a more holistic and cross-validated data set in which researchers can examine the physical activity patterns of a specific population from both a quantitative and qualitative perspective.

2.7 Physical activity and human circadian rhythms

Factors relating to the short- and long-term adherence to physical activity and exercise depend highly on the psychological and physiological responses to exercise that are altered during shift-work. There is a possibility that exercising at specific temporal points within a 24-h day might in fact exacerbate fatigue and negative experiences of exercising. If this is the case then exercising at a time that is out of synch with the 'body clock' during a shift-work schedule might be considerable enough to stop the activity rather than lack or opportunity or accessibility to participate in physical activity. A deciding feature for the shift-worker may be whether any exercise aggravates or improves the existing difficulties each specific shift-worker experiences in general.

What complicates the possible benefits of physical activity more so is the possibility that involvement in leisure-time physical activity is more agreeable to those individuals who are normally more tolerant to shift-work. General tolerance to shift-work does vary considerably between individuals, with some individuals exhibiting severe indications of intolerance even within a few weeks of starting shift-work. Whereas other individuals may take years to eventually leave shift-work because they just cannot tolerate the difficulties anymore. The exact antecedents for such large individual differences are difficult to identify from a chronobiological perspective. It has been suggested that higher amplitudes of circadian rhythms result in a greater 'stability', which could be valuable for coping with periodic rhythm disturbances. Of course this notion would be highly dependent on the shift system (Harma, 1996; Vidacek *et al.,* 1993; Harma, *et al.,* 1982, Harma *et al.,* 1988b; Harma *et al.,* 1988c; Andlauer *et al.,* 1979; Harma, 1993). Various individual parameters are believed to influence the ability to tolerate and cope with shift-work. Such factors include age, gender, experience, hardiness, circadian type, health behaviours, and marital status/family structure and number of dependents, rigidity of circadian rhythm amplitude and acrophase, job type, distance to travel to work and neuroticism and extroversion (Furnham and Hughes, 1999; Costa, 2004; Iskra-Golec *et al.,* 1995; Vidacek, 1993; Akerstedt and Torsvall, 1981). Patterns of behaviour are generally thought to be within an individual's control as opposed to personality traits or innate characteristics that are unable to be modified; however, this is still an area of contention and requires further attention (Nachreiner, 1998; Spelten *et al.,* 1993).

Exercise has recently been investigated as a treatment for jet lag and shift-work problems via the potential exercise has to '*re-entrain*' the 'body-clock' following circadian disruption. In these studies, there have been difficulties in controlling the characteristics of the exercise bout, the athletic status of research participants and exposure to other confounding synchronizers. Therefore, it is unclear at present whether exercise can help mitigate the problems associated with transmeridian travel and shift-work, via the manipulation/entrainment/zeitegbeir properties exercise might have. (Buxton *et al.,* 2003; Barger, *et al.,* 2004; Edwards *et al.,* 2002; Van Reeth, *et al.,* 1994; Marchant and Mistlberger, 1996; Mrososky and Salmon, 1987; Eastman *et al.,* 1998; Harma *et al.,*1988a, 1988b). Nonetheless, it has been suggested that higher amplitudes of circadian rhythms result in a greater 'stability', which could be valuable for coping with periodic rhythm disturbances. Of course this would be highly dependent on the shift system (Harma, 1996; Vidacek *et al.,* 1993; Harma, *et al.,* 1982, Harma *et al.,* 1988a; Harma *et al.,* 1988b; Andlauer *et al.,* 1979; Harma, 1993).

Harma (1983) and Atkinson, *et al.,* (1993) reported that the rhythm amplitudes of physically fit or physically active subjects were higher than those observed in unfit or inactive subjects. Whether such changes in rhythm amplitudes are a function of physiological adaptation that occurs with improved fitness or whether habitual physical activity acts as a zeitgeber mediating a 'stronger' rhythm is still a matter of debate. Nonetheless, it is conceivable that habitual physical activity, which undoubtedly improves physical fitness, increases circadian rhythm amplitudes and, in turn mediates a different level of tolerance to shift-work. The evidence for this causal nexus is, nevertheless, scant.

Vidacek and colleagues (1993) conducted a study in a large oil refinery and in general found that there were either small or no relationships between rhythm amplitudes and subsequent tolerance to shift-work. In fact the authors go as far as to suggest that those individuals who exhibit less pronounced amplitudes before entering shift-work may show better tolerance. It has been suggested that individuals with lower amplitudes adapt more easily to shift-work (Akeratedt and Froberg, 1976).

Clearly, the questions relating to the basic differences between a habitually active and an inactive individual in terms of shift-work tolerance and amplitude is fraught with difficulties. Such contention lies in the debate regarding exogenous and endogenous components of circadian rhythms. If for example the exogenous component is the antecedent then arguably a shift-worker's ability to adjust and adapt their lifestyle to such changes could conceivably be the major factor in determining amplitude and subsequent tolerance to shift-work. Moreover, it is possible that a shift-worker with naturally high amplitudes prior to starting shift-work would be more able to tolerate the demands of such unconventional hours. Other factors such as the flexibility/rigidity, languor/vigour and the whole concept of coping mechanisms must also be considered here as it has been suggested that they play a key role in the tolerance and changing circadian amplitudes of the shift-worker. Future research must attempt to tackle such complex problems in an attempt to address the issue of tolerance to shift-work. The simplest causal nexus for physical activity being beneficial to the shift-worker may revolve around the fact that physical activity generally improves sleep quality and therefore alertness on shift, rather than by increasing or attenuating the magnitude of circadian amplitudes (Youngstedt, 2005, Harma, 1996, Shapiro, *et al.,* 1984; Griffin and Trinder, 1978). Unfortunately, there is also a lack of empirical support regarding the precise association between physical activity and its hypothesised sleep promoting effects. Habitual bouts of physical activity have been found to increase both sleep duration (possibly a result of decreasing sleep latency) and more importantly sleep quality. Specifically the quality of slow wave sleep (SWS) which is thought to be crucial for brain restoration and recovery, which is likely to have clinical importance to those who suffer from poor sleep such as shift-workers (Hong and Dimsdale, 2003; Youngstedt *et al.,* 1999; Youngstedt, 2003; Youngstedt, 2005; Horne, 1981; Torsvall, 1981; Harma, 1996; Shapiro *et al.,* 1984; Trinder, 1988; Youngstedt, 1999; Naylor *et al.,* 2000). It is interesting that strong associates between habitual physical activity and the alleviation of sleep disturbances have been found. An epidemiologic study (N = 1104) established that number of hours of exercise per week was inversely related with apena-hypopnea severity (Peppard and Young, 2004). Recent studies have also suggested that short-sleep duration is autonomously associated with obesity in different populations (Moreno *et al.*, 2006). Vorona *et al.*, (2005) reported that a general medical population exhibited an increase in body mass index (BMI) from normal to overweight to obese was associated with a progressive decrease in total sleep duration. Individuals who frequently work irregular schedules or shifts repeatedly invert or disturb their sleep-wake cycle. Consequently this can lead to workers sleeping during daytime hours and being awake and active at night. It has been well documented that sleep deprivation and disturbance can be substantially worse in those working shifts (Moreno *et al.*, 2006). Moreover, shift-workers typically exhibit sedentary habits which have been directly linked to a lack of motivation and time often attributed with feelings of tiredness, sleepiness and fatigue associated with sleep deprivation (Bonnefond *et al.*, 2006; Lipovcan *et al.*, 2004). It is well known that sedentary habits have been associated to a high prevalence of obesity. Evidently this highlights the positive holistic implications chronic physical activity could have on those who suffer from poor sleep such as shift-workers. Youngstedt (2005) suggests that whilst the exact mechanisms to explain the aforementioned remain elusive it is possible that physical activity promotes sleep via the reduction of anxiety, thermogenic effect, antidepressant effects, and the possible circadian phase shift effects. Such mechanisms would appear to be favourable to a shift-worker especially since symptoms of anxiousness, depression and desynchronisation of various circadian rhythms are often reported (Costa, 2003; Costa, 2004; Harrington, 2001).

Horne and colleagues (1985; 1983) suggested that increases in sleep quality following exercise were mediated by temperature elevation, which increased SWS. Murphy and Campbell (1997) found that chronic physical activity promotes the sleep onset process by promoting more proficient temperature down regulation, which is generally thought to propagate sleep. Attenuated temperatures at night have been found in people with depression, sleep disruptions, and insomniacs. Such attenuations could be reversed with the successful use of chronic physical activity as a treatment (Youngstedt, 2005; Monroe, 1967; Avery *et al.,* 1982). With this in mind disruptions to the sleep-wake cycle and subsequent disturbances on sleep quality and quantity as a direct result of shift-work could plausibly be alleviated or attenuated by the administration of a successful physical activity intervention. A physical activity intervention could conceivably perpetuate increased sleep quality in shift-workers as a result of the themogenic effects, reduction in anxiety and depression and via the medium of circadian phase-shifting (as discussed later in the review). Yet research in the field of physical activity, sleep and shift-work is surprisingly scarce. Thus, the suggested benefits habitual physical activity could have on shift-workers sleep quality and quantity are still highly speculative.

Previous studies conducted within a 'normal diurnal' existence suggested that late-night physical activity (especially exercise of a high intensity) actually has an adverse effect on sleep. Optimal temporal positioning of physical activity was thought to be between 4-8 hours before bedtime (Harma, 1996). Such findings are somewhat problematic in relation to shift-workers who commonly cite lack of time as a fundamental barrier to participating in leisure time exercise. As such shift-workers often find themselves engaging in activities outside of a normal diurnal existence such as exercising directly before/after a sleep period or late at night, which previously have been thought to have adverse effects on sleep (Harrington, 2001; Costa, 2003; Pati *et al.,* 2001; Hornberger and Knauth, 1993). However, a body of evidence now exists suggesting that the data provides little support for the common assumption that late night physical activity disrupts sleep in fit or unfit subjects. For much of the population evening physical activity is more practical and could even be a factor in the adherence to exercise programmes and interventions (Youngstedt *et al.,* 2003, 1999; Youngstedt, 2005; O'connor *et al.,* 1998). Nonetheless, optimal timing and prescription of physical activity remains an area of debate. The use of physical activity to improve the quality and quantity of sleep in those with sleep disturbances has been studied extensively and shown positive and promising results. On the other hand, the relationship between physical activity, sleep and shift-work tolerance and the subsequent health benefits that might occur as a result of changing one's lifestyle has surprisingly received little interest. Since there are clear benefits to those with sleep disturbances such as shift-workers participating in chronic physical activity it is an area that requires further attention. Future research should focus on the optimal prescription and temporal placement of physical activity, sleep and shift-work tolerance.

There is evidence that the temporal placement of physical activity can also affect the adjustment to shift or night-work via advancing or delaying an individual's acrophase (Buxton *et al.,* 2003; Hennig *et al.,* 1998; Barger *et al.,* 2004; Edawrds *et al.,* 2002; Miyazaki *et al.,* 2001; Baehr *et al.,* 2003; Van Reeth, *et al.,* 1994; Marchant and Mistlberger, 1996; Harma and Lansimies, 1985; Redlin and Mrosovsky, 1997; Baehr *et al.,* 1999; Mrososky and Salmon, 1987; Boivin *et al.,*1996; Piercy and Lack 1988; Mistlberger and Skene, 2005; Schmidt *et al.,* 1992; Eastman *et al.,*1995; Dawson *et al.,* 1991). Adjustment of the acrophase is thought to be beneficial to the shift/night-worker. If the acrophase of various physiologic parameters can be adjusted to accommodate for shift-work it is possible that feelings of fatigue, tiredness, sleepiness and other short-term effects of working unusual hours may be attenuated. Schmidt *et al.,* (1992) found that 4 shift-workers exercising for 90-min between 21:30 and 2:30 significantly delayed core body temperature. Barger *et al.,* (2004) suggested that exercise may help to facilitate circadian adaptation to schedules requiring a delay in the sleep-wake cycle (Figure 2.8), the magnitude of such phase delays induced by exercise were significantly dependent on the relative timing of the exercise.

However, it should be stressed that Schmidt and colleagues used a small sample size and the intensity of activity was unspecified. Eastman *et al.*, (1995) attempted to account for light exposure and found that phase-delays occurred when subjects cycled for 15-min every hour for the first 3 of 8 consecutive night shifts. Unfortunately, Eastman, *et al.*, (1995) were unable to discount the influence of other zeitgebers, experiments in sleep laboratories and isolation chambers could prove to be more reliable regarding this matter. Consequently, the usefulness of physical activity as a nonphotic zeitgeber administered at different times of the day to adjust/accommodate for shift-work is still an area of much debate (Buxton *et al.*, 2003; Barger *et al.*, 2004; Miyazaki *et al.*, 2001).

2.8 Physical activity and shift-work

On a behavioural level, shift-work can restrict the opportunities to be physically active, although this can depend on individual choice of leisure pursuit (group- or individual-based). On a biological level, the circadian rhythm disruption and/or sleep deprivation that is associated with shift-work can alter the 'normal' physiological responses to a bout of physical activity as well as how well a particular exercise bout is tolerated (Harrington, 2001; Costa, 2004; Knutsson, 2004; Waterhouse *et al.*, 1992). The latter issue might have implications for the long-term adherence to physical activity regimens during shift-work. Unfortunately, studies in which physical activity interventions are administered to shift-workers are rare, possibly because adherence to such interventions is extremely difficult in this population (Harma *et al.*, 1982, 1988, 1996; Atlantis *et al.*, 2006) (Figure 2.9).

Shift-work clearly leads to additional difficulties in satisfying domestic and family responsibilities and the precise impact of shift-work on such roles has been researched empirically. It is likely that most immediate family members alter their behaviour when a shift-worker is present in that family. Partners and children will, for example, endeavour to be quieter while the shift-worker is trying to sleep during the day. Shift-work might also hamper participation in social and leisure activities. This disruption might be different from that of the domestic situation, since leisure activities and sports clubs are generally scheduled to accommodate those with comparatively 'fixed' diurnal existences, and there is little scope for adapting arrangements for a specific shift-worker (Lipovcan *et al.*, 2003; Costa, 2003, Pati *et al.*, 2001; Herbert, 1983; Hornberger and Knauth, 1993). Nonetheless, the divergence between the desire of a shift-worker to participate in leisure and sports activities and the accessibility/availability of these leisure opportunities doubtlessly depends on the specific type of interest (team or individual-based, organised or self-motivated) (Herbert, 1983; Hornberger and Knauth, 1993).

Many shift-workers may wish to, but cannot, perform leisure activities at the same times as day-workers (Hornberger and Knauth, 1993). For those people participating in group activities, team activities or competitive sport, a restriction in convenient leisure-time results in either the worker not participating in that particular activity or contributes to the decision to leave shift-work altogether (Herbert, 1983; Friese and Okenek, 1984; Eriksen and Bruusgaard, 2004; Fischer *et al.*, 2003; Hornberger and Knauth, 2003). For people involved in individual, rather than group, physical activities, shift-work may not be too problematic. For example, data collected as part of a project sponsored by the Health and Safety Executive (HSE) indicates that a reasonably large 9% of competitive cyclists are shift-workers (Reilly *et al.*, 1993; Atkinson and Reilly, 1995). Participation in other individual activities like jogging and swimming may also not be adversely affected by shift-work. Although the opportunity for some types of activity may not be hindered by shift-work, this activity often cannot be scheduled in the early evening, which is the time of day thought to be optimum for physiological benefit and may fit best with the family life of the shift-worker (Atkinson and Reilly, 1996). Lipovcan *et al.*, (2003) reported that night-workers had problems sustaining physical fitness compared to other groups of workers. Whilst the night-workers who were studied understood the importance of habitual physical activity, there were problems with the implementation and maintenance of an active lifestyle. A lack of time and the opportunity for exercise have been cited, alongside increased general fatigue, as reasons for a less active lifestyle. For those shift-workers who enjoy solitary or individual activities, the disruptive nature of shift-work might be less of a concern. For example, it is possible that shift-workers who join fitness and health clubs enjoy the benefits of 'off peak' membership rates and utilise the facilities at the quietest times avoiding the crowds who use the facilities at peak periods. Atkinson and Reilly (1996) indicated that a reasonably large 9% of competitive cyclists are shift-workers. However, participation in organised individual competitions may also be hindered by shift-work, since it is more likely that a rotating shift-worker is required to work on weekends, which will clash frequently with competitions/races (Herbert, 1983; Hornberger and Knauth, 1993).

2.8.1 Current physical activity recommendations

Current recommendations for shift-workers relating to physical activity are somewhat basic to say the least. In essence the guidelines available have been constructed on few physical activity intervention studies conducted in a shift-working environment (Atkinson *et al.*, 2008), or have been adapted from the general guidelines given from organisations such as the American College for Sports Medicine (ACSM), with little or no focus on the specific difficulties faced by the shift-working population. The current recommendations are as follows:

Additional advice is given by the Health and Safety Executive (HSE, 2006) stating:

> *'You can improve your fitness by spending 30 minutes a day on a physical activity including housework and walking. Consider joining a gym or taking part in a regular exercise classes.'*

It must be recognized that the recommendations in Table 2.2 which emanated from a structured physical activity intervention study in shift-working nurses (in 1988 in Finland), whilst useful, had number of methodological problems (Harma *et al.*, 1988). Moreover, current research relating to exercise (type, intensity, duration), sleep and fatigue now suggests that information regarding the proposed negative effects of exercise being performed close to a sleep period (as suggested in table 2.2) is equivocal and generally unfounded (Youngstedt, 2005). However, little attempt to build upon previous physical activity intervention studies specifically for shift-workers have been made. As such little or no informed development of physical activity/exercise guidelines/recommendations have been made (Atkinson *et al.*, 2008).

Since shift-work is a multi-faceted problem it would be important and necessary for future researchers not to study isolated factors. Rather, a multidisciplinary approach to investigating the specific problems faced by the shift-worker should be adopted, with a more detailed focus on lifestyle factors such as physical activity with more meaning recommendations being developed for the ever expanding shift-working population.

2.8.2 Physical activity interventions and health

A substantial body of evidence now demonstrates that the burden of ill-health attributed to inactivity during normal diurnal living can be alleviated by habitual physical activity. In fact it has been recognised that a healthy workforce equates to lower labour costs, higher productivity and lower attrition rates regarding employee absenteeism or resignation (Schneider and Becker, 2005, Burton and Turrell, 2000; Popham and Mitchell 2005, Dietz, 1996, Blair *et al.*, 1992, Sallis and Owen, 1998, Marcus and Forsyth, 2003, ACSM Position Stand, 1998, Hardman, 2001). Worksites may offer unique opportunities to encourage employees and their families to engage in physical activity. Researchers have explored the usefulness and value of an assortment of worksite-based physical activity interventions, ranging from 20 min of extremely vigorous exercise performed three times a week, to the more moderate physical activity related to fitness classes and group activities (Dishman, *et al.*, 1988; Kahn *et al.*, 2002). Shephard (1996) reviewed a number of studies and suggested that worksite-based physical activity interventions decreased body mass by 1-2%, decreased blood pressure by between 2-10 mmHg and decreased serum cholesterol by 15%, a reduction in absenteeism rates (although small) as well as an increase in productivity of 4-5%.

With this in mind it is surprising that physical activity, fitness and energy expenditure during nocturnal or in unconventional conditions, such as shift-work, have received very little attention (Harma, 1996, Atkinson and Reilly, 1996, Kivimak, *et al.*, 2001). However, it has been suggested that those shift-workers that adopt active/engaging coping mechanisms, such as the habitual involvement in physical activity are better able to tolerate the stresses and strains of shift-work (Spelten, *et al.*, 1993, Harrington, 1996, Harma, *et al.*, 1988a, Harma *et al.*, 1988b, Kivimaki, *et al.*, 2001, and Harma, 1996, Lipovcan, *et al.*, 2004, Eriksen and Bruusgaard, 2003). Harrington (2001) surmised that improved recreational facilities to promote active living might also be useful. To date only one physical training intervention designed specifically for shift-workers has been published. Harma and co-workers (1988) constructed a training programme for 119 women exercising between 2 to 6 times per week, between 60 –70% of maximal heart rate for a 4-month period. Harma *et al.*, (1988) found that moderate physical training has mostly beneficial effects on sleep (the training groups sleep length increased significantly after the evening shift, and sleep quality improved after the morning shift), fatigue (decreased significantly in the training group during the whole shift cycle) and the performance of shift-workers (Table 2.3).

The authors suggested that moderate exercise performed several hours before the main sleep period, with the best times for exercise to be performed after a morning/day shift and when performed after a night shift, before an evening nap. However, it should be noted that the training group experienced increased fatigue during the evening shift. Consequently, this raises issues surrounding the timing of exercise and shift-work and is an area that requires further investigation and study. Nervous symptoms did not decrease as expected following the intervention. Harma *et al.,* (1988) hypothesized that an increase in physical activity at the disbursement of leisure and family time might have increased stress more so than physical activity was able to attenuate it. This would be consistent with the idea that for any shift-work intervention to be successful it must involve family, significant others and social networks. Interventions of this nature might also indirectly deal with the issues surrounding 'lack of time', 'lack of opportunity', and 'lack of support' often cited by shift-workers as to why they do not adhere to physical activity (Lipovcan *et al.,* 2004; Hornberger and Knauth, 1993; Stains and Pleck, 1983). Therefore to gain a full understanding of the usefulness of physical activity during shift-work, timing of exercise, involvement of significant others must be researched in conjunction with more stringent and holistic monitoring techniques.

Atlantis *et al.,* (2006) conducted a health related worksite randomized controlled trial intervention in Australia. The research was undertaken in a casino setting which allowed for the recruitment of shift-workers and day-workers alike. Seventy-three participants aged 32 ± 8 years, 51% overweight/obese but otherwise classified as healthy, 73% shift-workers and 52% women were recruited to participate in the research, forty-four of whom completed the research (19 intervention and 23 control participants from n =3800). Components of the intervention included supervised moderate-to-high intensity exercise including combined aerobic (at least 20 min duration 3 days/week) and weight training (for an estimated 30 min completed 2–3 days/ week), and dietary/health education (delivered via group seminars, one-on-one counselling and literature through the provision of a worksite manual). Atlantis *et al.,* (2006) found that the mean waist circumference was significantly reduced (82.3 ± 9.2 versus 90.5 ± 17.8 cm, $p = 0.01$(Figure 2.10)) and predicted VO_{2max} values significantly increased (47 versus 41 ml/kg/min, $p < 0.001$ (Figure 2.11)) in those participants in the intervention group compared to the control group. Interestingly, higher intervention compliance predicted greater improvements in physical fitness. Therefore the worksite intervention significantly improved waist circumference and aerobic fitness in healthy but sedentary employees, most of whom were shift-workers. However, there were no significant effects of the 24week intervention on body mass or body mass index in either the intervention or control group. Furthermore, a large proportion of the significant effect on waist circumference being due to changes in one subject.

Atlantis and colleagues suggested that whilst the workplace may offer an ideal opportunity to prevent and alleviate a number of the health inequalities seen in shift-workers, substantial barriers to adoption and adherence of exercise in the worksite need to be overcome for greater effectiveness and impact on employee physical health, which could be the focus of future research.

The expediency of physical activity during shift-work is poorly understood (Atkinson and Reilly, 1996). In reality there is evidence that the majority of shift-workers do not follow the guidelines (Wedderburn, 1993). Whether this is due to the disruptive nature of shift-work or the reluctance to adopt a healthy lifestyle or the lack of education regarding the benefits of habitual physical activity is a matter of debate and further research (Burton and Turrell, 2000, Tepas, 1993). Future research should focus on the implementation of a holistic and multidisciplinary intervention to attend to the complex phenomena that is shift-work (Costa, 2003; 2004).

Physical activity is one of the few leisure activities, which may mediate long-term favourable changes in physiological functions as well as alter the fatigue levels of the shift-worker (Reilly *et al.*, 1997; Harma *et al.*, 1988). Physical activity performed at least twice a week is usually included in guidelines for improving shift-work tolerance (Monk and Folkard, 1992; Harrington, 2001; Knauth and Hornberger, 2003) but the usefulness of exercise during shift-work is poorly understood and there is evidence that shift-workers find it difficult to follow that particular piece of advice (Wedderburn, 1993). More research is needed regarding not only how leisure interests are affected by shift-work but, conversely, how leisure activities, especially those involving exercise affect tolerance to shift-work and the health of the shift-worker. Only a qualitative and quantitative "multi-strategy" (Bryman, 2001) can consider the impact of physical activity on both biological and behavioural factors during shift-work. There have been recent calls for such a strategy in order to adequately research the problems of working at unusual hours (e.g. Ballard *et al.*, 2004).

2.9 Behavioural interventions (including motivational interviewing) in a shift-work context

It can be seen above that most previous studies on shift-workers have attempted to implement supervised physical activity programmes rather than individualised programmes which encourage independence and longer-term behaviour change. Whilst interventions can do little to change genetic predispositions and social circumstances, people's behaviour – as individuals and collectively – may be easier to change. Nevertheless, many behavioural interventions have either been unsuccessful or only partially successful. Often, this has been a direct result of not taking into account the theories and principles of successful planning, delivery and evaluation (NICE 2007). Systematic reviews of behaviour change interventions have tended to find modest and worthwhile effects but no clear pattern of results favouring any one particular method. Where effects are found, it is often unclear what behaviour change processes are responsible for observed changes (Michie, 2009). If effective interventions to change behaviours are to be delivered to influence outcomes at population, community, organisational or individual levels (NICE, 2007), the field must produce greater clarity about the functional components of those interventions. These should then be matched to population, setting, and other contextual characteristics (Green and Glasgow, 2006). Whilst the CONSORT guidelines (e.g., Moher, Schultz, & Altman, 2001) and the TREND statement (Des Jarlais, Lyles & Crepaz, 2004) have helped specify information which should be included in published evaluations of behaviour change interventions there are still no standardised terminology with which to describe the "content or elements" of behaviour change interventions. Nonetheless, a health professional endeavours to move clients from a state of physical or mental illness, or being out of shape or unhappy, towards an optimal state of wellbeing it is important to minimize barriers to program adherence and maximize motivation. Assessing mental health status and using counselling techniques that improve clients' motivation to change can be very useful to facilitate behavioural change. This can be important because it is reasonable to expect that people who feel sad, down or miserable most of the time and/or lose interest in most of their usual activities are less likely to adhere to healthy behaviours such as physical activity and exercise. Robroek *et al.,* (2009) reviewed 23 studies in a workplace setting, 10 studies on educational or counselling programmes, 6 fitness centre interventions, and 7 studies examining determinants of participation in multi-component programmes. All studies incorporated some form of behaviour change techniques. Robroek *et al.,* (2009) found that participation levels varied from 10% to 64%, with a median of 33% (95% CI 25–42%). In general, female workers had a higher participation than men (OR = 1.67; 95% CI 1.25–2.27), but this difference was not observed for interventions consisting of access to fitness centre programmes. For the other demographic, health- and work-related characteristics no consistent effect on participation was found. Interestingly, pooling of studies showed a higher participation level when the programme consisted of multiple components, or when the programme was aimed at multiple behaviours.

An emerging method of changing behaviour is a technique termed motivational interviewing (MI). The theory of MI evolved from the knowledge of treating alcoholism, and was first described by Miller in 1983. This basic experience was developed into a coherent theory, and a detailed description of the clinical procedure was provided by Miller and Rollnick(1991). MI can be defined as a 'directive, client-centred counselling style for eliciting behaviour change by assisting clients to explore and resolve ambivalence' Miller and Rollnick(1991). Miller and Rollnick's theory was heavily influenced the non-directive counselling model described by Carl Rogers' in 1953 (cited in Miller and Rollnick 1991). The examination and resolution of ambivalence is the central purpose of non-directive counselling, and the counsellor is intentionally directive in pursuing this goal. MI is designed to help clients in a particular way to recognise and act upon their current or potential problems. It is viewed as being particularly useful for clients who are reluctant to change or who are ambivalent about changing their behaviour. The strategies of motivational interviewing are more persuasive than coercive, more supportive than argumentative, and the overall goal is to increase the client's intrinsic motivation so that change arises from within rather than being imposed from without (Miller and Rollnick, 2002). MI is practiced by health professionals such as psychologists, social workers, nurses, medical practitioners, physiotherapists and dieticians. The method can be applied in settings ranging from 'in the clinic' to at home or via telephone. Although effects are immediate and two treatments can be sufficient, effect sizes diminish over time (from d = 0.77 at post-intervention to d = 0.30 at 6-12 months) (Hettema, Steele, & Miller, 2005) and 6-monthly follow-up sessions are likely to increase the effectiveness of MI in the management of chronic diseases. Motivational interviewing is in line with Choice Theory (Glasser, 2000a). Exploiting the differences between clients' perceived pros and cons of changing behaviour and enhancing ownership of the interventional program can assist clients in moving towards sustained adherence to healthy behaviours such as physical activity and exercise. It is the task of the counsellor to enhance ownership in clients' plans to adopt and sustain these behaviours (Schoo, 2008). Groeneveld *et al.,* (2008) implemented MI in an RCT with an aim of improving the lifestyle of participants. 692 participants were involved and assigned to either an intervention or control group via a randomisation process. The intervention lasted 6 months and comprised of 3 face-to-face and 4 telephone contacts, consisting of individual counselling aimed at increasing daily physical activity (PA) and improving dietary behaviour, and/or smoking cessation. Primary outcome variables were lifestyle behaviours of concern, i.e. daily PA, dietary intake, and smoking status. 20% of the workers who were invited decided to participate; 8.6% of the participants dropped out before the first follow-up measurement. In the intervention group there was a significant decrease in snacking, alcohol consumption (following the intervention on average participants were drinking an and half glasses of alcohol less that pre-intervention) and BMI ($p>0.001$), increase in fruit consumption, smoking cessation was extremely successful and the number of minutes participants engaged in sport was also increased (98 v 88) minutes working in the intervention and control group respectively). Clearly, whilst these results are positive further research exploring the usefulness of MI in increasing physical activity in the adult population is needed. Moreover, exploratory research examining activity within a shift-working population is needed.

2.10 Health interventions in a Police Force context

Police are at high risk from medical conditions related to unhealthy life-style habits. Police are twice as likely to die from alcoholic liver disease than the general population. Lung cancer deaths are also more common among police (7%) than the general population (5.4%) (Richmond *et al.,*1998; 1999). Furthermore, Sorensen *et al.* (2000) found that policemen and women were not physically active in their leisure time. Richmond *et al,*(1998) suggested that the prevalence of smoking among male and female police (27%, 32%) were higher than in general population surveys (24%, 21%), (27%, 20%), particularly among policewomen. Almost half the policewomen 50 years and over were smokers, nearly double the smoking prevalence in the 18-29 years age group. Furthermore, the Depression, Anxiety and Stress Scale (DASS) used measured five symptoms of stress: difficulty relaxing, nervous arousal, agitation, irritability and overreaction one in eight police suffered moderate to severe symptoms of stress, with policewomen aged 30-39 years more likely to report stress symptoms. Following on from this (Richmond *et al.,* 1999) carried out a randomised intervention with five focus groups designed to improve the health of the police officers through counselling and behaviour change. Primary outcomes were, weekly alcohol consumption and binge drinking, smoking and symptoms of stress were measured by a self-administered Health and Fitness Questionnaire. Recorded responses to set questions provided qualitative data. Participation was high (89%) at both quantitative assessments. Alcohol consumption, particularly among men, was high at both baseline and follow-up assessments, although comparisons between groups across occasions showed no significant intervention effects. Excessive drinkers and those reporting moderate to severe stress levels reported more sick leave days ($p<0.05$, $p<0.05$). A significant increase in awareness of alcohol policies in the work-place showed in both experimental and control groups over time ($p < 0.01$). The percentage of smokers declined significantly in both intervention and control groups. Overall, women had significantly more symptoms of stress than men. Only 20% of police thought they would seek advice from work-place staff about alcohol consumption, 14% for smoking and 61% for stress. In the qualitative study, employees generally distrusted their organization's involvement in health unless work performance was affected. Seeking professional assistance for life-style issues was viewed as a sign of weakness. Alcohol use was seen as a way of obtaining information or group membership, self-medication and socializing. The brief interventions did not produce significant improvements in three life-style factors beyond positive trends in alcohol consumption among women and general reductions in smoking among both study groups. Combining quantitative and qualitative approaches helped identify interactive individual and organizational factors which influence behavioural and cultural norms. Sorensen *et al.*, (2000) evaluated changes in the physical activity, fitness and body composition of 103 police officers during a 15-year follow-up following a health intervention. The absolute aerobic capacity was similar in 1981 and 1996, muscular performance had declined, and body weight had increased approximately 0.5 kg/year. More than half the subjects (53%) had increased their leisure-time physical activity in 1996. The correlation was significant between physical activity in 1981 and physical fitness in 1996, but weak between physical activity in 1996 and fitness in 1996. It was also significant between waist circumference and waist/hip ratio in 1996 and physical activity during the previous 5 and 15 years. No significant correlations were found between physical activity and work ability or perceived physical or mental job stress. The physical fitness of middle-aged police officers seems to be predicted strongly by physical activity in early adulthood. Interestingly, there are only a few studies examining the effectiveness of lifestyle and health interventions within a police force context. Details outlining the interventions are somewhat scant. However, a need for health interventions to change lifestyle behaviours from both individual and organisational perspective is essential to ensure the well-being of the police force population.

2.11 Synopsis

The review of the literature has clearly highlighted that there has been little or no attempt to examine, the influence of physical activity on the problems associated with shift-work. It is unknown whether these problems are due to disturbance of the circadian rhythm (the "body clock") and/or a decreased opportunity to adopt the desired timing of lifestyle and social factors. Only multi-strategy (Bryman, 2001) and multi-level (NIH, 2000) research has the potential to unravel the influence of these factors, and these approaches have not yet been attempted in the area of energy expenditure of shift-workers. Therefore the research work in this thesis will adopt a multi-strategy model in an attempt to address the multi-factorial issues surrounding physical activity and the health of shift-workers. The exact design of this thesis has enabled a broad number of physiological and psychological variables to be covered, employing a variety of research techniques and will progress in an inverted pyramid fashion (as seen in the schematic below) to allow for the exploration of the complex issues surrounding shift-work and health behaviours.

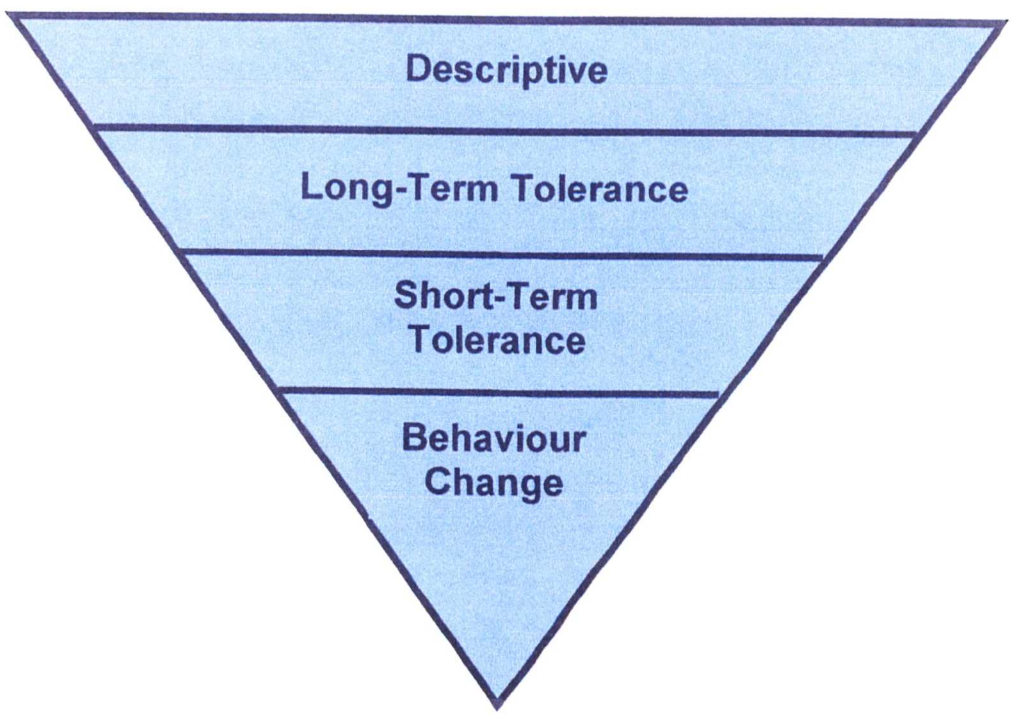

Figure 2.12 Schematic of the inverted pyramid research process utilised within this thesis.

Chapter 3

Physical activity in shift-workers: a mixed-methods approach

Aspects of this work were presented at the 13th Annual Conference of the European College of Sport Science, Estoril, Portugal, July 2008.

3.1 Introduction

Shift systems that disturb or alter sleeping and waking hours are commonly perceived to be detrimental to the short- and long-term health and productivity of the worker (Scott, 2000; Costa, 1997; Taylor *et al.*, 1997; Wedderburn, 1978; Harrington, 2001; Tepas *et al.*, 2004; Kundi 2003). The potential impact on health includes increased risks of insomnia, chronic fatigue, anxiety and depression, adverse cardiovascular and gastrointestinal effects, as well as some impaired aspects of reproduction in women. The biological and behavioural reasons for such health problems have been discussed extensively in a number of reviews (Atkinson *et al.*, 2008; Harrington, 2001; Waterhouse *et al.*, 1992; Scott, 2000; Costa, 2003; Costa, 2004). A few authors have highlighted a possible causal nexus between the negative health effects associated with working shift schedules and poor energy balance. Harrington (2001) identified improvements in recreational facilities as a factor that can ameliorate shift-work problems in the short-term. A number of authors have also mentioned the importance of physical fitness and activity in helping workers reduce the problems associated with shift-work (Atkinson *et al.*, 2008; Harma *et al.*, 1988; Atkinson *et al.*, 1993; Harrington 2001). Nevertheless, the complicated relationships between all the various biological and behavioural health factors that influence energy balance during shift-work have not yet been fully established. Research regarding habitual physical activity and physical fitness has shown strong links between those individuals who are more active, have increased fitness levels and are in 'good health'. Moreover, habitual physical activity has been shown to alleviate the negative effects upon health that a shift-worker may face. Therefore, it is surprising that physical activity, fitness and energy expenditure during nocturnal or in unconventional hours of work have received very little attention (Atkinson *et al.*, 2008; Harma, 1996, Atkinson and Reilly, 1996, Kivimak, *et al.*, 2001). Information is needed not just on mode, duration and intensity of exercise but also *when and why* shift-workers exercise. Such information will provide researchers with a greater understanding of not only current physical activity behaviours but also, how and why shift-work might affect individuals' LTPA participation, which invariable could be utilised to promote and support future physical activity interventions in the shift-working population (Fontana and Frey, 2000; Atkinson *et al.*, 2008). A mixed-method approach, that combines quantitative and qualitative (the reasons for this scheduling) strategies and cross-sectional and longitudinal designs, is preferable to answer such complicated questions. Using such an approach, our aim is to provide the first detailed examination of LTPA and its correlates in shift-workers.

3.2 Method

3.2.1 Participants

One-Hundred and sixty-one participants (56 females and 105 males; median and inter-quartile range age 39: 14 yrs) volunteered to complete a modified version of the SSI, together with the leisure-time physical activity questionnaire validated by Lamb and Brodie (1990). Ninety-five of the one-hundred and sixty-one participants involved in this study were also involved in the study entitled relationships between leisure-time energy expenditure and individual coping strategies for shift-work, which can be found in chapter 4 of this thesis. Ten of these participants (5 females and 5 males; median and inter-quartile range age 43.5 and 10 yrs) also completed a physical activity diary designed for shift-workers and wore an accelerometer for a seven-day period; this was then followed up by an email interview. All participants worked on rotating shift systems, which included a period of night work. Some characteristics of the overall sample are shown in Table 3.1.

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Table 3.1. Characteristics of shift-workers studied in the overall sample

Characteristics of Overall Shift-workers Studied	
Number Studied	161
Number of Females	24
Number of Males	71
Median (Inter-quartile - IQ) Age	39 (14) yrs
Age Range	22-59 yrs
Median (IQ) Experience working shift patterns	120 (168) Months
Median Height (IQ)	1.78 (0.12)m
Median Female Height (IQ)	1.67(0.1)m
Median Male Height (IQ)	1.8(0.43)m
Median Weight (IQ)	82.5(16.09)kg
Median Female Weight (IQ)	70(15)kg
Median Male Weight (IQ)	85.5(14.4)kg
Median BMI (IQ)	26.37(4.40)%
Median Female BMI (IQ)	28.37(5.52)%
Median Male BMI (IQ)	26.45(4.92)%
Shift Rotation (Direction & Speed)	Forward/Backward, Fast/Slow, All incorporated a period of nights
Percentage of Participants with dependents	44% (1-3 dependents age range 0-70+)
Job Type/Title & Number of Participants:	
Police Officers	Group 0 –26
Communications Officers (Police Service)	Group 1 –55
Firefighters/Watch Managers/Control Operators/Station Officer	Group 2 –70
Bus drivers/Bus Engineers	Group 3 –6
Flight Attendant	Group 4- 2
Midwives	Group 5 - 2

3.2.2 Research Design

3.2.2.1 Modified Standard Shift-work Index (SSI):

Copies of an adapted version of the SSI were distributed by the research team to the various organisations that participated in the study, along with pre-paid envelops in which the SSIs were to be returned to the research team within four-weeks of receiving the SSI. These ensured participants were allowed enough time to complete the questionnaire as well as maintaining anonymity. However, if a participant wished to take-part in further research they were asked to complete a form provided giving both their name and contact details (this was on a voluntary basis). The SSI represents a well-established and validated (Barton *et al.*,

1995) battery of questions that have been used frequently on shift-workers to measure perceived problems and issues. The SSI is also easy to implement and can offer a wealth of information. The SSI covers items referring to: biographical and demographic information, chronotype, major difficulties caused by working shifts (adaptation to shift-work, fitness to undertake job content, social life, fatigue, daytime sleepiness, shift system advantages, psychological well-being), and problems associated with each shift (sleep disturbance, alertness on the job, workload, and items specific to the night-shift), health and well-being, and the ability to cope with night work (Takahashi *et al.*, 2005). Since the aim of the study was to collate a myriad of information regarding shift-work and physical activity the SSI was the most appropriate tool. Those sections and sub-sections allowing for overall/summed scores all used a Likert scale.

To date, the SSI has not included sections designated to explore diet and physical activity during leisure time. Therefore, nutrition and leisure time physical activity (LTPA) questionnaires were initially added to the SSI. The LTPA questionnaire was an adapted version of Lamb and Brodie's (1990) LTPA questionnaire, which measures the physical activity, participated in during leisure time over a 14-day period, and is a cost effective, short and easy assessment method to utilise within such a large and non-diurnal population. The LTPA was complemented with additional questions regarding time spent watching television, transportation, adherence to exercise regimens, availability/accessibility to exercise facilities, and barriers to participating in LTPA . Whilst combining the LTPA questionnaire with the social and domestic component of the SSI helped shorten the questionnaire, it was felt that, at 40 pages, the questionnaire was too long to expect participants to complete. Since it was deemed essential to maintain the measurement of all variables in the original SSI, the solution adopted was to use shortened and modified versions of specific sections in the original SSI. Accordingly, the original Composite Morning Questionnaire (CS) was changed for the validated shortened version of the preference scale questionnaire (PS). Diaz and Lopez (2004) found that the relationship between the CS and the PS was high (r= .76), which indicates adequate convergent validity. Smith *et al.*, (2002) suggests that whilst both CS and PS are quite adequate psychometrically, the PS is preferable as it is simpler to use and is not influenced by the respondent's sleep-wake schedule. The SSI manual contained the formulae and calculations for each sub-questionnaire within the SSI itself, which has been validated previously (Barton *et al.*, 1995).

3.2.2.2-A 7-Day-Activity Diary and Accelerometer:

Surprisingly, a physical activity diary specifically for shift-workers exploring, activity, duration, frequency, mode and timing of activity has never been developed. Since physical activity diaries that do not rely on memory have been cited to be useful (Wickel, *et al.*, 2005), it was deemed appropriate and necessary to develop and administer a physical activity diary specifically designed for shift-workers examining the abovementioned factors. The 7-day activity diary was completed during 7 consecutive days, by ten participants who volunteered to take part in further research as indicated following the completion of the SSI. The questions covered were type of day (night shift, day shift, and rest day), duration, mode, time, frequency, perceived exertion and enjoyment of activity. The participants were asked to complete the diary as accurately as possible at the end of their respective 'wake-time' period.

To objectively assess activity levels participants also wore an ambulatory 'actiwatch AW4' monitor (Cambridge Neurotechnology Ltd, Cambridge) on their dominant wrist for 7-consecutive days. This site was chosen because of previous research showing that motor activities measured at this site is most appropriate and is also thought to correlate best with general physical activity (Middelkopp *et al.*, 1993; Gretler *et al.*, 1993). Participants' were only asked to remove the actiwatch during any activity which involved water immersion such as bathing, showering or swimming and participants were asked to identify such occasions by highlighting them in their diaries. The actiwatch AW4 resembles a wrist watch and is a convenient light weight device (16g) which contains a miniature uniaxial accelerometer that produces a signal as the wearer makes physical movement. This signal is measured 32 times per second and processed to provide the digital integration of the amount and duration of movement, within a given period, or epoch. The actiwatch has a variable epoch length of between 0.25 and 15.0 min. At a1-min epoch, the unit has a maximum recording capacity. Actigraph data (activity counts) were therefore recorded using 1-min Epochs. The Actiwatch AW4 recorded all movement over 0.05g. The resultant activity count was stored within an internal memory; until data was transferred via the Sleep Analysis 5 software create by Cambridge Neurotechnology Ltd. The actiwatch in combination with the activity diary allowed for the mean activity counts during work, leisure, and bed time to be recorded. In addition to this number of hours spent out of bed and number of hours spent in bed could be calculated. Energy expenditure could not be calculated directly since exercise intensity had not been recorded, therefore the arbitrary activity counts were analysed. Each participant was given a detailed explanation and demonstration of the activity diary method and actiwatch. This information gained from the activity diary was compared to the actigraph data as a general cross validation of the measurements.

3.2.2.3 Email Interviews

The same ten participants involved in the 7-day activity monitoring were also asked to complete an email interview. The primary purpose of the email interviews was to expand upon the experiences and complexities shift-workers faced with regards to participating in physical activity. The email interviews were designed to explore any trends found from the quantitative data collection methods discussed. Adapting interviewing methods to an e-mail format is relatively a new concept but very straightforward (Rebekah *et al.*, 2006). The email interview consisted of twelve pre-disposed questions which were based upon both previous findings from the SSI, 7-day diary and accelerometer data and on an extensive literature review. The questions were written and formatted appropriately on to a word document, the document was attached to an email and sent to participants individually, with instructions on how to complete the questions. Participants were asked to be as open and as honest as possible. Each participant was given a period of 4-weeks to complete the email interview. Once completed, each participant sent the completed interview back to the researcher to code.

4.2.3 Data Analysis

4.2.3.1 Survey

The choice of statistical analysis was based upon the design of the study and the distribution of the data collated. Since the energy expenditure data were positively skewed in this particular sample, non-parametric statistical analyses were employed (Vincent, 1999). The potential moderators of energy expenditure in leisure time analysed from the SSI were gender, job type, age and experience of shift-work, which were analysed using Mann Whitney U tests (gender) or Kruskal-Wallis tests (job type) or Spearman's Rank Order Correlation (age, experience). In all cases leisure-time energy expenditure over a 14-day period was considered as the outcome variable. Following the Kruskal-Wallis test, multiple contrasts between groups were analysed using Mann Whitney tests with a Bonferroni correction for type I error rate to determine the exact differences between leisure-time energy expenditure and job-type.

4.2.3.2 Diary

The outcome variables from the physical activity diary and the accelerometer data were the mean activity counts during work, leisure, and bed time, and differences in these outcomes between type of day (night-shift, day-shift or rest-day) were analysed using a linear mixed model analysis. Linear mixed models can be used for the analysis of correlated, repeated measures data. The correlation arises because subjects may contribute multiple responses to the data set (Krueger and Tian, 2004). The model assumes a continuous outcome variable which is linearly related to a set of explanatory variables; it expands on the ordinary general linear model by allowing one to incorporate lack of independence between observations and to model more than one error term. The types of data that can be analysed using the general linear mixed model include longitudinal data, repeated measures data (including cross-over studies), growth and dose-response curve data, clustered (or nested) data, multivariate data and correlated data (Cnaan *et al.*, 1997). A strength of the linear mixed model is the ability to accommodate missing data points often encountered in longitudinal datasets and (2) the ability to model nonlinear, individual characteristics. (Krueger and Tian, 2004). Missing data during the 7-day activity collection phase utilising the acti-watch was a key determinate in the choice of mixed models as the statistical protocol most suitable for the specific data set.

4.2.3.3 Qualitative data collection

The transcripts (word documents completed and returned by participants to the researcher) formed the medium for which the analysis of the data could take place (Silverman, 2002). E-mail interviewing keeps the audit of the data one step closer to the participants, as there is no need for any transcription from the researcher's perspective to occur as the participant has already formed a transcript (i.e. there is no need to listen to recordings of the interview and articulate the interview in written format as is the case in face-to-face interviews). This might be an advantage of e-mail interviewing, as criticism of transcription practices in terms of it being a "tidying up" of data and a loss of the "raw form" of data have been suggested (Seale, 1999). The objective of the email interview analysis was to educe shift-worker experiences to leisure-time physical activity and building an organized system of categories from unstructured data (Côté *et al.*, 1995, p6.). The email interview script/questions were utilised as a "*descriptive analytical framework*", with a "cut and paste" procedure outlined by Krane (1997) being used to apply category labels to the interview transcripts (Patton, 2002, p.376). This consists of grouping similar phrases and sentences to form similarities, patterns, categories and themes that collectively become meaningful. Data were then coded to factors that were relevant to the research. Expansion of themes and where, appropriate incorporation of sub-themes occurred following extensive reading of the text. Therefore a combination of deductive techniques (analysis according to existing framework, i.e.

information that is already known from previous research) and inductive analysis (discovering patterns, themes and categories that are new and have not been presented previously) were used to generate categories, patterns and themes (Miles and Huberman, 1994; Marshall and Rossman, 1995).

3.3 Results

Leisure-time physical activity was found to be greater in males in comparison to females (z = 3.027; $p<0.002$; Median (inter-quartile range) energy expenditure females: 8.4 MJ (16.3MJ); males: 16 MJ (23.4MJ) (Figure 3.1). Leisure-time energy expenditure was also found to different between job types ($X^2(5) = 20.26$; $p<0.0005$); with leisure-time physical activity being greater in fire fighters ($p<0.0005$; median (inter-quartile range) 19.1 (25.1) MJ and midwifes expending less energy during leisure-time ($p<0.001$; median (inter-quartile range) 0 (0)MJ) in comparison to all other job types (Figure 3.2). There were found to be no significant correlations between leisure-time physical and both age (Figure 3.3) and experience of shift-workers (rs = -0.81; n =156; p >0.313 rs = 0.51; n =151 p >0.532 respectively) (Figure 3.4).

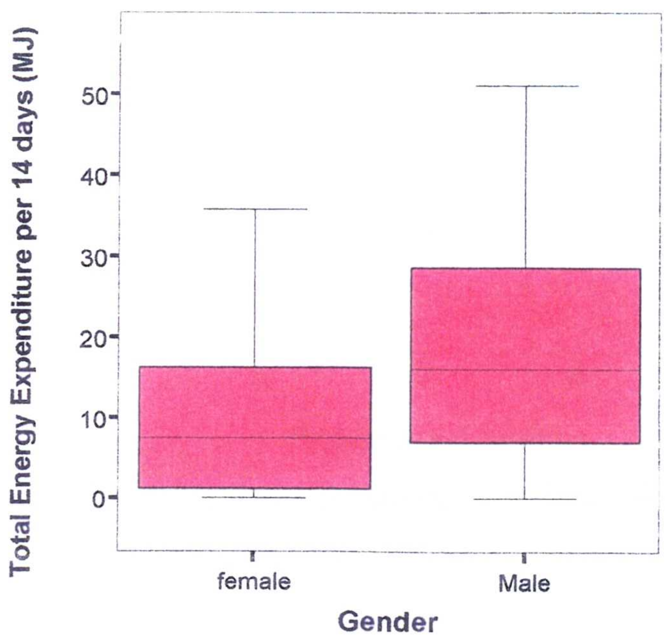

Figure 3.1. Difference in Leisure-Time Energy Expenditure and Gender. Data are median± IQ.

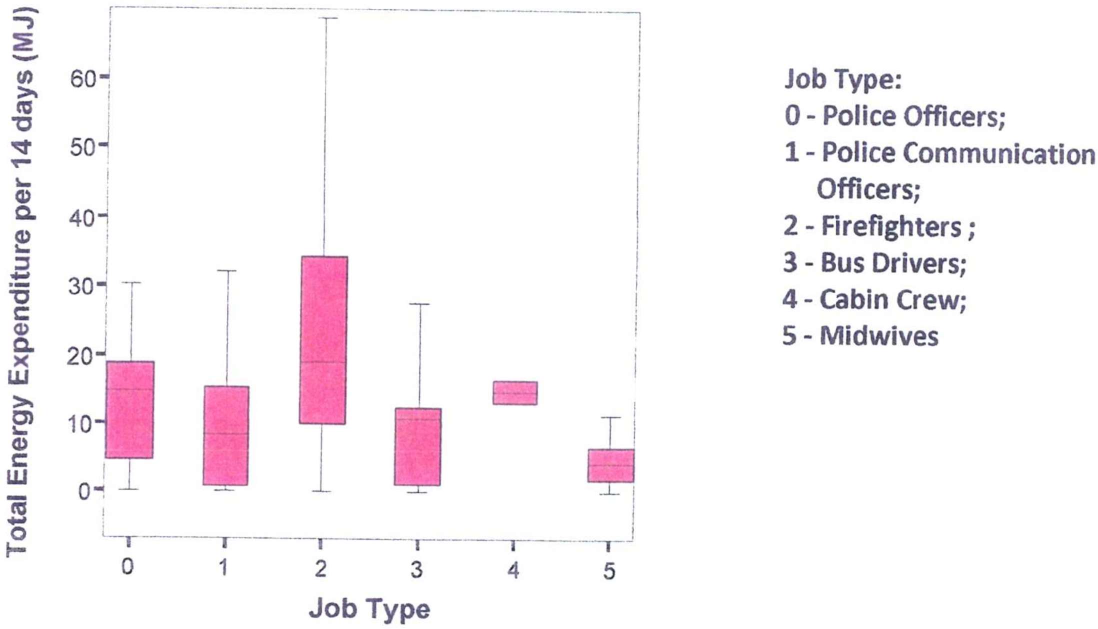

Figure 3.2. Difference in Leisure-Time Energy Expenditure between Job Types. Data are median± IQ.

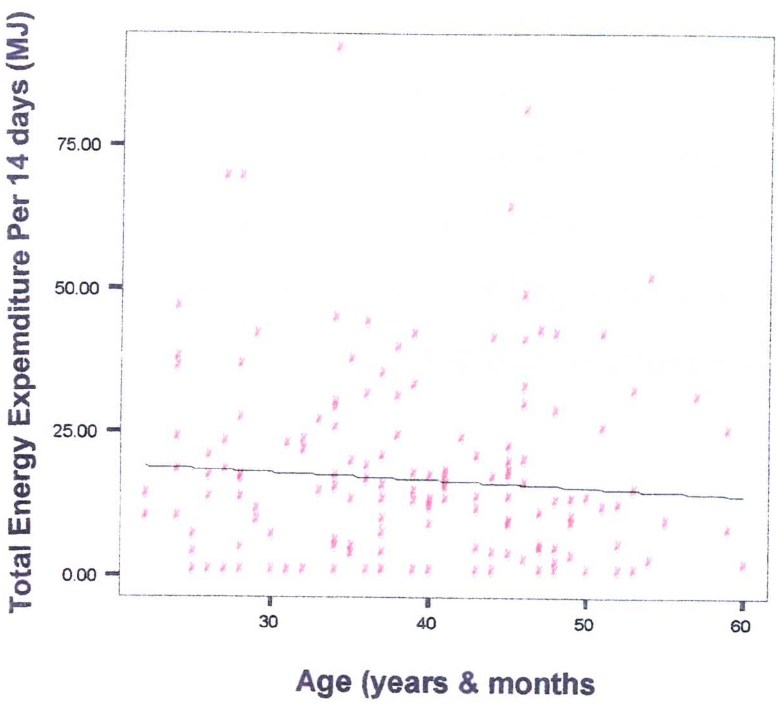

Figure 3.3. Lack of relationship between Leisure-Time Energy Expenditure and Age. Data are median± IQ

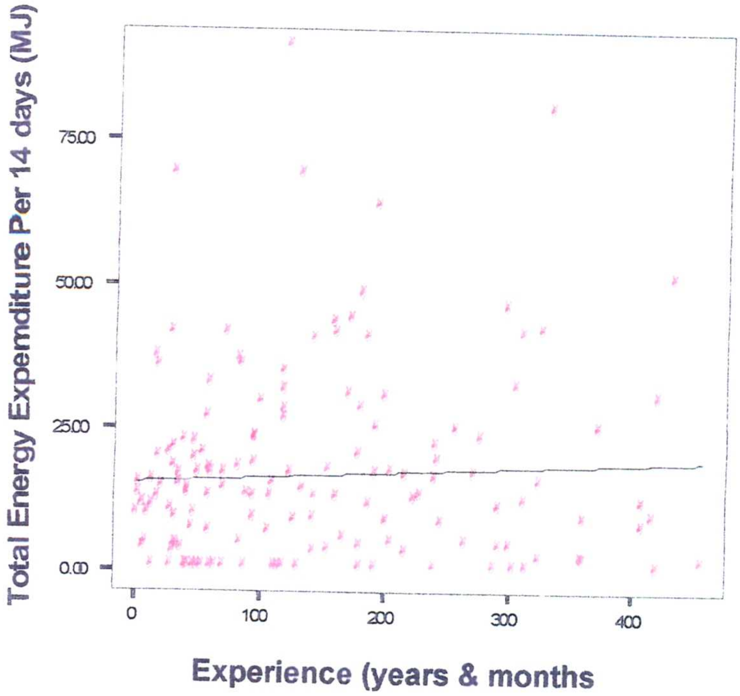

Figure 3.4. Lack of relationship between Leisure-Time Energy Expenditure and Experience of Shift-Work. Data are median± IQ

There were found to be no significant differences between the type of day and mean leisure-time activity counts (*p*<0.492), mean work time activity counts (*p*<0.828), and mean bed time activity counts (*p*<0.857) respectively. However, a significant difference in overall hours spent out of bed during different days was found (*p*<0.005), with shift-workers spending a significantly greater number of hours out of bed during night shift days in comparison to rest days (*p*<0.004; mean(SD±) 17.41hours(3.5); 14.60hours(2.5) respectively) (Figure 3.5).

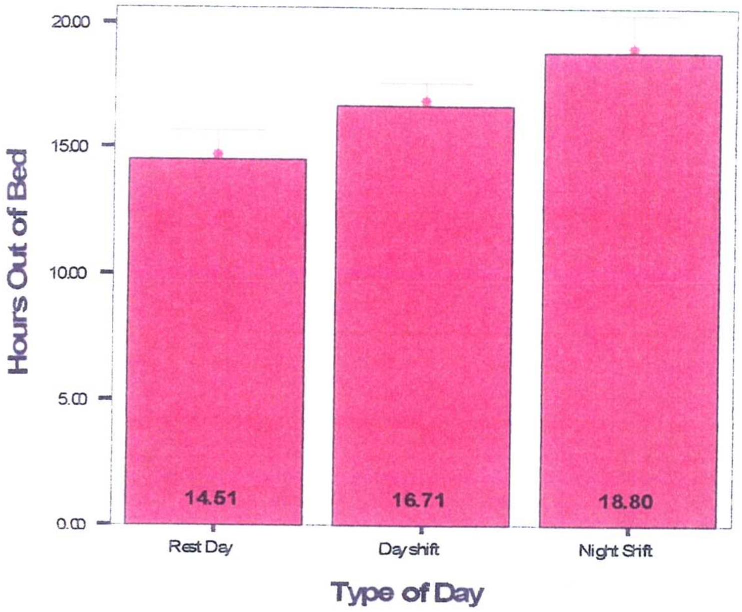

Figure 3.5. Relationship between hours spent out of bed and type of day. Data are mean± SD

3.3.1 Presentation of Qualitative Data

Previously Miles and Huberman (1994) have presented their findings visually using the hierarchical tree diagram. The ordering principle of the display is the general conceptual themes develop in accordance with the key research questions. Since an assumption of qualitative analysis is that knowledge is socially constructed direct quotes from participants were used in addition to researcher analysis and themes, to allow the participants to speak for themselves (Krane *et al.*, 1997). Each quote is followed by a code which enables the reader to determine participant number, gender and the section of interview in which the quote was taken (for example P1F -11-13 (participant number, gender, line number in transcript)) (Figure 4.6).

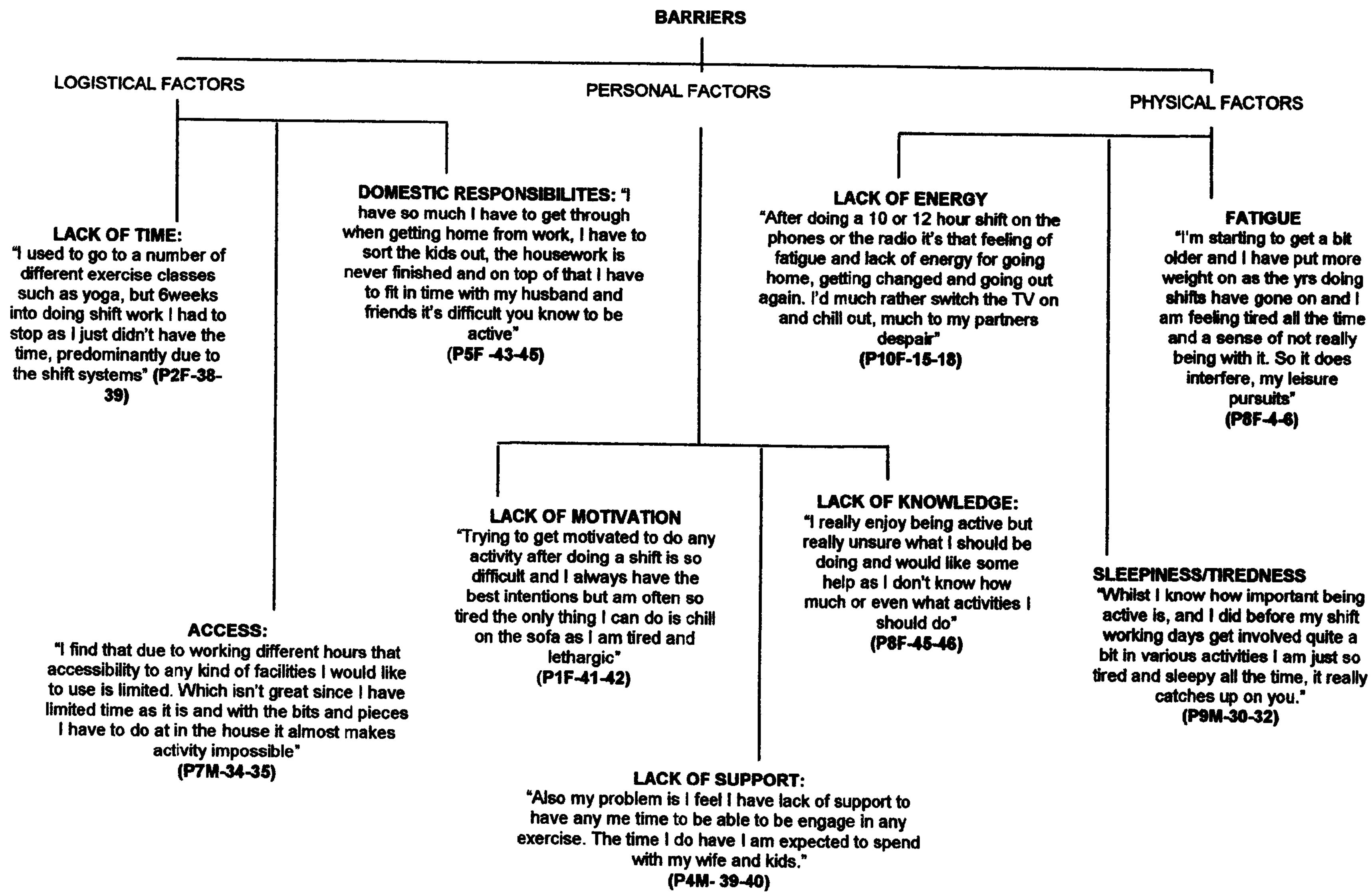

Figure 3.6. Hierarchical tree diagram representing barriers to participating in leisure time physical activity shift workers face

3.4 Discussion

Male shift-workers within the fire and rescue services were found to participate more so in LTPA, with female midwives having the lowest levels of LTPA. In fact gender and job-type were also found to be much more influential on the LTPA of shift-workers than age or experience. In addition to this shift-workers highlighted a number of barriers they face to participating in LTPA.

The data from this study indicates that LTPA is generally low amongst shift-workers. Whilst there is a distinct lack of direct comparable data between day– and shift-workers regarding LTPA, it is possible to observe differences between the shift-working population within the present study and the Lamb and Brodie study conducted in 1991. Lamb and Brodie (1991) utilised the LTPA questionnaire with 118 university employees and students (77 males and 41 females), with an age range 18-64 yrs (mean = 37.9; SD = 11.72). Interestingly, Lamb and Brodie (1991) indicated that the male cohort were found to have an average energy expenditure of 19.3 MJ (15.3 MJ) and the female cohort exhibited values of 12.9 MJ (12.3 MJ) over a 14 day period. Such findings in comparison to the data found in the present study (males: 16 MJ (23.4MJ); females 8.4 MJ (16.3MJ)) suggest that shift-workers expend less energy over a 14 day period. Whilst interesting and useful such comparisons must be treated with caution and at best should be described as suggestive. Lamb and Brodie (1991) completed the study over a decade ago within a relatively specific population; this highlights a real need for comparative data regarding day-workers and shift-workers completing similar roles must be obtained in order to fully explore and understand LTPA within shift-workers and how this may differ from those with a 'normal' diurnal existence.

The question of gender related effects of shift-work is not new, however, the cause and extent of such differences are still relatively unclear (Beermann and Nachreiner, 1995; Oginska, *et a.l,* 1993; Pati *et al.,* 2002; Costa 2003; Harrington 2001). Nonetheless, a number of studies have surmised that the gender differences observed in shift-working environments originate in social rather than biological antecedents (Beermann and Nachreiner, 1995; Oginska, *et al.,* 1993). Women often cite the 'double burden' or 'double-shift' effect related to working a shift and then returning home to complete the domestic chores, this is often further confounded by those female shift-workers who have children or significant others in which to care for. As such female shift-workers often cite 'a lack of time' or their 'shift system' as factors affecting their participation in leisure time physical activity (Bird and Fremond, 1991; Nomaguchi and Bianchi, 2004; Baker *et al.*, 2004, Demerouti *et al.*, 2004; Lipovcan *et al.*, 2004; Beermann and Nachreiner, 1995; Oginska, *et al,*1993; Pati *et al,* 2002; Costa 2003; Harrington 2001). Gender differences regarding LTPA might also be attributed to the quality of leisure time activity rather than the quantity. Males are less likely to combine their leisure time activities with other activities such as housework, childcare, time with family and friends. All of the aforementioned variables are affected by working shift schedules, which increases the likelihood of female workers having to combine their 'spare/leisure' time with domestic and social obligations to ensure they have fulfilled their duties. Clearly, this influences female shift-workers participation in leisure time physical activity (Bird and Fremond, 1991; Nomaguchi and Bianchi, 2004; Baker *et al.*, 2004, Demerouti *et al.*, 2004; Lipovcan *et al.*, 2004). Participant **P5F -43-45** reiterated this during the email interview, where she said "I have so much I have to get through when getting home from work, I have to sort the kids out, the housework is never finished and on top of that I have to fit in time with my husband and friends it's difficult you know to be active". This certainly was not a 'stand alone' comment with all female interviewees citing the combination of the shift pattern and domestic responsibilities leaving them with limited time to participate in LTPA. Whether this is a perceived or actual barrier remains a matter of debate, nevertheless, this 'gender' difference must be addressed if LTPA participation is to be increased in the shift-working population.

Differences in job type or more specifically high work/job specific stress could decrease physical activity but the evidence of the relationship has remained equivocal (Barsade and

Wiesenfeld, 1997; Princeton Survey Research Associates, 1997; Goetzel, 1998; Jones *et al.*, 1988; Kouvonen *et a.l,* 2005). It has been suggested that employees who have concurrent low job control and high job demands ("high job strain") are less likely to be physical active and therefore potentially have a greater risk of ill-health. This "high job strain" might be elevated further by the sheer nature of shift-work and might also explain the differences in LTPA participation between job types. Group 3 (fire fighters) were able to have regular 'sleep' breaks as well as scheduled work breaks (although this could change depending on the situation), which would alleviate not only work stresses but also some of the difficulties caused by shift-work itself, which, might inadvertently have a positive impact upon LTPA of a fire fighter. Whereas all other groups rarely had 'rest bite' within their role, which could increase the feeling of high job demands and low control confounded by the effects of the shift-pattern, which could increase the overall feelings of stress, fatigue and could therefore explain the lower LTPA levels in all other groups (Barsade and Wiesenfeld, 1997; Princeton Survey Research Associates, 1997; Goetzel, 1998; Jones *et al.*, 1988; Oginska *et al.*, 1993; Beermann, 1993; Nachreiner, 1998; Costa, 2003; Harrington, 2001). However, we must be cautious since on further examination it can been seen that the majority of fire fighters were male and all midwives for example were female, and since a marked gender difference with male shift-workers participating more so in LTPA than female shift-workers has been found within this study job-type, shift-work and LTPA must be explored further. Moreover, the number of questionnaires returned via the midwives, cabin crew and bus drivers were somewhat lower than that returned by the fire fighters this may of course also play a role. Finally, the issue of access during the email interview stage was highlighted, with fire fighters generally having 'gymnasium style' equipment available to them within the workplace to use as they chose. However, this was the only group to have such access to such LTPA facilities and equipment and this might in part be a contributory factor effecting LTPA participation amongst other groups of shift-workers who do not have such accessibility to facilities and equipment. Participant **P7M-34-35** who is a male Police Call Operator stated that "I find that due to working different hours that accessibility to any kind of facilities I would like to use is limited. Which isn't great since I have limited time as it is and with the bits and pieces I have to do at in the house it almost makes activity impossible". However, participant **P3M-18-23** who is a male fire fighter stated "Often after nights I am tired, but because we can get some rest at work if we are not called out, this usually just means that I don't plan anything important for the day after nights. The shift pattern that I work also allows me to be more flexible in partaking in hobbies and interests. Exercise isn't really an issue anyway as we have (albeit very basic) a gym at work and when I have a free moment I can use the equipment free of charge, which is pretty useful." Accessibility of LTPA facilities and equipment within a job also seems to have an impact upon LTPA levels and should therefore be explore more so in the future.

Interestingly, age and experience of a shift-worker were seemingly not strong predicators of LTPA. It is generally believed that an individual's experience of shift-work will increase exponentially with age. Changes regarding all areas of life occur with age including work. Whilst a number of researchers have suggested that aging shift-workers have more pronounced difficulties, inequalities and issues in comparison to younger shift-workers, which decreases the amount of time spent engaging in LTPA (Harma, 1993; Furnham and Hughes, 1999; Nachreiner, 1998; Baker *et al.*, 2004; Rouch *et al.*, 2005, Seo *et al.*, 2000; Pati *et al.*, 2001) a confounding body of research suggests that whilst age may cause unfavourable changes with regards to working shifts, time spent in shift-work could be a moderating factor with regard to adaptation and increased attempts to engage in 'positive' health behaviours such as LTPA might occur (Baker *et al.*, 2004; Bohle and Tiley, 1998; Oginska *et al.*, 1993; Bonnefond *et al.*, 2006). However, this research has shown there to be no such links between LTPA, age and experience of the shift-worker. Such disparity could in fact be attributed to the vastly different shift systems/patterns between job-types, but also due to the differences in shift systems and patterns within the jobs themselves. Additionally, differences in job role could also contribute to the lack of relationship found between LTPA, experience and age of a shift-worker.

Interestingly shift-workers were also found to spend more of their time on rest days in bed, in an attempt to rectify a perceived sleep debt, which is emphasised more than LTPA. Shift-work is associated with circadian rhythm dysfunction and therefore influences an individual's sleep pattern and often causes sleep problems. The most troublesome acute symptoms are difficulty getting to sleep, shortened sleep, poor sleep quality and somnolence during working hours that continues into successive days (Åkerstedt, 2003; Costa, 2003; Harrington, 2001; Atkinson *et al.*, 2008). Symptoms often have an accumulative, long-term impact upon the shift-worker causing 'sleep debt' or 'chronic fatigue/shift-work malaise'. Feelings of fatigue, sleepiness, and tiredness might in part influence the shift-workers willingness and motivation to participate in LTPA, and could invariably be perceived as a barrier to participating in physical activity (Harrington, 2001; Costa, 2003; Monk and Folkard, 1992; Wedderbrun 1991; Atkinson *et al.*, 2008; Trost *et al.*, 2002; Salmon *et al.*, 2003). Participant **P9M-30-32** suggested sleepiness and tiredness impacts upon LTPA participation, "Whilst I know how important being active is, and I did before my shift-working days get involved quite a bit in various activities I am just so tired and sleepy all the time, it really catches up on you." Participant **P8F-4-6** also stated "I'm starting to get a bit older and I have put more weight on as the yrs doing shifts have gone on and I am feeling tired all the time and a sense of not really being with it. So it does interfere, my leisure pursuits. Clearly, feelings of tiredness, fatigue and sleepiness impact upon a shift-workers participation in.

3.5 Limitations

Caution should be exerted when interpreting some of the findings in the present study. For example, in the analysis of the influence of job-type, there were only 2 midwives. As in any cross-sectional study, there could also be interactions between certain moderators, the sample of firefighters comprised almost wholly of men. Both of these issues could have influenced the subsequent results. Nonetheless, the findings of this study provide useful primers for the subsequent studies in this thesis and provide valuable descriptive information regarding LTPA in different shift-working populations.

3.6 Conclusion

Whilst these results should be taken with a certain amount of caution, due to an imbalance in participant numbers within each occupational group and between genders, a number of useful conclusions can be drawn from this study. LTPA is significantly low amongst shift-workers, with females generally having the lowest levels of LTPA. Job type and gender are much more influential on LTPA than age or experience. Shift-workers spend more of their time on rest days in bed, in an attempt to rectify a perceived sleep debt, which is emphasized more than LTPA. In addition shift-workers highlighted a number of barriers they face a participating in LTPA. Clearly, these results highlight the complexities and multifaceted issues surrounding shift-worker participation in LTPA. In order to increase participation in LTPA in shift-workers in order to alleviate or prevent the number of health inequalities often associated with shift-work; it is evident that a holistic intervention tackling not only gender and job type issues but also exploring barriers affecting shift-worker participation in LTPA need to be addressed. With this in mind the qualitative data from this study will help inform the intervention study in chapter 7.

Chapter 4

Relationships between leisure-time energy expenditure and individual coping strategies for shift-work

This work has been published in the April 2009 edition of Ergonomics. Aspects of this work were presented at the Sixth International Ergonomic Conference, Cheshire, England, November 2007.

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Chapter 5

Effects of a 1-hour bout of moderate-intensity exercise on vigilance and performance during a subsequent period of night-work

5.1. Introduction

The previous chapter has discussed the potential affects shift-work as been postulated to have on both physiological, psychological and performance parameters. Study 2 specifically suggested that a shift-workers ability to cope with the demands of a job can influence the participation in physical activity and 'healthier lifestyle habits'. It is therefore reasonable to suggest that a decline in the ability to cope with shift-work could negatively impact upon both a workers levels of vigilance and performance within the work environment. However, the parameters relating to performance and vigilance have not been discussed in-depth. Shift-work is now known to be a significant stressor in society. Shift systems that alter the sleep-wake cycle are known to be detrimental to the short- and long-term health and productivity of the worker (Costa, 2004). Although these associations between shift-work and longer-term health consequences are relatively well-documented, little is known about how the shorter-term psychophysiological-related responses to shift-work lead to impaired health over time. Nevertheless, it is clear that on-shift impairments in psychophysiological or performance factors, even if transitory, could have serious human and material consequences, particularly during critical phases of the work process or in response to unexpected events, where rapid and accurate responses are required (Ansiau *et al.,* 2008).

Shift-work-mediated impairments in performance are due mainly to the combined influences of sleep deprivation and the body clock (Petrilli *et al.,* 2005). Rogers (2003) found that nearly two-thirds of nursing staff working long and irregular hours struggled to stay awake during their shifts and suffered episodes of drowsiness and diminished alertness. Such episodes of diminished performance during shift-work have been found to be related to increases in the number of errors made by nursing staff (Scott *et al.,* 2006). In order to reduce these stresses, it is important to scrutinise the shift-system that is adopted for parity to chronobiological-based advice (Costa, 2004). It is clear that an analysis of the lifestyle habits of the shift-worker is also important, since physical activity and eating habits can influence the sleep-wake cycle (Atkinson et al., 2007; Edwards *et al.,* EJAP review).

Alterations in short-term dietary intake influence cognitive performance and mood (Kanarek, 1997). Following the ingestion of a large meal, aspects of mental performance (reaction time and vigilance) are reduced. There can be increased feelings of lethargy, as well as metabolic and physiological changes peaking approximately 1 h after the consumption of the meal and these impairments may last for several hours (Craig and Richardson, 1989). Even in day-workers, post-lunch 'dips' in work-related performance have been reported (Smith and Miles, 1987). Although the overall quantity of food which shift-workers ingest is not necessarily different to day-workers, shift-workers often have irregular meal patterns, large variations in meal size and composition as well as an increased intake of snacks (Waterhouse *et al.*, 1997). Paz and Berry (1997) found that meal composition could influence cognitive performance and mood in shift-workers. Love *et al.*, (2005) reported that the composition and size of meals eaten during a nightshift affect cognitive performance. One behavioural factor which interacts with the physiological effects of meals and indeed on general appetite is physical activity (Atkinson *et al.*, 2008).

A physically-active lifestyle is generally associated with positive mental well-being, reduced stress, increased arousal levels, and reduced feelings of sleepiness, emotional exhaustion and fatigue (Szabo, 2003). There are also reports of reduced perceived exertion during work for individuals who are more habitually physically active (Szabo, 2003; Stathi *et al.*, 2002). Harma *et al.*, (1988a and 1988b) found that physically fit day workers had lower levels of general fatigue and sleepiness and less perceived exertion of work performed during the day and night as compared to workers of low or average fitness. Nevertheless, not all differences between the active and inactive shift-work cohorts were favourable, and there was a trend for increased fatigue on the evening shift that followed a bout of exercise. Therefore, our aim was to examine the acute effects of evening exercise and meal frequency on psychophysiological and performance-related variables during a subsequent period of simulated night-work.

5.2. Method

5.2.1. Participants

Nine healthy participants (8 men and 1 woman; aged 20-42 y) gave their written informed consent to take-part in this crossover experiment. These participants also volunteered for the subsequent study presented in chapter 6.The range of maximal power output following a VO_{2peak} was 250 to 375 watts; the range of power outputs for participants at 50% VO_{2peak} was 120 to 180 watts. All procedures were undertaken in accordance with institutional guidelines that were approved by an institutional review committee and those expected by Chronobiology International (Portaluppi *et al.*, 2008). All participants were non-smokers, had no history of cardiovascular disease, were not taking any medication and engaged in regular physical activity (defined as greater than 2 h per week) and had no prior experience of shift-work. The characteristics of the sample are shown in Table 5.1. The female participant was tested during the first week within her follicular phase on every occasion. In terms of 'chronotype', two of the participants were 'morning-types', five were 'intermediates', and two were 'evening-types'.

Table 5.1. Participant Characteristics:

Participant Characteristics	
Mean (SD) Age	30.5(8.0)yrs
Mean (SD) Weight	75.3(6.8)kg
Mean (SD) Height	1.8(0.1)m
Mean (SD) BMI	22.9(1.7)kg/m$_2$
Mean (SD) VO_2 Peak	49.2(6.7) ml·kg^{-1}·min^{-1}
Mean (SD) Systolic BP	116.5(3.2) mmHg
Mean (SD) Diastolic BP	69.4(4.8) mmHg
Mean (SD) MAP	87.1(2.9) mmHg
Mean (SD) HR	57.8(5.1) bpm

5.2.2. Generic Procedures

After a preliminary visit to the laboratory for anthropometric measurements and a test of maximal oxygen uptake, at least two main trials (exercise and control) were administered in a randomised order. Forty-eight hours prior to all trials, participants were asked to refrain from exercise, alcohol and caffeine and recorded their eating habits in a food diary. On the night prior to each trial, participants retired to bed at 23:00 h. They were asked to rise the following morning on the day of the experiment at 07:00 h and only eat before 10:00 h. Water was consumed *ad libitum* with the time and amount recorded by the participant. During all trials, participants were given 100 ml of water to consume every 60 min throughout the night. The light level within the laboratory was approximately 200 lux and ambient temperature was approximately 21°C throughout all trials.

At the start of the main trial at 18:00 h, participants were allowed 15 min to eat a standard meal. The energy content of this meal was equivalent to 60 kJ.kg^{-1} body mass, with 52% of the energy derived from fat, 38% from carbohydrate and 10% from protein. The exercise trial involved cycling between 19:00-20:00 h at an exercise intensity corresponding to 50% VO_{2peak}. In the control trials, participants sat at rest between 19:00-20:00 h. Subsequently, participants in all trials worked on laptop computers, read books, watched television and listened to music until 05:15 h. At 21:00, 01:00 and 05:00 h, participants completed standard tests of mental and physical performance, lasting approximately 20 min.

Six of the nine participants completed both the exercise and resting control trials under two conditions of meal frequency during the night-shift (a total of four trials completed). The remaining three participants completed two trials (exercise and control) in only one of the meal conditions. Two of the three participants completed two trials (exercise and control) under the one-meal condition. One participant completed two trials (exercise and control) under the two-meal condition. During the one-meal trial, participants consumed, at 22:00 h, a meal with the same energy content as the standard meal consumed at 18:00. In the two-meal trial, meals were consumed at 22:00 h and 02:00 h, with the energy content of each of these meals equivalent to 30 $kJ.kg^{-1}$ body mass. All these meals had the same relative energy contributions as the standard meal eaten at 18:00 h. All meals were required to be ingested within a 15-minute period. Participants had cannulas inserted into their arms so that blood samples could be drawn throughout the simulated night-shift for the measurement of metabolic variables. The data for the metabolic variables can be found in another publication.

5.2.3. Preliminary Measurements and Experimental Procedures

Prior to the main trials, all participants completed a peak oxygen consumption (VO_{2peak}) test using an incremental and continuous protocol on a cycle ergometer (Bird and Davison, 1997). Ten min of sub-maximal exercise was performed as a standard warm-up. The test began at 100 W and comprised increments of 25 W every two-minutes until volitional exhaustion was reached. The criteria for volitional exhaustion included the point at which the participant could no longer maintain the required pedal cadence (>60 rev.min-1), the respiratory exchange ratio being > 1.15, a plateau in oxygen consumption and heart being close to the age-predicted maximum. Participants were familiarised with the with the Vienna Test System, which was used to test reaction time, Profile of Mood State questionnaire (POMS), Stanford Sleepiness Scale (SSS), Arousal Scale, Self-Chosen Work-Rate, Core Body Temperature (T_c) and actigraph to measure activity. Anthropometric data (height and weight) were also collected within the preliminary sessions. After the preliminary tests, participants were given seven-days in which to recover from the exercise test before the main trials began. Anthropometric data (height and body mass) were also collected at this time. Height was measured to the nearest 0.1 cm using a stadiometer (Seca 222 stadiometer). Body mass was measured to the nearest 0.01 kg using a Seca scales (Seca Mechanical 761 scales). Body mass index (BMI) was calculated as body mass in kilograms divided by the square of height in meters.

5.2.4. Core Body Temperature Measurement (T_c)

Eight-hours prior to both of the main experimental trials at 10:00 h disposable temperature capsules (Cor-100, HQinc, Palmetta FL) were ingested with a glass of water. On arrival to the isolation chamber serial T_c measurements were obtained to establish that the sensor was working correctly and to ensure that the T_c was in a steady state. The temperature was measured using a portable ambulatory data recorder (CorTemp 2000, HQinc, Palmetta FL). In both trials the data loggers were packed into a low profile waist pouch, which was tightly secured to the posterior lumbar region of the torso. T_c was measured every 60 seconds.

5.2.5. Vienna Test System: Determination Unit: Reaction Time Task:

At three time points during the night-work participants were asked to complete the determination unit test (21:00 h, 00:00 h and 05:00 h). The determination unit is a complex , multi-stimuli reaction unit (Pouw, 1991) and is designed to assess participants' reaction speed, reactive stress tolerance and ability to demonstrate sustained multi-choice reactions to rapidly changing stimuli (Schuhfried, 1996). The unit allows for the presentation of optical stimuli coloured white, yellow, red, green, blue, which are presented in 10 different positions. Participants had to respond by pressing one of the five reaction keys which are assigned to each of the colours. Two additional white lamps, which were set apart from the coloured lamps, require stepping on the left or right pedal. This was the time-controlled version, where every stimulus was presented for a certain time and then followed by the next stimulus. The number stimuli, correct and incorrect reactions as well as the reaction time were recorded (Deijen et al., 1996).

5.2.6. Activity Measurement

The actiwatch AW4 resembles a wrist-watch and is a light-weight (16 g) device which contains a miniature uniaxial accelerometer. This signal is measured 32 times per second and processed to provide the digital integration of the amount and duration of movement within a given period, or epoch. The actiwatch has a variable epoch length of between 0.25 and 15.0 min. At a10-sec epoch, the unit has a maximum recording capacity. Actigraph data (activity counts) were therefore recorded using 10-sec Epochs and average counts calculated per 1-min. The Actiwatch AW4 recorded all movement over 0.05g. The resultant activity count was stored within an internal memory; until data was transferred via the Sleep Analysis 5 software create by Cambridge Neurotechnology Ltd. All 1-min epochs were summed and averaged into 30-minute bins for the purpose of statistical analysis.

5.2.7 Self-Chosen Work Rate Protocol

At three time points during the simulated night shift (21:00 h, 00:00 h and 05:00 h), participants were instructed to cycle for 5 min on a cycle ergometer (ergobike medical 8, Daum Electronics) adjusting the work-rate themselves to a load in which they felt they could sustain if they were to continue cycling for 30 min. The display of the ergometer was occluded so that participants used self-perception of effort alone. The power output was recorded every 1 min by the researcher and the mean power output over the 5-min test was calculated. This test has been found to be sensitive to circadian variation in a previous study (Atkinson *et al.,* 1993).

5.2.8. Profile of Mood States (POMS)

At 21:00 h, 00:00 h and 05:00 h, participants completed the POMS questionnaire, which is a standard method of measuring mood state, consisting of the subscales Depression, Anger, Fatigue, Vigour, Tension, confusion, friendly and Total Mood Disturbance. The questionnaire consisted of 65 questions in total (McNair, 1992; Atkinson *et al.,* 1992).

5.2.9 Subjective arousal and Stanford Sleepiness Scale (SSS)

At 21:00 h, 00:00 h and 05:00 h, participants were instructed to record subjective arousal and sleepiness. Participants indicated their level of arousal by placing a mark on a 10cm horizontal line between extremes of 'alert' and 'drowsy'. The SSS is an introspective measure of sleepiness. At each time point the participant was asked to look at the seven statements presented on the SSS form and highlight the statement that applied most to them at that time. Each statement was assigned a number from one to seven (Atkinson *et al.,* 1993).

5.2.10 Data Analysis

Data were analyzed using the Statistical Package for the Social Science (SPSS) software (version 14.0, SPSS, Chicago, IL). , arousal, mood (Depression, Anger, Fatigue, Vigor, Tension, confusion, friendly and Total Mood Disturbance) reaction-time and number of incorrect stimuli, self-paced test, T_c and wrist activity were analysed using a linear mixed model with the factors being exercise (exercise vs no exercise), meal frequency (one meal vs two meals) and measurement time (every 30 min). Exploration of cross-correlations between repeated measures levels indicated that a covariance type of compound symmetry was appropriate. The model assumes a continuous outcome variable which is linearly related to a set of explanatory variables; it expands on the ordinary general linear model by allowing one to incorporate lack of independence between observations and to model more than one error term. The types of data that can be analysed using the general linear mixed model include longitudinal data, repeated measures data (including cross-over studies), growth and dose-response curve data, clustered (or nested) data, multivariate data and correlated data (Cnaan *et al.,* 1997). Two strengths of the mixed model are (1) the ability to accommodate missing data points often encountered in longitudinal datasets and (2) the ability to model nonlinear, individual characteristics. (Krueger and Tian, 2004). As a direct result of missing data occurring at some time points during the simulated night shift in relation to a number of variables; in conjunction with the study being unbalanced in nature mixed models was deemed the most appropriate statistical analysis. Data are presented in the text as mean (SD) and 95% confidence intervals (95%CI). Exact *p* values are cited (values of *p* of "0.000" provided by the statistics package are reported as "<0.0005"). Statistical significance was delimited at $P < 0.05$.

5.3 Results

5.3.1 Core Body Temperature (T_c)

Core temperature generally decreased as the night-shift continued into the early hours of the morning ($p<0.0005$) (Figure 5.1). Nevertheless, the mean (SD) core temperature over the night-shift was 36.79 (0.51)°C after exercise compared with 36.91 (0.51)°C without exercise. The difference between trials was 0.05°C (95% CI = -0.002 to 1.01, $p<0.05$, Figure 5.1). There was no significant effect of test meal nor was there any interaction between, exercise, meal or time ($p>0.40$).

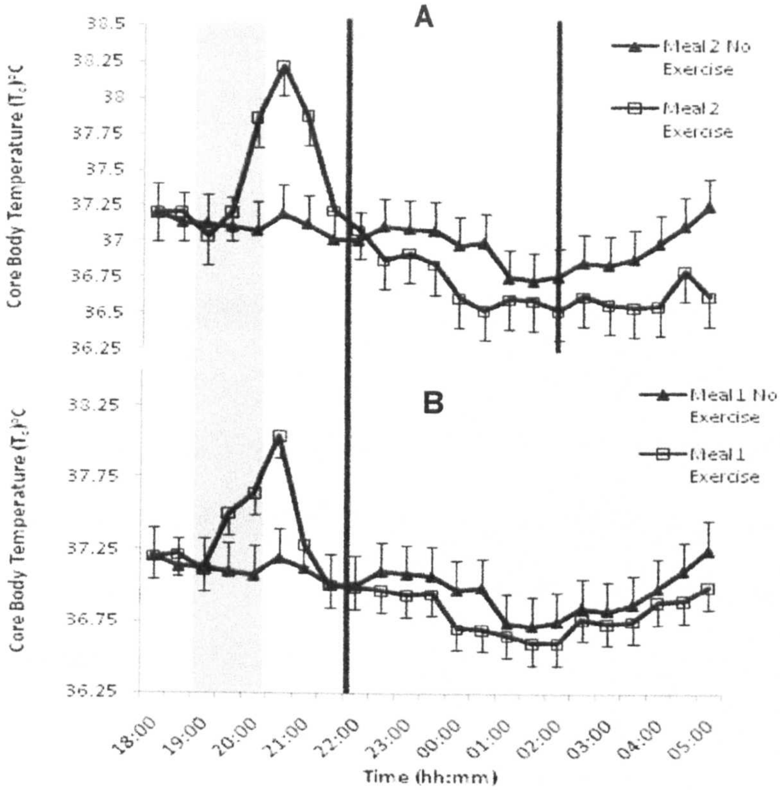

Figure 5. 1. A. 12-h reactivity of T_c during a simulated night-shift with and without prior exercise with two test meals (22:00 and 02:00-h. **B.** 12-h reactivity of T_c during a simulated night-shift with and without prior exercise with one test meal (22:00-h). All data are mean ± SE.

5.3.2. Reaction Time and Number of Incorrect Stimuli

Reaction time generally decreased as the night-shift continued into the early hours of the morning (p<0.044). Nevertheless, the mean (SD) reaction time was 800 (0.02) ms quicker after exercise compared with 900 (0.02) ms without exercise. The difference between trials was 0.007ms (95% CI = -0.030 to 0.029, p<0.047). There was a significant effect of test meal and exercise (p<0.03) with the two-meal trials exhibiting significantly slower reaction time scores in comparison to the one meal-trials. There was no significant interaction between time, exercise and meal (p>0.715).

The number of incorrect stimuli generally decreased as the night-shift continued into the early hours of the morning (p<0.042). Nevertheless, the mean (SD) of number of incorrect stimuli was 8.9 ± (2.6) after exercise compared to 10.8± (2.6) without exercise. The difference between trials was 1.9 (95% CI = -1.06 to 4.94, $p<0.021$). There were no significant effects or interactions of meal and exercise or meal, exercise and time ($p>0.608$ and $p>0.852$ respectively).

5.3.3 Wrist activity

Prior exercise mediated an increase in wrist activity by 85 (11) counts.min^{-1} throughout the subsequent night-shift compared with a slight reduction of 21 ± (11) counts.min^{-1} without exercise (Figure 5.2). The difference between trials was 106 (8) counts.min^{-1} (95% CI =90 to 122, $p<0.0005$). Meal frequency significantly moderated these exercise-related effects on activity ($p<0.0005$). In the two-meal trial, the exercise-related increase in subsequent wrist activity was much larger (120 counts.min^{-1}) compared with the one-meal trials (51 counts.min^{-1}).

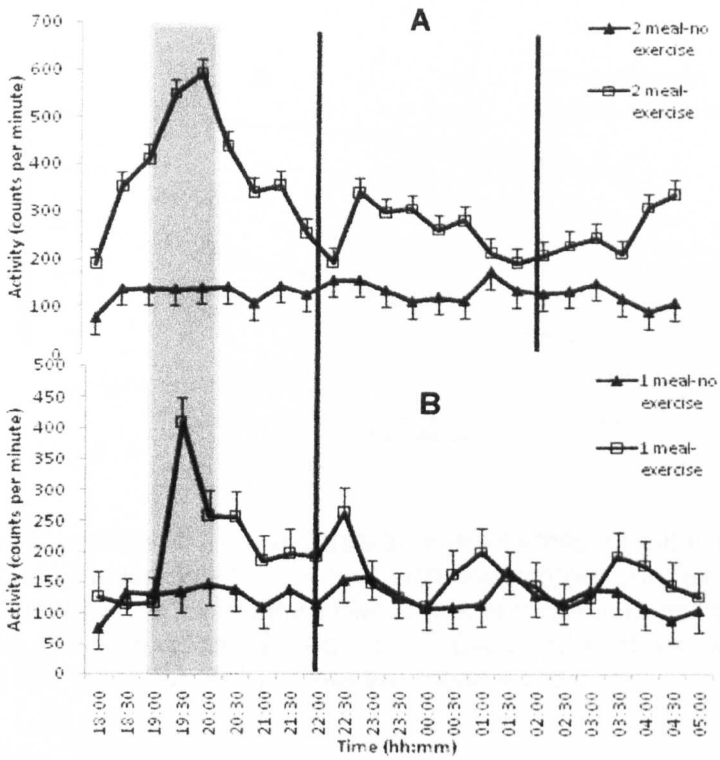

Figure 5.2. A. 12-h reactivity of activity (counts per minute) during a simulated night-shift with and without prior exercise with two test meals (22:00 and 02:00-h. **B.** 12-h reactivity of activity (counts per minute) during a simulated night-shift with and without prior exercise with one test meal (22:00-h). All data are mean ± SE.

5.3.4 Self-Chosen Work Rate

Self-chosen work-rate generally decreased as the night-shift continued into the early hours of the morning ($p<0.012$) (Figure 5.3). Nevertheless, the mean (SD) self-chosen work-rate the night-shift was 141.± (12.4) watts after exercise compared to 109.8±(12.4) without exercise. The difference between trials was -31.5 (95% CI = -42.8 to -20.3, $p<0.0005$). There were no significant effects or interactions with regard to exercise and test meal and exercise, test meal and time ($p>0.86$ and $p>0.96$ respectively).

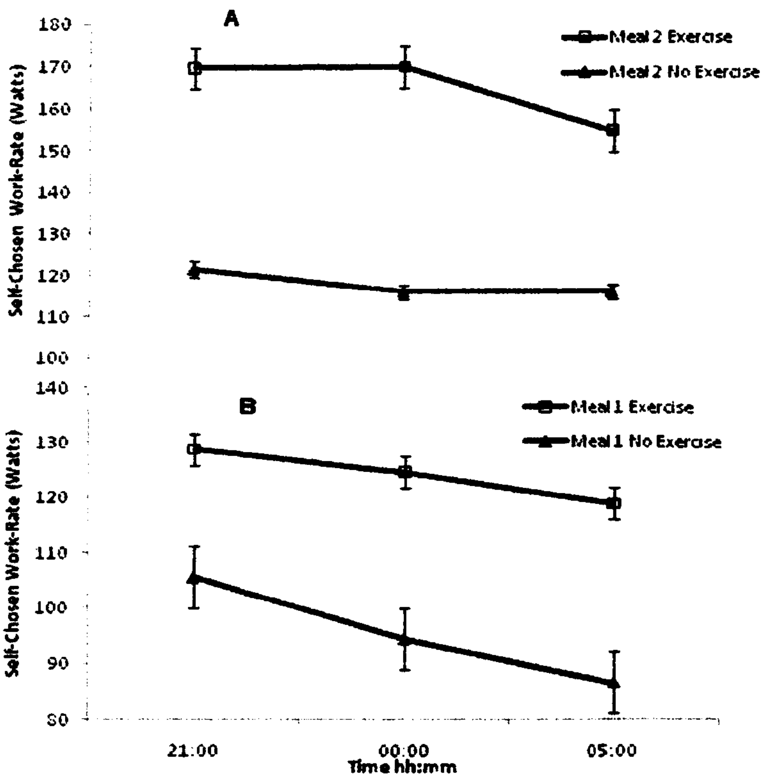

Figure 5.3. A. Self-chosen work-rate at three time points throughout the night shift with and without exercise during a simulated night-shift with and without prior exercise with two test meals (22:00 and 02:00-h). **B.** Self-chosen work-rate at three time points throughout the night shift with and without exercise during a simulated night-shift with and without prior exercise with one test meal (22:00-h). Data are mean ± SD.

5.3.5 Mood

Confusion generally decreased as the night-shift continued into the early hours of the morning ($p<0.036$). Nevertheless, the mean (SD) confusion scores over the night-shift was

7.3 ± (0.6) after exercise compared with 8.3± (0.6) without exercise. The difference between trials was 1.0 (95% CI = 0.09 to 1.93, $p<0.03$). There were no significant interactions of exercise and meal and confusion ($p>0.73$). Fatigue generally decreased as the night-shift continued into the early hours of the morning ($p<0.037$). Nevertheless, the mean (SD) fatigue scores over the night-shift was 13.2 ± (1.2) after exercise compared 16.8± (1.2) with without exercise. The difference between trials was 3.5 (95% CI = 1.8 to 5.3, $p<0.0005$). There were no significant interactions of exercise and meal and confusion ($p>0.37$).

Total mood disturbance generally decreased as the night-shift continued into the early hours of the morning ($p<0.04$). Nevertheless, the mean (SD) total mood disturbance scores over the night-shift was 45.9 ± (5.3) after exercise compared with 50.9± (5.4) without exercise. The difference between trials was -4.8 (95% CI = -11.3 to 1.5, $p<0.0005$). There were no significant interactions of exercise and meal and confusion ($p>0.56$).

Vigour generally decreased as the night-shift continued into the early hours of the morning ($p<0.035$). Nevertheless, the mean (SD) vigour scores over the night-shift was17.0±(1.2) after exercise compared with 15.5± (1.2) without exercise. The difference between trials was -4.6(95% CI = -2.2 to 1.3, $p<0.05$). There were no significant interactions of exercise and meal and confusion ($p>0.33$). There were no significant effects of exercise, meal, time and anger, tension, depression and friendly constructs of mood ($p>0.36$, $p>0.75$, $p>0.62$ and $p>0.85$ respectively).

5.3.6 Sleepiness and Arousal

Sleepiness and arousal generally decreased as the night-shift continued into the early hours of the morning ($p<0.0005$, $p<0.0005$ respectively) (Figure 5.4 and figure 5.5 respectively). Nevertheless, the mean (SD) sleepiness and arousal over the night-shift was 3.2± (0.3) and 4.8± (0.4) cm after exercise compared with 4.2± (0.3) and 6.1± (0.4) cm without exercise respectively. The difference between trials was 1.3 (95% CI = 0.7 to 1.4, $p<0.0005$) and 1.3

(95% CI = 0.9 to 1.8, *p*<0.0005) respectively. There was no significant sleepiness effect of test meal nor was there any interaction between, exercise, meal or time (*p*>0.60). However, there was a significant effect of test meal arousal levels were also significantly increased in the two meal trial in comparison to the one-meal trial (*p*<0.037) suggesting that two-meals heightened participants perception of arousal. There was no significant interaction between exercise, meal and time (*p*<0.16).

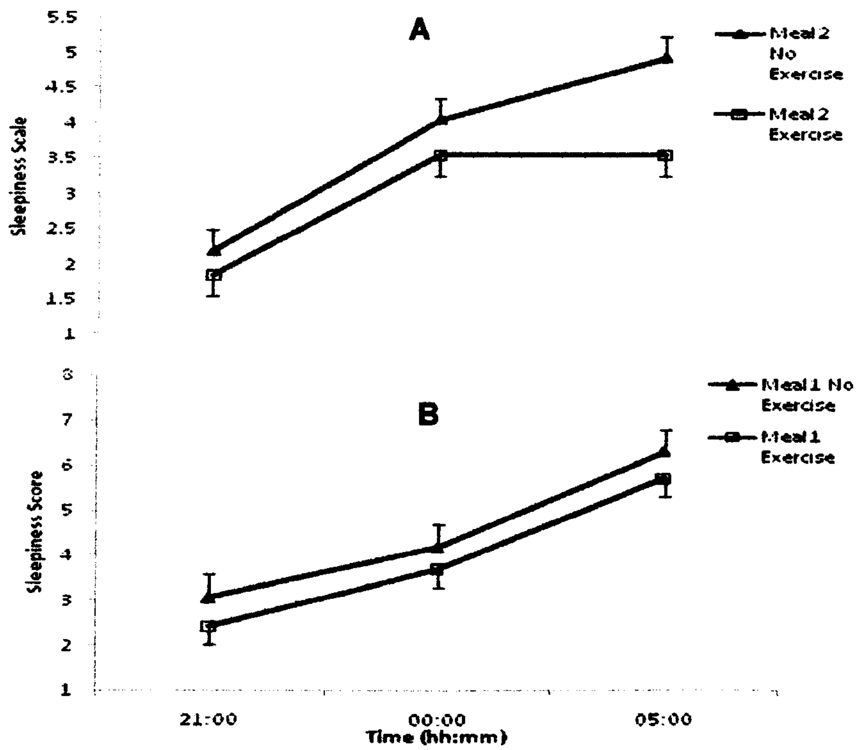

Figure 5.4. A. Sleepiness score at three time points throughout the night shift with and without exercise during a simulated night-shift with and without prior exercise with two test meals (22:00 and 02:00-h). **B.** Sleepiness score at three time points throughout the night shift with and without exercise during a simulated night-shift with and without prior exercise with one test meal (22:00-h). Data are mean ± SD.

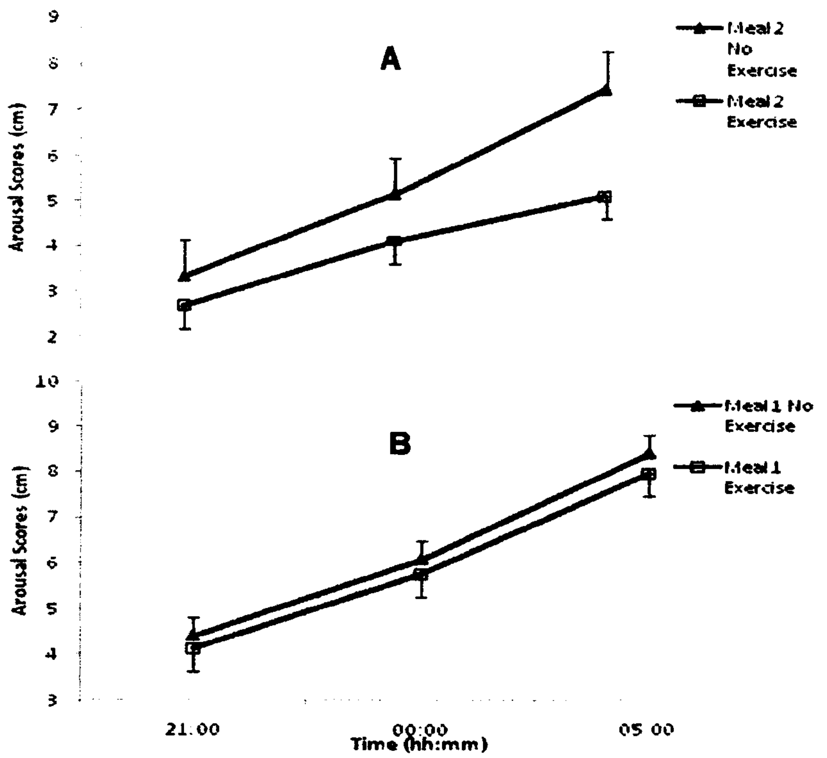

Figure 5.5. A. Arousal score at three time points throughout the night shift with and without exercise during a simulated night-shift with and without prior exercise with two test meals (22:00 and 02:00-h). **B.** Arousal score at three time points throughout the night shift with and without exercise during a simulated night-shift with and without prior exercise with one test meal (22:00-h). Data are mean ± SD.

5.4 Discussion

The novel findings of this study are that a 1-hour bout of moderate intensity exercise taken at 19:00 h (i) significantly improved mental and physical performance during a subsequent simulated night-shift and (ii) initially increased core body temperature, but then induced hypothermic effects after 23:00 h which persisted during the night. We also found that the influence of meal frequency on our outcomes was generally smaller than that of exercise, although there was evidence that more frequent, smaller meals elicited higher levels of activity and subjective arousal and quicker reaction times.

Previous study results have indicated that exercise can have acute and chronic effects on the human circadian rhythm in core body temperature (Atkinson *et al.*, 1996). The rhythm amplitudes of physically fit subjects have been found to be higher than in unfit individuals (Harma *et al.,* 1982; Atkinson *et al.,* 1993), which can be explained by a lower nadir for the fit subjects in the early hours of the morning. In agreement with our data on the acute effects of exercise, Mermin and Czeisler (1987) found exercise during the day increased body temperature, but a proportional drop in body temperature can occur below what was observed during "normal" sleep (sleep following no activity during the day). It is plausible that exercise mediates changes in sleep architecture which in turn alter core body temperature; there is generally an increase in slow wave sleep and sleep length with physical fitness which is associated with lower body temperatures (Mermin and Czeisler, 1987). However, the subjects in our study remained awake throughout the night and the exercise-mediated nocturnal hypothermia was still observed, even though nocturnal levels of wrist activity were higher following exercise than in the no-exercise trials.

A novel finding in our study is that self-paced physical work-rates were consistently higher throughout the simulated night-shift that followed exercise in comparison to the control trials regardless of meal frequency. Harma *et al.,* (1988a) found that, after completion of an exercise programme, physically fit night-workers had less perceived exertion of work performed during the day and night as compared to workers of low or average fitness. However, there were higher levels of fatigue observed in the training group directly after the completion of exercise. This suggests that night-shift workers participating in exercise prior to a night shift could potentially perceive work to be less stress and therefore cope better with job. Decreases in job stress have been linked to positive physiological and psychological effects for workers and would potentially promote good health in this population (Florida-James *et al.,* 1996; Ansiau *et al.,* 2008). A more likely explanation for acute affective benefits of exercise could in fact be associated with the mental interpretation of the activity that the participant is engaged in. This is known as the 'cognitive appraisal hypothesis' (that was proposed in relation to stressful experiences by Lazarus in 1993) immediate beliefs and thoughts influence the view one takes on the situation or an activity.

Consequently, any life experience interpreted as pleasant is likely to trigger positive affect. Therefore an acute bout of exercise that has positive psychological effects also have a positive relationship to the perception of the amount and intensity of work performed (Sazbo, 2003). It is possible that the cycle ergometry exercise which preceded the night-shift could have 'primed' the participants to have decreased the perception of difficulty encountered by the participants during the subsequent self-chosen work-rate tests and therefore increased the load chosen by each participant. Nevertheless, the participants were already well-accustomed to cycle ergometry and the study was counterbalanced so several subjects completed the self-chosen work-rate tests without preceding exercise as their first trial.

The exact reason for the increase in activity levels following exercise is somewhat unclear, however, since exercise is thought to increase feelings of vigour and delays the onset of fatigue as seen in the present study and postulated to increase work productivity this could in fact account for the significant changes in activity between trials (McArdle *et al.*, 1996). Again changes in activity levels could be linked to the 'cognitive appraisal hypothesis' with participants increasing levels of activity as perception of work performed is more favourable following a bout of exercise in comparison to trials without exercise. The higher activity counts exhibited during the two-meal trials in comparison to the one-meal trials could in fact be related to the meal size, composition and frequency. However, research relating to short-term effects of meal size and frequency is unequivocal to say the least (Kanarek, 1997).

Cognitive performance is a multifaceted phenomenon and somewhat more complex than the T_c or melatonin circadian rhythms and is often masked or is clearly differentiated from but correlated to mood states, subjective fatigue and sleepiness (desire to sleep), and length of time in which an individual has been awake, all of which have been documented to be effected by an acute as well as sustained bout of shift/night-work (Blatter and Cajochen, 2007). Gander *et al.*, (2008) examined sleep (actigraphy and diaries) and performance (reaction time and vigilance tasks) in 28 anaesthesia trainees and 20 specialist shift-workers (all of which worked night-shifts). Gander and colleagues found that post-night-shift performance was worse than post day-shift performance for the median and slowest 10% of reaction times. The poor performance recorded following the night-shift was attributed to greater length of time since waking, acute sleep loss, more total work performed within a 24-h period. Santhi *et al.*, (2008) found during night-work reaction times with regard to perceptual tasks were greatly reduced with increases in attentional lapses. Most notably, the nocturnal increases in attentional lapses were three-fold greater after the first night-shift. Interestingly, low intensity exercises both acute and chronic have been found to enhance cognitive performance both in relation to reaction time and the choice of correct or incorrect stimuli. The present study agrees with a number of previous studies conducted in day-time conditions exploring the associations between exercise and cognitive performance. Arcelin *et al.*, (1997) measured participant choice-reaction times whilst subjects were being exercised on a cycle ergometer at 60% of their $VO_{2\,max}$. The cognitive task was administered after 3 min of exercise and again after exercising 8 min. Participants reaction times were significantly shorter during exercise than when they were not exercising; furthermore, reaction times were quicker at the end of the exercise period than at the beginning. Tomporowski (2003) conducted a review of studies that assessed the effects of acute bouts of physical activity on adult participants' cognitive performance. The review concluded that sub-maximal aerobic exercise performed for periods up to 60 min facilitate specific aspects of information processing this is in agreement with the present study.

Shift-work, specifically night-work has been associated with changes in mood, increased levels of fatigue (decreased feelings of vigour), increased feelings of sleepiness all of which influence worker productivity (Harma *et al.*, 1998; Samaha *et al.*, 2007). Tamagawa *et al.*, (2007) indicated that night shift-work tolerance was significantly associated with mood states and personality traits. Tamagawa and colleagues found police officers that scored highly on trait anxiety, repressive emotional style and negative mood showed a greater intolerance to night shift-work in terms of somatic, psychological and sleep health all of which have been thought to be alleviated by acute and chronic physical activity/exercise (Harma *et al.,* 1988a, 1988b; Harma *et al.,* 1998; Samaha *et al.,* 2007). Szabo (2003) suggested that a 20-minute bout of acute aerobic exercise (running at a self-chosen intensity) utilising two different methodologies (filed based and laboratory based experiments) generated significant affective-benefits in mood as measured by the shortened POMS questionnaire. During the field based methodology perception of vigour was greater and perceived fatigue reduced following the bout of exercise, with the laboratory showing similar trends to the field based study, however, the trends were not strong enough to produce significant results. Nonetheless, both field based and laboratory based methodologies indicated that total mood disturbance decreased significantly following exercise. These changes in mood mimic the observed effects in the present study. Such findings are not new in the context of 'day-work' but are of great interest to the night-working population. Such positive changes in mood, which are elicited by exercise, could be associated with increased cognitive performance, increased productivity and a reduction in errors. Since changes in mood states are thought to be one of the many factors influencing cognitive performance and work productivity any positive effects of an acute bout of exercise could plausibly enhance a night-workers overall performance (Blatter and Cajochen, 2007).

5.6 Conclusion

Whilst the findings of this study should be taken with relative caution, this research has highlighted the potential benefits an acute bout of low intensity exercise performed directly prior to a period of night work could have on the shift working population. The significant effects of lower $T_{c,}$ enhanced mood, a reduced feelings of sleepiness and fatigue, increased levels of activity and arousal and increased work rates via the medium of exercise not only reflect the plausible use of exercise as a non-pharmacological intervention preventing and or alleviating a number of psychosomatic issues/health problems in a population where the prevalence of such an illness is magnified, but also as a tool to enhance tolerance to night shift work. Whilst, the exact mechanisms as to why exercise has such positive effects in the night shift workers requires further attention it is clear that exercise could have both acute and chronic benefits enhancing health in this special population. Further research needs to explore the exact implications of both short and long term exercise interventions on acute and chronic health issues that surround night shift work, within a larger sample size, with lower levels of fitness and with the addition of more female participants.

Chapter 6

Prior exercise lowers blood pressure during simulated night-work with different meal schedules

This work has been published in the April 2009 Edition of the American Journal of Hypertension. Aspects of this work were also presented at the 14th Congress of the European College of Sport Science, Oslo, Norway 2009.

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Chapter 7

"A Pilot Randomised Controlled Trial" in line with the MRC directives on complex interventions: Effects of a lifestyle intervention based on motivational interviewing on shift worker's physical activity and health outcomes

7.1 Introduction

Interestingly, chapters 5 and 6 have shown that a single bout of low-intensity exercise performed prior to a night-shift can have positive effects upon blood pressure and some cognitive performance parameters, which invariably could be highly beneficial in either alleviating or preventing incidences of cardiovascular problems in a shirt-working population. What is more chapter 4 highlighted the potential influential effects that shift-work might have upon an individuals resolve to participate in LTPA and their subsequent ability to cope with a non-diurnal existence. However the results presented in chapters 3 provided an extensive depiction of the direct negative implications and multifaceted interactions shift-work has upon an individual's ability to actually participate in LTPA. Furthermore, the qualitative data gathered during the email interviews allowed for the exploration of barriers to LTPA shift-workers suggest they face. Whether the negative influences upon LTPA participation are perceived or actual barriers is still a matter of debate. Nonetheless the data provided from the email interviews have guided the choices of interventions made throughout this nexy chapter. Such data collation 'pre-intervention' is common practice and vital if an intervention is to be successful (Lewin *et al*,2009). Therefore the following chapter will explore a unique and bespoke intervention that could have the potential to overcome the identified barriers a shift-worker may face in relation to LTPA participation whilst trying to elicit the positive cardiovascular and psychological changes exhibited in previous chapters. Whilst such findings from previous chapters provide useful information, the study designs were of a cross sectional nature, and therefore has a number of limitations, especially in relation to causality. These limitations found within cross-sectional studies can be avoided by implementing a randomised controlled trial.

A substantial body of evidence now demonstrates that the burden of ill-health attributed to inactivity during normal diurnal living can be alleviated by habitual physical activity. In fact it has been recognised that a healthy workforce equates to lower labour costs, higher productivity and lower attrition rates regarding employee absenteeism or resignation (Burton and Turrell, 2000; Popham and Mitchell 2005, Dietz, 1996). Worksites may offer unique opportunities to encourage employees and their families to engage in physical activity.

Researchers have explored the usefulness and value of an assortment of worksite-based physical activity interventions, ranging from 20 min of extremely vigorous exercise performed three times a week, to the more moderate physical activity related to fitness classes and group activities (Kahn *et al.*, 2002). Shephard (1996) reviewed a number of studies and suggested that worksite-based physical activity interventions decreased body mass by 1-2%, decreased blood pressure by between 2-10 mmHg and decreased serum cholesterol by 15%, a reduction in absenteeism rates (although small) as well as an increase in productivity of 4-5%. With this in mind it is surprising that physical activity, fitness and energy expenditure during nocturnal or in unconventional conditions, such as shift-work, have received very little attention (Harma, 1996, Atkinson and Reilly, 1996, Kivimak, *et al.*, 2001). However, it has been suggested that those shift-workers that adopt active/engaging coping mechanisms, such as the habitual involvement in physical activity are better able to tolerate the stresses and strains of shift-work (Spelten, *et al.*, 1993; Harrington, 1996; Harma, *et al.*, 1988; Kivimaki, *et al.*, 2001; and Harma, 1996, Lipovcan, *et al.*, 2004). Harrington (2001) surmised that improved recreational facilities to promote active living might also be useful. Despite this health inequality, only two randomised control trials (Harma *et al.,* 1988; Atlantis *et al.,* 2006) have investigated the effect of altering a shift-work's dietary and/or physical activity habits upon cardiovascular risk factors.

Harma *et al.*, (1988) found that moderate physical training has mostly beneficial effects on sleep (the training groups sleep length increased significantly after the evening shift, and sleep quality improved after the morning shift), fatigue (decreased significantly in the training group during the whole shift cycle) and the performance of shift-workers. The authors suggested that moderate exercise performed several hours before the main sleep period, with the best times for exercise to be performed after a morning/day shift and when performed after a night shift, before an evening nap. However, it should be noted that the training group experienced increased fatigue during the evening shift. Consequently, this raises issues surrounding the timing of exercise and shift-work and is an area that requires further investigation and study.

Atlantis *et al.*, (2006) indicated that a 6-month supervised worksite intervention consisting of moderate-to-high intensity exercise including combined aerobic (at least 20 min duration 3 days/week) and weight training (for an estimated 30 min completed 2–3 days/ week), and dietary/health education (delivered via group seminars, one-on-one counselling and literature through the provision of a worksite manual) significantly reduced mean waist circumference values (82.3 ± 9.2 versus 90.5 ± 17.8 cm, p <0.01) and increased predicted VO_{2max} values (47 versus 41 ml/kg/min, p <0.001) in those participants in the intervention group in comparison to the control group. Interestingly, higher intervention compliance predicted greater improvements in physical fitness. However, there were no significant effects of the 24week intervention on body mass or body mass index in either the intervention or control group. Furthermore, a large proportion of the significant effect on waist circumference being due to changes in one subject. Atlantis and colleagues suggested that whilst the workplace may offer an ideal opportunity to prevent and alleviate a number of the health inequalities seen in shift-workers, substantial barriers to adoption and adherence of exercise in the worksite need to be overcome for greater effectiveness and impact on employee physical health, which could be the focus of future research.

Whilst the abovementioned studies provide some insight into implementing a physical activity intervention for shift-workers the study designs are some unilateral in there approach to improving a shift-workers health through physical activity. The use of supervised and structured sessions may be a direct factor linking to high attrition rates in both studies (Morey *et al.*, 2003). Whilst structured and supervised physical activity interventions have a number of benefits to those living a 'normal diurnal existence' is such rigidity related to these programmes really suitable to a shift-worker? (Morey *et al.,* 2003). Shift-workers face a multitude of issues that interrelate with all facets of their lives. Therefore each shift-worker faces a very unique and individual problem relating to the engagement of sustainable positive health behaviours such as physical activity. Therefore an individualised lifestyle program is possibly more suitable than a rigid or supervised one for shift-workers because their work-rest schedules are constantly changing.

Motivational interviewing (MI) is a client-centered, directive method for enhancing intrinsic motivation to change by exploring and resolving ambivalence (Knight *et al.,* 2006). MI has been demonstrated to improve many long-term health outcomes in individuals, through the augmentation of an individual's motivation to change problematic behaviours (Hecht *et al.,* 2005). A recent meta-analysis indicated that MI significantly reduces BMI to a greater extent than standard treatments in day-workers (Rubak *et al.,* 2005). Such findings can probably be associated to MI increasing habitual physical activity participation and/or improving dietary habits to a greater extent than standard traditional treatments in some but not all studies (Bennett *et al.*, 2007). Whilst MI has a proven track record within the fields of addiction (Dunn *et al.,* 2001), no controlled investigations into the efficacy of MI for decreasing blood pressure and improving perceived stress and quality of life through changes in habitual physical activity participation in UK shift-workers who do not require physical fitness for their job and remain awake during all night-shifts has been undertaken.

Therefore, the primary aims of this study were to determine using a 12-week randomised controlled trial, involving UK shift-workers who do not require physical fitness for their job and remain awake during all night-shifts, the effect of physical activity and dietary centred pilot trial using motivational guided counselling upon blood pressure (systolic, diastolic, mean arterial pressure and heart rate) and perceived stress and quality of life.

7.2 Methods

7.2.1 Participants and setting

Shift-workers were recruited from the Operational Communications Branch of Greater Manchester Police between December 2008 and February 2009, using the forces radio station, leaflets, emails posters, dissemination of the intervention y management and the organisation's monthly magazine for staff. Approximately 800 shift-workers were exposed to all methods of promotion. Initially, participants contacted the researcher and were emailed information about the project and eligibility. If shift-workers met the inclusion criteria (Table 7.1.) and provided written informed consent, baseline data were obtained and then participants were assigned to either the control or intervention group using minimisation strategies (Altman & Bland, 2005).

Table 7.1: Inclusion criteria for the study population.

Variable	Criteria
Age:	18-65 years.
Availability:	Available for the study for 3 months following inclusion.
Shift type:	Rapidly rotating shift-work (mornings, afternoons and nights) for a minimum of 6 months.
Health status:	Free from clinically diagnosed diseases.
	Physically capable of being physically active.

The allocation sequence was minimised to reduce any baseline differences between intervention and comparator groups in age, gender, shift-work experience and education level. All participants were involved in rapid, forward rotation shift-work which involved periods of night-work (workers were awake throughout this shift). All measurements and face-to-face contacts occurred at work-sites belonging to Greater Manchester Police. Ethical approval was granted by a local ethics committee.

7.2.2 Study design

A randomised controlled trial was conducted according to the guidelines laid down in the CONSORT statement (Altman *et al.*, 2001). The study included 2 groups; a comparator and intervention group.

7.2.3 Intervention group –motivational guided counselling

MI is a client-centred, directive method for enhancing intrinsic motivation to changeby exploring and resolving ambivalence (Miller & Rollnick, 2002). MI is more focused and goal-orientated than traditional counselling which is often non-directive (Rollnick & Miller, 1995). Counsellors are able to implement a wide variety of different techniques (e.g., key questions and reflective listening) and styles (e.g., empathy) to increase an individual's motivation or readiness to change. An integral technique utilised by practitioners is reflective listening which, is a key aspect of MI. Reflective listening allows for the clarification of worries, goals and inducing motives for change in the client's own words.

One essential characteristic of MI is supporting clients through their ambivalence regarding behaviour change. The client is encouraged to agree on a part of their behaviour they would ideally like to modify and explore the benefits and barriers to such a change. The counsellor can if required to facilitate this process by helping the client to think of specific mechanisms that would help them overcome their difficulties. In addition to this and prior to the end of the session the client sets individualised, realistic goals for their behaviour change. The counsellor provides objective feedback regarding personal goals and highlights any discrepancies between current behaviours and individual aspirations in a neutral manor in order to solidify and anchor conversations. If when resistance and defensiveness is exhibited reflective comments are used in order to prevent progress to behavioural change being damaged (Amrhein *et al.,* 2003).

In the present study, due to the counsellors only being exposed to minimal MI training a motivational guided counselling technique was adopted sessions followed the stipulations of MI, however, due to lack of training the intervention could not be termed as MI in its true sense. Nonetheless, the motivational guided counselling sessions explored individual reasons for increasing physical activity levels and improving dietary habits. When client's requested information regarding physical activity and diet, the counsellor provided such information (see Haskell *et al.,* 2007; Joint British Societies', 2005) and referred the individual to the healthy lifestyle booklet previously provided during baseline measurements, with all information being based upon the nutritional and exercise guidelines developed by the Joint British Societies (2005) and American College of Sports Medicine (2007) respectively. Each shift-worker in the intervention group received 3 motivational guided counselling sessions (Table 7.1). The first session occurred in study week 1, was face-to-face, lasted approximately 30 minutes and occurred whilst the participant was at work (Table 7.2). The remaining 2 sessions occurred in study weeks 5 and 9, were via telephone and lasted between 15-20 minutes (Table 7.2). To serve as a reminder, the counsellor provided a form containing the participant's goals at the end of the face-to-face motivational guided counselling sessions . The sessions were conducted by an individual with basic training in MI and therefore the sessions were termed as motivational guided counselling sessions. For ease of use throughout the study the motivational guided counselling sessions will be referred to as MI.

Table 7.2. Contact/time schedule for each participant in the intervention group, the comparator group will only be present at the measurement stages.

Week number	Event
0	Baseline measurements
1	Face-to-face MI
5	Telephone MI
9	Telephone MI
13	Post intervention measurements

7.2.4. Comparator group

Participants in the comparator group were not actively encouraged or discouraged from modifying any aspects of their lives. Shift-workers in this group did not have contact with the researchers at anytime, except for when measurements were obtained in study weeks 0 and 13 (Table 7.2). Whilst attending baseline measurements, the control group received an identical healthy lifestyle booklet (see Appendix) to that provided to the intervention group.

7.2.5 Measurement protocol

Assessments were made by researchers un-blinded to experimental conditions. Measurements were recorded at baseline (0 weeks) and post-intervention (13 weeks; Table 7.2). In an attempt to control for possible circadian variation in some outcome measures, participants attended each measurement session at the same time of day (within 1 hour), having fasted for approximately 8 hours.

On arrival, participants completed a physical activity questionnaire, quality of life questionnaire (QOL) and perceived stress scale, and provided information (only at baseline) regarding age, gender, shift-work experience, education level, marital status and number of children. Following this, body mass was measured without heavy items of clothing (e.g., shoes, belts, keys) to the nearest 0.01 kg with calibrated, digital scales. Then height was measurement without shoes to the nearest 0.5 cm using a portable stadiometer. BMI was calculated as body mass in kilograms divided by the square of height in meters (one research assistant took all measurements relating to anthropometric variables in order to prevent inter-observer variance). Thereafter, participants were seated for 10-15 minutes before systolic and diastolic blood pressure and resting heart rate values were measured via an automated device whilst seated according to the British Hypertension Societies' guidelines.

7.2.6 Physical activity questionnaire

Physical activity was assessed using the long version of the International Physical Activity Questionnaire (IPAQ). This questionnaire has been demonstrated to be both valid and reliable (Craig *et al.*, 2003; Hagströmer *et al.*, 2006). The self-administered questionnaire covers 4 areas of physical activity: work-related, transportation, housework/gardening and leisure-time activity. In all of the areas, information pertaining to number of days per week and time spent per day in both moderate and vigorous activity are recorded. Walking time is also recorded during transportation and leisure-time. Practical examples relating to activities of moderate and vigorous intensity are given.

Outcome measures from the IPAQ used were: total walking Metabolic Equivalent of Task (MET)-min·week^{-1}, total moderate intensity activity MET-min·week^{-1}, total vigorous intensity activity MET-min·week^{-1} and total physical activity MET-min·week^{-1}. These data were calculated according to the IPAQ scoring system (IPAQ, 2005).

7.2.7. Perceived Stress Scale (PSS-10)

Tolerance to shift-work is also a complex phenomenon, related to several aspects dealing with both 'external' conditions and 'internal' factors. Such complexities are thought to impact upon the stress levels a shift-worker perceives to have (Harrington, 1995, Costa, 2003; Costa 1996). The PSS was designed for use with community samples with at least a junior high school education. The items are easy to understand and the response alternatives are simple to grasp. Moreover, as noted above, the questions are quite general in nature and hence relatively free of content specific to any sub population group. In light of the generality of scale content and simplicity of language and response alternatives, it was felt that data from representative samples of the general population would not differ significantly from those reported (Cohen *et al.,* 1983; Cohen, 1986).

The PSS similarly to the administration of the LTPA was distributed to the participants at the beginning of the testing sessions. PSS-10 scores are obtained by reversing the scores on the four positive items, e.g., 0=4, 1=3, 2=2, etc. and then summing across all 10 items. Items 4,5, 7, and 8 are the positively stated items.

7.2.8 Quality of life scale (QOLS)

Over the ensuing 20 years, several researchers have used the 16-item English language adapted version of the QOLS as well as translations of the QOLS to gather quantitative QOL information from people with chronic illnesses and healthy samples. The QOLS is a reliable and valid instrument for measuring domains of quality of life important to participants across groups and cultures (Burckhardt *et al.,* 2003). A revised version of the QOLS has already been utilized as a part of the Standard Shift-work Index (SSI) which is a validated and specific to shift-workers.

QOLS similarly to the administration of the PSS and the LTPA was be distributed to the participants at the beginning of the testing session. The instrument is scored by summing the items to make a total score. Subjects should be encouraged to fill out every item even if they are not currently engaged in it (e.g. they can be satisfied even if they do not currently participate in organizations). Or they can be satisfied about not having children. Missing data can be treated by entering the mean score for the item.

7.2.9. Measurements of blood pressure and heart rate during main trials

Blood pressure and heart rate were measured following the completion of the PSS, IPAQ, QOL questionnaires and anthropometric measurements being obtained and following a 10-15minute rest period in which the participants were seated. In both trials blood pressure values were obtained using an automated blood pressure monitor (Dinamap Pro 100, 400V2). The non-dominant arm was used for measurement using an appropriate-sized cuff. If the arm circumference was ≥31 cm, a large cuff was used. Prior to the study, the BP monitor was cross-validated with 3 resting BP readings obtained by a research assistant using a mercury sphygmomanometer according to British Hypertension Society guidelines[18]. Reinders *et al.*, (2006) found that the DINAMAP ProCare Monitor achieved all the required criteria of the International Protocol of the European Society of Hypertension. The mean difference (standard deviation) between the DINAMAP monitor, and the nine sequential same-arm measurements and alternating between two trained observers for systolic and diastolic pressures, respectively, were -2.5 (5.4) and 0.5 (4.5) mmHg. This degree of bias and random error falls within the pass criteria for the Association for the Advancement of Medical Instrumentation Standard (ANSI/AAMI SP-10). De Greef *et al.*, (2007) also found that the DINAMAP ProCare Monitor fulfilled the pass criteria of the ANSI/AAMI SP10 with a mean difference (standard deviation) for systolic and diastolic BP between the DINAMAP monitor and nine sequential same-arm measurements made with a manual sphygmomanometer of -0.3 (6.9) and -4.0 (5.9) mmHg, respectively.

7.2.10. Data analysis

Baseline comparisons between study groups with respect to age, shift-work experience and number of children were analysed with independents samples *t*-test or Mann-Whitney tests if a Gaussian distribution was not observed; Chi-square tests were used to determine if baseline values between groups in regard to gender, education level and marital status were different. A covariance analysis was undertaken, with treatment group as a fixed factor and baseline measurement as a covariate in order to obtain adjusted group differences in regard to both continues and ordinal outcome variables (Vickers & Altman, 2001). Sullivan & D'Agostino (2003) demonstrated that analysis of covariance can accommodate an ordinal outcome variable. The covariate-controlled analysis was performed in an Intention-to-treat manner (Hollis & Campbell, 1999). Intention to treat analysis is an analysis based on the initial treatment intent, not on the treatment eventually administered. Intention to treat analysis is intended to avoid various misleading artefacts that can arise in intervention research (Lachin, 2000). For example, if people who have a more refractory or serious problem tend to drop out at a higher rate, even a completely ineffective treatment may appear to be providing benefits if one merely compares the condition before and after the treatment for only those who finish the treatment (ignoring those who were enrolled originally, but have since been excluded or dropped out) (Hollis and Campbell, 1999). For the purposes of intention to treat analysis, everyone who begins the treatment is considered to be part of the trial, whether they finish it or not (Lachin, 2000). Intention to treat analyses are done to avoid the effects of crossover and drop-out, which may break the randomization to the treatment groups in a study. Intention to treat analysis provides information about the potential effects of treatment policy rather than on the potential effects of specific treatment (Hollis and Campbell, 1999). Multiple imputations were performed in order to account for missing datum bias. Ten imputations for each missing value were created, generating 10 imputed data sets. Each data set was analysed according to the abovementioned covariance analysis. Results from the 10 analysis were then pooled. Sensitivity analysis (data not shown) indicated no significant differences in effects based on another approach (i.e., last observation carried forward) to missing data. Multiple imputation is a statistical technique for analyzing incomplete data sets, that is, data sets for which some entries are missing. Application of the technique requires three steps: *imputation*, *analysis* and *pooling*. Imputation refers to filling in the missing entries of the incomplete data sets, not once, but in this studies case 10 times. Imputed values are drawn for a distribution (that can be different for each missing entry). This step results is 10 complete data sets. Each of the 10 completed data sets are then analyzed. This step results in 10 analyses. Following on from this the 10 analysis results are integrated/pooled into a final result. Rubin (1987) has shown that if the method to create imputations is 'proper', then the resulting inferences will be statistically valid. The most challenging step is IMPUTATION, that is, the construction of the 10 completed data sets. This step accounts for the process that created the missing data. Typical problems are:

- the fact that something is missing could be related its value (e.g., people with higher incomes tend to skip income questions more often);
- missing entries can appear anywhere in the data;
- the method used in the imputation step must foresee the intended complete-data analyses.

The repeated ANALYSIS step on the imputed data is actually somewhat simpler than the same analysis without imputation, since there is no need to bother with the missing data. The POOLING step consists of computing the mean over the 10 repeated analysis, its variance, and its confidence interval or P value. In general, these computations are relatively simple. All statistical procedures were performed via SPSS for Windows, version 17. Statistical significance was set at $P<0.05$. Data are presented as mean ± standard deviation.

7.3. Results

Participant flow through the study can be seen in Figure 7.1. A total of forty-four shift-workers were eligible to participate in the study and were therefore entered the minimisation process. Data with respect to age, gender, shift-work experience (duration spent in shift-work), marital status and number of children did not differ significantly between the comparator and intervention group at baseline (Table 7.3). Participant attrition could be considered as moderate, with 68% retention at study week 13. Attrition was greater in the comparator group (48%) than the intervention group (14%).

Table 7.3 . Baseline characteristics of participants.

	Total sample	Comparator	Intervention	*P* for comparisons between groups
n	44	23	21	
Age (years)	45±9	46±7	45±10	0.749
Gender (m/f)	17/27	9/14	8/13	0.944
Education (%)				
Secondary	50.0	52.2	14.3	0.915
College	38.6	34.8	23.8	
University	11.4	13.0	61.9	
SW experience (years)	39±17	17±11	18±10	0.758
Marital status (%)				
Single	20.5	13.0	14.3	0.903
Co-inhabiting	13.6	17.4	23.8	
Married	65.9	69.6	61.9	
Number of children	4±1	1±1	1±1	0.683

No significant differences between experimental groups were present with respect to SBP, DBP, MAP or HR. Nonetheless, the data has shown a slight trend towards decreased blood pressure values in favour of the intervention group. Post-intervention SBP was 123.3mmHg ± 13.1 in the MI group and 128.8mmHg ±15.8 in the comparator group (p>0.26; Table 7.4 and 7.5). Post-intervention DBP was 74.1mmHg ± 9.9 in the MI group and 77.8mmHg ±11.6 in the comparator group (p>0.24; Table 7.4 and 7.5). Post-intervention MAP was 95.6mmHg ± 10.2 in the MI group and 99.1.mmHg ±9.4 in the comparator group (p>0.48; Table 7.4 and 7.5).Post-intervention HR was 65.1mmHg ± 9.4 in the MI group and 67.9mmHg ±13.8 in the comparator group (p>0.86; Table 7.4 and 7.5).

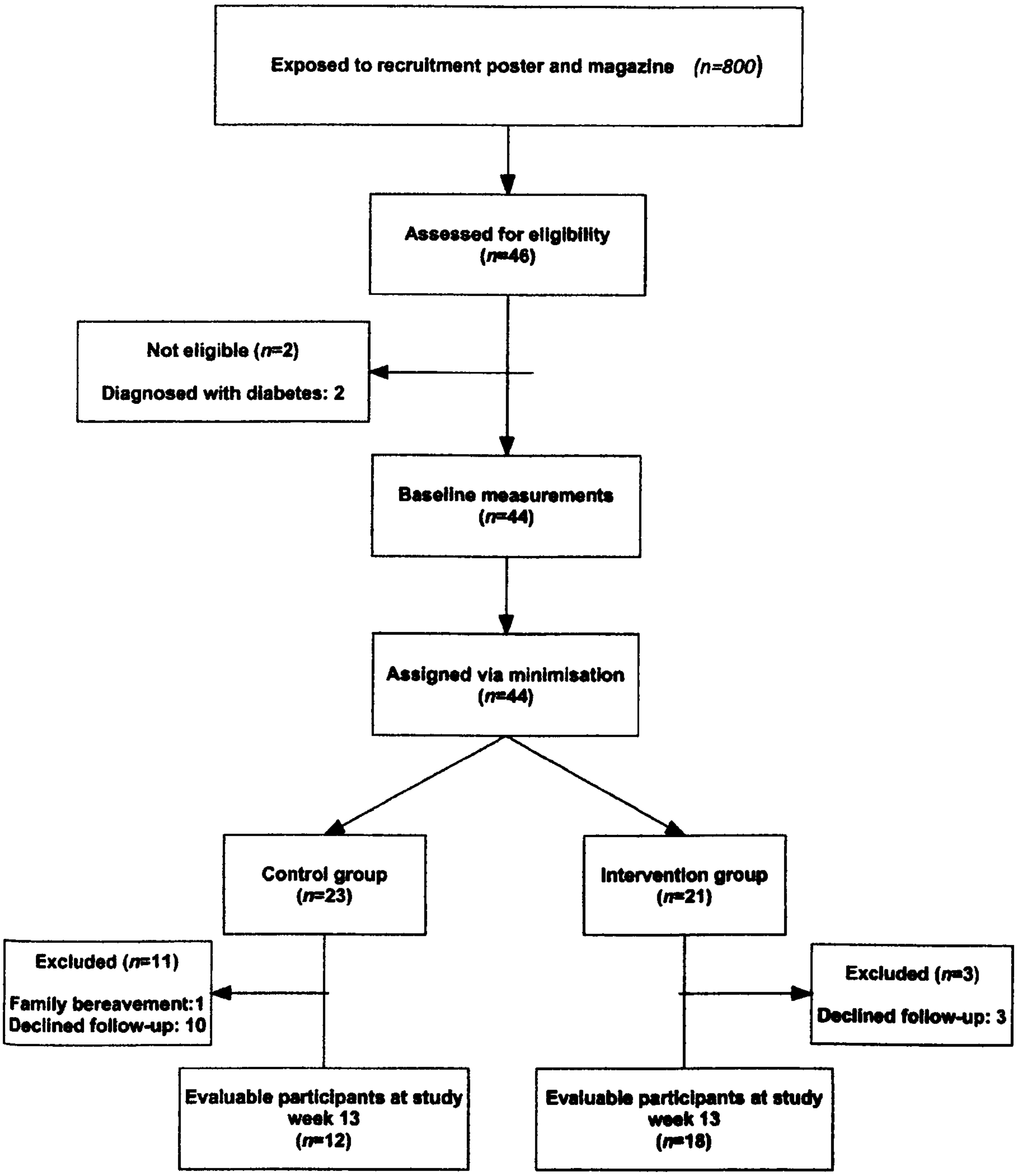

Figure 7.1. Study flow diagram

With baseline covariate control, PSS scores were significantly lower at study week 13 in the intervention group (12.8±7.8) than comparator group (17.9±6.8 p<0.05; Table 7.4). Over the course of the study, the intervention group also appeared to a significantly positive increase in QOL scores (89.5±9.1) compared to the comparator group (81.2±11.2 p<0.05; Table 7.4).

Table 7.4. Raw and Adjusted baseline and post-study data for the comparator and intervention group.

	Baseline				Post-intervention				Effect
	Comparator Group		Intervention group		Comparator group		Intervention group		
	Raw data	Adjusted Data	Raw data	Adjusted Data	Raw data	Adjusted Data	Raw data	Adjusted Data	
SBP mmHg	131.8±16.3	129.5±12.8	133.1±16.1	131.3±15.2	129.7±13.2	128.8±15.8	124.25±10.2	123.3±13.1	*p*=0.26
DBP mmHg	85.2±11.4	84.5±10.1	83.65 ±11.2	83.76±12.2	79.4.±12.8	77.8±11.6	75.26±10.2	74.1±9.9	*p*=0.24
MAP mmHg	99.7±30.1	103.4±11.5	98.4±32.2	102.5±9.4	101.2±11.2	99.1±9.4	94.1±9.4	95.6±10.2	*p*=0.48
HR bpm	66.6±10.5	68±12.3	67.2±10.7	70±10.71	68.51±15.2	67.9±13.8	66.52±10.9	65.1±9.4	*p*=0.86
PSS	17.2±10.3	16.6±5.2	16.5±8.7	15.81±6.1	18.5±8	17.9±6.8	13.3±6.5	12.8±7.8	*p*=0.05
QOL	80.1±10.2	79.8±13.1	79.7 ±13.5	81.2±12.62	79.4±8.7	81.2±11.2	87.9±8.5	89.5±9.1	*p*=0.04
Walking	625±60.0	638.7±64.6	551.2±55.0	566.1±43.0	812±288.1	826.1±265.8	633±240.1	645.9±232.2	*p*=0.48
Moderate intensity PA	1810.5±220.1	1798.8±182.0	1381.9±125.7	1347.7±106.77	3892.7±1829	3944.5±1781.5	4557.8±1567.9	4885.1±1461.3	*p*=0.34
Vigorous intensity PA	716.6±77.2	765.8±68.1	972.5±82.1	947.3±84.1	696.2±386.4	722.1±262.5	744.2±3±402.1	797.5±302.8	*p*=0.48
Total PA	3376.2±250.4	3256.1±227.5	2649.5±165.2	2718.1±158.9	4746.7±1333.2	4870.5±1272.5	5678.1±1238.5	5832.9±1658.3	*p*=0.36

Adjusted and raw data for SBP, Systolic blood pressure; DBP, Diastolic blood pressure; MAP, Mean arterial blood pressure; HR, Heart rate; PSS, Perceived stress scale; QOL, Quality of life questionnaire; all physical activity data are reported as MET-min·week^{-1}.

Post-intervention total walking level was 645.9±232.2 MET-min·week^{-1} in the intervention group and 826.16±265.83 MET-min·week^{-1} in the comparator group (p>0.481; Table 7.4, and 7.5). Moderate intensity physical activity level was similar at study week 13 in the intervention (4885.1±1461.3 MET-min·week^{-1}) and comparator group (3944.5±1781.5 MET-min·week^{-1}; p>0.349; Table 7.4, and Table 7.5). Post-study vigorous activity level was similar in the intervention (797.5±302.8 MET-min·week^{-1}) and comparator group (722.1±262.5 MET-min·week^{-1}; p>0.483; Table 7.4 and Table 7.5). At study week 13, total physical activity level was similar in the intervention (5832.9±1658.3 MET-min·week^{-}1) and comparator group (4870.5±1272.5 MET-min·week^{-}1; p>0.366).

Table 7.5. Baseline and post-study 95% Confidence Intervals

Variable	Baseline		Post-intervention	
	Comparator Group	Intervention Group	Comparator Group	Intervention Group
	95% Confidence Interval	95% Confidence Interval	95% Confidence Interval	95% Confidence Interval
SBP mmHg	121.8-139.1	121.3-138.2	120-137.5	120.3-132.2
DBP mmHg	72.3-86.6	73.7-82.5	70.7-84.4	73.3-81.8
MAP mmHg	94.9-105.3	94-102.1	95.1-103-4	94-100.8
HR bpm	62.9-73.4	63.1-72.6	62.1-72.8	62.4-71.3
PSS	5.9-22.2	8.9-25.6	6.6-21.1	7.7-20.6
QOL	75.7-85.8	74.1-83.1	76.8-86.9	78.1-87.1
Total PA	925.6-3854.4	1057.3-5893.5	910.7-3943.2	1002.7-5943.2

SBP, Systolic blood pressure; DBP, Diastolic blood pressure; MAP, Mean arterial blood pressure; HR, Heart rate; PSS, Perceived stress scale; QOL, Quality of life questionnaire; all physical activity data are reported as MET-min·week⁻1.

7.4. Discussion

This is the first lifestyle intervention study specifically on UK-based shift-workers who do not require physical fitness for their job and remain awake during all their night-shifts. The intervention used in this study significantly reduced shift-workers perceived stress and significantly enhanced the shift-workers self-reported quality of life, but did not exhibit any significant changes in systolic, diastolic, mean arterial pressure or heart rate. However, there were slight trends in positive blood pressure values found in the intervention group. The finding of a reduction in perceived stress and increased perception of quality of life after only 12 weeks of intervention in shift-workers is encouraging considering stress and a poor psychological state has previously been associated with CVD (Ohlin *et al.*, 2004). The positive findings with respect to perceived stress and quality of life does not appear to relate to alterations in physical activity levels measured, but may be related to alterations in diet and as a direct result of the support of the MI practitioner and support initially offered to the worker by their organisation which employs them, although this study could not assess such hypotheses.

The significant finding that perceived stress and quality of life had markedly reduced following a lifestyle intervention, especially an intervention incorporating physical activity and utilising an individualised approach is in line with previous research (Ohlin *et al.*, 2004). Previous randomised control trails utilising physical activity as an intervention have on the whole exhibited positive results relating to an individual's psychological health such as perceived stress and quality of life. Blumenthal *et al.*, (2005) implemented a specific randomized controlled trial of 134 patients (92 male and 42 female; aged 40-84 years) with stable ischemic heart disease (IHD) and exercise-induced myocardial ischemia. The intervention utilised consisted of routine stress management techniques and supervised aerobic exercise training for 35 minutes 3 times per week for 16 week. Patients in the exercise and stress management groups had lower mean (SE) stress and depression scores (exercise: 8.2 [0.6]; stress management: 8.2 [0.6]) vs usual care (10.1 [0.6]; $p < 0.02$); reduced distress by GHQ scores (exercise: 56.3 [0.9]; stress management: 56.8 [0.9]) vs usual care (53.6 [0.9]; $p < 0.02$). For patients with stable IHD, exercise and stress management training reduced emotional distress and improved markers of cardiovascular risk more than usual medical care alone. Brand *et al.*, (2005) implemented a structured and supervised exercise intervention with 110 day-workers over a 13-week period, the intervention took place within the workers own leisure time. Interestingly, the mean quality of life increased for the intervention group by 13.7 score-points, which, can be interpreted as a high or medium intervention effect ($p<0.001$). In addition to this the sub-element of the quality of life score 'psychological health' was significantly improved in the intervention group ($p<0.003$). Atlantis *et al.*, (2004) carried out a randomised control trial on employees from a casino, most of which participated in shift-work (73% of the cohort) over a 24-week period incorporating aerobic and weight training. The findings were extremely encouraging with the intervention group exhibiting improved mental health ($P<0.0005$), increased vitality ($P<0.001$), decreased levels of stress and reduced feelings of depression ($P< 0.036$ and $P<0.048$ respectively). All authors concluded that multi-model interventions incorporating some form of physical activity and accompanied by additional individualised counselling markedly improves psychological health, especially perceived stress and quality of life. Blumenthal *et al.*, (2005) added this by stating that physical activity interventions and stress management could go some way to preventing or alleviated some CVD problems.

The precise mechanism relating to the positive effects exercise and physical activity on stress, depression, quality of life and other psychological parameters are still not clear. Some researchers have hypothesised that positives changes in some physiological parameters will ultimately improve psychological health or even the stimulation and release of specific hormones such as endorphins or serotonin (higher levels of both hormones have been linked to positive perceived psychology health) (Scully *et al.*, 1998). However, such casual relationships could be somewhat misguided as perceived psychosocial benefits may occur in the absence of clearly identifiable changes in physiological parameters, just as it is possible to establish physiological changes in the absence of any perceived psychological benefits (Rejeski, 1995). However, it must be noted that not all randomised controlled trials utilising physical activity and behaviour change methods have elicited positive results. Sjogren *et al.*, (2006) found no significant effects of the physical activity intervention in 90 office-based workers psychosocial wellbeing, whilst there was a clear effect on physical well-being ($p<0.015$).

There is little or no data relating to MI being implemented in workers to elicit favourable effects on stress, since most work has been performed in those individuals with posttraumatic stress or stress relating to psychological illness. However, a number of studies have shown comparable results in those individuals being treated with MI in clinical settings (Westra and Dozois, 2006). MI has however also been found to significantly reduce other parameters directly relating to CVD in clients. Kreman *et al.,* (2006) examined the effects of a MI intervention on physiological outcomes among hyperlipidemic persons randomly assigned to an MI (*n* = 12) or an attention–control (AC; *n* = 12) group. Lipid and cardio-respiratory fitness levels were measured pre- and post-intervention. The MI intervention was significant in reducing total cholesterol and low-density-lipoprotein cholesterol but not in increasing VO_{2max} when compared with the AC group. Contrary to what was expected, the MI intervention significantly reduced high-density-lipoprotein cholesterol. Although this study was limited by a small sample size, findings suggested that an MI telephone session can have a positive effect on lipid profiles and fitness levels and therefore prevent or alleviate CVD problems. Stress and poor quality of life have been suggested to be a major occupational health problem which can emanate into serious physiological disturbances and eventually cause emotional and physical 'burnout' as well as being associated with CVD (McVicar 2003). Furthermore, it is known that shift-workers not only suffer from high levels of psychological disturbance (high levels of stress) but are also 40% more likely to be affected by CVD (Boggild and Knutsson 1999). With this in mind and coupled with the effects of shift-work being extremely multi-faceted and specific to the worker any individualized interventions incorporating MI that could potentially alleviate the psychosocial strains of shift-work and positively influence physiological parameters such as CVD can only be useful for the shift-working population. However, positive changes in mood as a result of a lifestyle intervention, those particularly using exercise have found improvements to occur in just 6 weeks (Weinstock ,*et al.,* 2008).

Interestingly, there were no significant changes in SBP, DBP, MAP or HR which is supervising since the changes in perceived stress and quality of life have been postulated to indirectly improve cardiovascular parameters such as blood pressure (Dimsdale 2008). However, an important open question to discuss is whether the found psychological effects in this study are simply due to the organisational offer to invest in the employees' health or whether the implementation of MI relating to health behaviours was itself the ancient to the encouraging psychological findings? (Brand *et al.*, 2005). If the former is the case then this might not affect the perceived stressfulness of the job content or indeed the perception of shift-work itself which would potentially have little or no effect on job strain and therefore not influence any physiological parameters such CVD. What is more there we no significant changes of physical activity levels within the intervention group, which could go some way to explain why there were no significant changes in blood pressure variables. Nevertheless, there were slight trends in reduced values of blood pressure. Clearly such changes cannot not be attributed to changes in physical activity levels, however, it could be surmised that changes in nutritional behaviours or psychological effects might be the antecedents to such encouraging changes but this is merely postulations and further research would need to investigate such theories.

In this study, no differences in regard physical activity levels were observed this data is in line with a number of studies (Bennett *et al.*, 2008; Elliot *et al.*, 2007) but is not universal (Bennett *et al.*, 2007). The exact reasons pin pointing disparities between studies in relation to changes in physical activity levels and MI are difficult to determine. However, potentially differences in study protocols, training and level of practitioners, frequency and duration of MI sessions, measurement of base-line self-efficacy and readiness to change, length of intervention and the tool utilised to measure physical activity might go some way in explaining discrepancies between studies (Rubak *et al.*, 2005). Furthermore a recent critical review by Proper *et al.*, (2003) indicated that after examining five worksite physical activity, physical fitness and health interventions (two randomised control trails and three nonrandomised control trials) that there was no evidence for any previous worksite health and lifestyle interventions having any real significant effects on a workers blood pressure (intervention periods were between 12-48 weeks in length). Interestingly, post-intervention total physical activity level increased by 1614.48 MET-min·week^{-1} in the comparator group in this study. This large post-study increase in total physical activity level could be considered as 'unusual'. Nevertheless, both experimental groups received a healthy lifestyle booklet which contained information relating to the health benefits of increasing physical activity level and evidence exists which suggests that the screening process *per se* can increase an individual's physical activity level (Mai *et al.*, 2007). Therefore, the healthy lifestyle information alone or in combination with the screening process may explain why the control group increased their physical activity level over the study period.

As in all studies, especially those that attempt to change lifestyle behaviours in and individualised fashion in a 'real life' environment there were a number of limitations. Firstly, attrition was notably greater in the comparator than intervention group and hence a between group difference in the amount of missing data was present. Such a high attrition rate within the comparator group is in part related to the fact that participants did not want to be allocated into the control group and felt that they were missing an opportunity to receive an individualised MI session. Steps were taken to reassure participants in the comparator group that at the head of the study individuals would receive the opportunity to engage in MI sessions. Furthermore, the need for comparator data was expressed to participants prior to the engagement in the study itself, however, this did not seem to pacify a large group of participants who were fairly minimised and placed into the comparator group. Future researchers should attempt to provide small incentives (e.g., free cinema or theatre tickets) for all participants to remain within the study. Second, the study sample size was sufficient to provide adequate statistical power for the primary outcome of blood pressure; however statistical power may have been insufficient in regard to secondary outcome variables (e.g., physical activity level). Third both MI practitioners were extremely flexible and often participated in shift-work themselves in an attempt to meet participants for MI sessions. Nevertheless, the logistical demands on the MI practitioners and the somewhat indifferent communication often exhibited in large organisations made meeting for MI sessions extremely problematic. Which lead to a number of MI sessions being consistently rearranged. Forth, staff involved in the study were often used to cover for colleagues who were absent and this would also affect MI sessions and meetings. Future, research should consider having a larger group of MI practitioners who would be accessible 24 h a day.

7.5 Critical narrative of the pilot RCT

Hundreds of volunteers are usually needed for randomized controlled trials (RCTs) focusing on the promotion of a healthy lifestyle, and sufficient participants need to be recruited in order to find a statistically significant effect of the intervention. However, the first problem that is commonly encountered in the recruitment phase is low response, and prolonging the recruitment phase in order to achieve sufficient power is not always possible. This issue was apparent within this RCT (Rotham *et al.,* 2008). Whilst 800 participants were exposed to the potential of participating in the study only 46 were assessed for eligibility. The reasons for this appeared to be three-fold. Firstly, previous studies had been completed within Greater Manchester Police, which required worker contribution. Workers felt there was little or no and in some cases negative benefits as a direct result of taking part in the previous study. This had deterred workers from taking part in this and future studies. Secondly, workers often perceived themselves as 'healthy' and did not require any involvement in a health intervention. Finally, suspicions and misconceptions that the intervention would lead to job losses and further monitoring by the organisation. This belief remained even after educational communication highlighting that the research team was an independent body and individual data would not be released.

A second problem in the recruitment phase was the selection bias many of the individuals involved in the RCT. Non-respondents could have systematically differed from respondents in certain (health-related or socio-demographic) characteristics, and selection bias could have impeded generalizations of the results to the Greater Manchester shift-working population (Groeneveld *et al.,* 2009). As a direct result of this it is possible that for the RCT to have been more rigours the characteristics of non-respondents should have also been reported, this would have ensured/minimised any selection bias. Once the recruitment phase had been completed the next issue was drop-out. During recruitment the importance of a comparator group that was allocated utilising a statistical process that can and should not be influenced by the researchers was impressed. However, issues surrounding participants being allocated to the comparator group and not the intervention group become apparent. Other issues relating to time, ill-health and pregnancy resulted in a number of participants dropping out of the RCT.

Problems also arose in relation to the flexibility of Greater Manchester police releasing workers for short periods of time for testing and counselling. This created tension between the participants the organisation and the researchers. Furthermore, the areas/facilities in which the researchers were given to operate were often stationary cupboards or small rooms which appeared to show a lack of support for the intervention. These issues highlighted the importance of engaging the organisation fully with regard to committing to supporting behaviour change with individual workers. Issues relating to time and lack of training of the counsellors also became apparent. Since the coun sellers had limited training the intervention sessions were not truly MI. Furthermore, future RCTs should employ the MITI scale to monitor the effectiveness of the counsellors ensuring they adhere to the philosophy of MI. In addition to this it is possible if more time was spent on recruitment participant numbers would have increased and drop-out numbers decreased. In future studies, some of these problems could be anticipated, thereby increasing participation and completion rates.

7.6 Conclusion

This study involved an exclusive population, UK shift-workers who do require physical fitness for their job and often undertake nocturnal wakefulness. In this population, a 12 week MI intervention which focused upon increasing physical activity level and improving dietary habits significantly reduced workers perceived stress and increased the perception of quality of life, but not blood pressure or LTPA. The positive finding in regard to stress and quality of life was not due to increased energy expenditure via physical activity and therefore may be related to improved dietary habits (e.g., less energy intake) or as a result of the organisational invest into the employees health. Long-term (i.e., over years) MI focussing upon lifestyle factors may be a useful strategy for tackling stress, perceived quality of life and potentially CVD in shift-workers.

Chapter 8

Synthesis of Findings

8.1 Introduction

The purpose of this Chapter is to summarise and critically analyse the various findings from Chapters 3 to 7 in this thesis. In the first part of Chapter 8, the original objectives are returned to with respect to how they have been realised. The main findings from this thesis are then analysed collectively and an overall conclusion is presented. The next section explores the study-specific limitations and delimitations. Finally, future research avenues resulting from the work presented in this thesis are outlined.

8.2 Realisation of Objectives

Objective 1: ***To describe, using a combination of quantitative and qualitative research strategies, the problems associated with leisure-time physical activity in shift-workers and their families.***

Objective 1 was achieved by adopting a seldom-used mixed-method design, comprising both quantitative and qualitative research strategies (Bryman, 2000). A detailed cross-sectional survey, a longitudinal activity diary, and email interviews solely involving shift-workers from different occupations were implemented with an aim to provide the first detailed examination of LTPA and its correlates in shift-workers the findings from this assessment are presented in Chapter 3. The data from this study indicated that LTPA is generally low amongst shift-workers, especially communications workers in the Police and midwives. The former population would later be selected for the participants in the intervention study. Whilst there is a lack of comparable data between day– and shift-workers indirect comparisons between Lamb and Brodie's (1991) study can be made which suggest shift-workers expend less energy over a 14 day period than a university population, intuitively such findings can be attributed to shift-work generally decreasing opportunities for physical activity and participation in sports (Atkinson *et al.*, 2008; Lipovcan *et al.*, 2004). The other explorations in this chapter were designed to offer some information about whether this notion was true. Females were found to have the lowest levels of LTPA. Gender differences relating to physical activity and shift-work related effects are well documented with females generally citing a 'double burden' or 'double-shift' effect relating to working a shift and then returning home to complete the domestic chores (Bird and Fremond, 1991; Nomaguchi and Bianchi, 2004; Baker *et al.*, 2004). Job type and gender were found to be much more influential on LTPA than age or experience. Shift-workers spent more of their time on rest days in bed, in an attempt to rectify a perceived sleep debt, which is emphasized more than LTPA. In addition shift-workers highlighted a number of barriers they faced a participating in LTPA. The specific barriers were categorized into three main themes, logistical factors (e.g. lack of time), personal factors (e.g. lack of motivation) and physical factors (e.g. lack of energy). These themes were relevant to the next study in the thesis which entailed an exploration into how individuals differed in terms of coping strategies for these problems.

Objective 2: *To examine the different coping strategies utilised by shift-workers and how these relate to leisure-time physical activity.*

Objective 2 was achieved by conducting the first detailed cross-sectional survey of shift-work coping strategies and leisure-time physical activity solely involving shift-workers from similar occupations. Shift- workers completed an adapted version of the Standard Shiftwork Index which included chapters on coping (questions on coping were based upon the Coping Strategies Inventory created by Tobin *et al.*, (1989)) and leisure-time physical activity (an adapted version of Lamb and Brodie's (1990) LTPA questionnaire was utilised) the findings from this assessment are presented in Chapter 4. The data from this study indicated that experienced male shift-workers participate in the most leisure-time physical activity. Experienced male shift-workers also 'disengaged' more from their domestic-related problems, but less from their sleep-related problems. This gender-specific information was useful in the final intervention study for interpreting the individualised counselling sessions from male and female shift-workers. Before this stage, however, it was relevant to explore the possible shorter-term benefits of physical activity during night-work, and this was the focus of the following two studies.

Objective 3: *To examine the acute effects of evening exercise on vigilance and performance-related outcomes during a subsequent simulated period of night work.*

This objective was achieved by conducting the first cross-over type nocturnal experiment on the effects of prior exercise on vigilance and performance and the findings are presented in Chapter 5. The data from this study indicated that following exercise, T_c was significantly lower throughout the night-shift compared with no prior exercise even though activity was higher and sleepiness was lower after exercise. Furthermore self-chosen work-rate was significantly higher and reaction time faster during the night-shift that followed exercise. Reaction time and alertness were worst when only one meal was ingested during the night-shift compared to the two meal trial. It was concluded that a single bout of evening exercise can improve sleepiness as well as mental and physical performance during a subsequent simulated night-shift, especially when food intake is smaller but more frequent during the shift. Performance was improved even though core body temperature was lower during the night-shift after exercise, adding weight to the notion that performance and temperature are not so tightly linked in certain chronobiological conditions (Atkinson and Davenne, 2007). This highlights the potential benefits an acute bout of low intensity exercise performed directly prior to a period of night work could have on a shift-workers vigilance and performance within the work place. These findings were also useful from a methodological angle. Shift-work research has in the past been difficult since employers might perceive that productivity of their employees could be compromised by an intervention designed to improve well-being. The data generated in this study indicate that exercise might actually be beneficial to on-shift performance.

Objective 4: ***To examine the acute effects of evening exercise on blood pressure during a subsequent simulated period of night work.***

This objective was achieved by conducting the first cross-over type nocturnal experiment on exercise and blood pressure and the findings are presented in Chapter 6. BP was selected as the parameter of interest because it is one of the few health-related outcomes that show immediate and prolonged benefits following one bout of exercise. Furthermore, shift-workers have a 40% increased risk of cardiovascular disease, with changes in BP being attributed in part to this increased risk (Bøggild *et al.*, 2001). Therefore, BP seemed an obvious and potentially useful parameter selection to study as the well-documented increase in BP over time could therefore be ameliorated (MacDonald, 2002). The data from this study indicated, that prior exercise lowers BP (reductions from 4-7mmHg) throughout a subsequent 8-hour night-shift (Jones *et al.*, 2008). The post-exercise reductions in systolic BP and MAP were not moderated by diet, but the reduction in diastolic BP was slightly greater when only one meal was eaten (Van Baak, 2008). BP was lower even though wrist activity and heart rate were significantly higher following exercise.

Objective 5: ***To examine the effectiveness of a 3-month lifestyle intervention on health outcomes during actual shift-work.***

In view of the previously-found substantial individual differences in how shift-workers perceive and cope with the various barriers to physical activity together with the fact that exercise was found to acutely benefit some health- and performance-related outcomes (depending on dietary factors), the final chapter in this thesis involved a lifestyle intervention administered to shift-workers. Therefore, this final objective was achieved by conducting a randomised controlled trial and the findings are presented in Chapter 7. The data from this study indicated that a 12-week motivational interviewing intervention which focused upon increasing physical activity level and improving dietary habits significantly reduced workers perceived stress and increased the perception of quality of life, but not blood pressure or LTPA

8.3 Main Findings

The overall aim of this thesis was to determine the behavioural and biological relationships between leisure-time physical activity and health outcomes during shift- and night-work. Despite the fact that there are 3.6 million shift-workers in the UK and these people are confronted with significant chronobiological and behavioural disturbances, there is a dearth of research on this topic. Data gained from studies involving shift-workers and simulated night-shifts also provide novel information regarding associations between physical activity and the abovementioned factors. Thus, this thesis makes a significant contribution to the field of physical activity and shift-work. Detailed below are the main findings of this thesis and prospective recommendations that could potentially assist the shift-working population.

The data obtained from study 1 and 2 revealed, for the first time, a unique heterogeneous approach to coping with shift-work, which interestingly exhibited interactions with the participation of physical activity, gender and shift-worker experience. In line with previous research female shift-workers exhibited significantly lower levels of LTPA (Lipovcan *et al.*, 2004). Job-type and gender were found to be far more influential on LTPA levels of shift-workers than age and experience. Moreover, shift-workers spent more of their time on rest days in bed, in an attempt to rectify a perceived sleep debt, this was emphasised more than LTPA, with a number of barriers being cited as reasons preventing shift-workers being more active. The thematic nature of such barriers could be categorized as logistical, personal and physical factors. As to whether these barriers were actual or perceived was beyond the capacity of study 1 and 2 to establish but should receive further attention in future research. Such studies (n>161; n>95 respectively), adopting multi-faceted research approaches, were important in gaining a unique insight into shift-workers physical activity habits and the potential associations of such habits with an individual's ability to cope with the demands of shift-work coupled with the inter-individual differences relating to participation in physical activity. Such multi-faceted and inter-related findings linking physical activity (energy expenditure) with shift-work are illustrated in Figure 8.1 adapted from Atkinson *et al.,* (2008). Whilst descriptive data collated from self-reported surveys, activity levels and emails should be interpreted with an element of caution, the results from the observational study provided the basis for further investigation into the potential associations between shift-work, physical activity, performance, vigilance and blood pressure. Study 1 was presented at the 13th Annual Conference for the European College of Sport Science and study 2 was presented at the 2007 Ergonomics Conference and has been published in the journal 'Ergonomics'.

In order to further explore the potential positive associations between physical activity and the health of a shift-working population i.e. the associations between physical activity, performance, vigilance and BP during a night/shift work it was necessary to design a specifically controlled experimental protocol. The experimental protocol was piloted on two separate occasions to establish the functionality of the study design. The experimental protocol was designed to explore the acute effects of night-work on healthy individuals who had previously never participated in non-diurnal activities. Both study 3 and 4 indicated a number of interesting findings relating to physiological and psychological variables. The data collated indicated clearly that prior exercise significantly lowers BP throughout an 8-hour night-shift. Therefore, raising the potential that regular low-intensity exercise has the potential to attenuate the longer-term increase in blood pressure in shift-workers. Moreover, the data clearly indicated that a single bout of evening exercise can improve sleepiness as well as mental and physical performance during a subsequent simulated night-shift, especially when food intake is smaller but more frequent during the shift. Performance was improved even though core body temperature was lower during the night-shift after exercise, adding weight to the notion that performance and temperature are not so tightly linked in certain chronobiological conditions. The studies provided a potential insight into favourable short and possibly long-term associations between exercise, BP, vigilance and performance within a shift-working population. Study 4 was presented at the 14th Annual Conference for the European College of Sport Science and has been printed in the American Journal of Hypertension.

Following on from the two descriptive based studies and the two laboratory based studies, a longitudinal field based randomised control trial designed to explore the longer term effects of physical activity and shift-work was undertaken. Study 5 examined the effectives of a 12-week individualised motivational interviewing intervention with a main focus on changing physical activity and eating habits. Whilst there were no significant findings relating to specific physiologic variables such as blood pressure over a 12-week intervention, there were trends for positive effects of the intervention beginning to emerge with blood pressure. Nonetheless, the intervention did make significant improvements in perceived stress and quality of life of shift-workers participating in the intervention. Suggesting that a long-term individualised health intervention could have the potential to prevent and alleviate problems relating to shift-work in which the shift-workers face on a daily basis.

8.4 Overall conclusions

Physical activity has been shown to have the potential to alleviate and prevent a number of health issues related to shift-work. However, shift-workers participation in physical activity appears to be hampered by actual and/or perceived barriers, and has clear participation patterns relating to gender and job content. Future cross-sectional studies of a larger scale across a greater variety of job type, coupled with more extensive interviews with a larger proportion of the shift-working population is essential to explore the complex associations between shift-work and participation in physical activity. More experimental research is required to determine the true extent of the short-term effects of an acute bout of low intensity exercise on both physiological and psychological parameters observed in chapters 5 and 6. Whilst it is clear that physical activity can positively influence a shift-workers 'life' (as seen in chapter 7) the use of sustainable and effective individualised health interventions must be explored more so and mechanisms effecting changes in shift-workers requires further attention. Shift-work is multi-factorial and therefore requires a multi-disciplined approach to gain a true understanding of the problems faced by shift-workers and to move towards a clear consensus on how to improve shift-workers health in both the short and long-term.

8.5 Study Specific Limitations and Delimitations

8.5.1 Relationships between leisure-time energy expenditure and individual coping strategies for shift-work and A survey of physical activity in shift-workers using a mixed-methods approach

The number of female participants was less than the number of male participants, which should be considered as a limitation. There was also an imbalance between the numbers of participants recruited from the six different occupations utilized within this study which could cause an element of bias. Significant variations in numbers recruited from the variety of occupations could have influenced any inter-occupational differences found between groups.

Furthermore, a greater variety of shift-workers with varied job content should have been included to allow for fuller and more consistent generalisations. The questionnaire utilised for data collection within this study was thirty-five pages long, since the length of a SSI questionnaire has previously been found to influence the participants' likelihood not only to complete the questionnaire but also to complete the questionnaire honestly and accurately. Therefore it is likely that participants perceived the SSI questionnaire to be too long and laborious. The type of LTPA questionnaire utilised could also have been reconsidered to focus on physical activity as a whole, and not just LTPA. Participants were asked to complete a seven-day diary at home away from the researcher. Therefore the accuracy of the information gained from the diary might not be as accurate or detailed.

Participants during this study were also asked to wear a wrist accelerometer for the full seven day period, with the accelerometer only being removed for anything bathing activities (these activities were to be recorded by each participant on their diary along with bedtimes and times in which they woke up). Therefore some data points collected from the participants could have been mistaken for rest periods when in fact the accelerometer was taken off and not put back on. The placement of the accelerometer could have influenced the data collected. The accelerometer was place on the dominant wrist of the participant. However, if a different accelerometer had been chosen and placed centrally (for example the hip), specific information elating to energy expenditure could have been examined, in conjunction with the valuable diary data obtained Email interviews were also utilised in a bid to gain an overarching holistic understanding of shift-workers physical activity patterns, barriers and other issues. However, in order for the interview data to be trustworthy and credible the participants had to be honest with their answers and opinions. Therefore it is possible that some answers retrieved from the email interviews were not honest, this would therefore influence the formulation of themes and would therefore have potentially affect the overall results relating to physical activity patterns and shift-workers. What is more, the number of email interviews were somewhat small and for qualitative data to have true impact upon the population of interest larger sample sizes are essential (Lewin *et al.*,2009). However, recruitment and engagement of participants was often problematic. Generally this was due to participants completing a number of questionnaires, interviews and other forms for work regarding satisfaction and health on a regular basis.

8.5.3 The effects of prior exercise on blood pressure during simulated night-work with different meal schedules and Effects of a 1-hour bout of moderate-intensity exercise on vigilance and performance during a subsequent period of night-work

There were a number of limitations in both of the abovementioned studies. Initially, the proposed four-simulated night shifts with at least a seven-day wash out period seemed to be appropriate. However, a few participants reacted unfavourably to the simulated night work and therefore only completed two trails. Whether this be due to acute physiological or psychological (i.e. the acute effects of sleep deprivation) problems experienced during the simulated night work or whether the attrition rate could be attributed to low motivation, normal 'diurnal' commitments that could not be rearranged to fit in with the 'unsocialable' hours in which participants were expected to participate in it is not clear. Perhaps the order and shear number of tests implemented in the studies could have been streamlined, which would have prevented researchers moving from test to test at a high rate ensuring that the temporal position of data collated was comparable during all tests. Working at such high rates could have potentially caused errors. This could have been overcome with a larger research team and this should be considered for future research. Whilst participants were asked to follow a strict 48 h physical activity ban and to follow the exact diet in which they had recorded on the first trial, this was self-regulated and therefore uncertainty around compliance to such requirements is a real concern. The use of subjective measures might also be reconsidered in future research since subjective measures are less reliable in comparison to objective methods and can often cause bias to occur. The fitness levels of the participants were somewhat high and this could have inherently influenced the final results of the study. Future research should recruit participants with low levels of fitness to establish if similar affects are observed in such a population. The imbalanced nature of the studies in relation to the number of participants and lack of gender split is something that also needs to be addressed, and an attempt to engage a greater number of participants is always desirable.

8.5.4 A randomized-controlled trial of the effects of motivational interviewing on shift-worker's physical activity

Firstly, attrition was notably greater in the comparator than intervention group and hence a between group difference in the amount of missing data was present. Such a high attrition rate within the comparator group is in part related to the fact that participants did not want to be allocated into the control group and felt that they were missing an opportunity to receive an individualised MI session. Steps were taken to reassure participants in the comparator group that at the head of the study individuals would receive the opportunity to engage in MI sessions. Furthermore, the need for comparator data was expressed to participants prior to the engagement in the study itself, however, this did not seem to pacify a large group of participants who were fairly minimised and placed into the comparator group. Future researchers should attempt to provide small incentives (e.g., free cinema or theatre tickets) for all participants to remain within the study. Second, the study sample size was sufficient to provide adequate statistical power for the primary outcome of blood pressure; however statistical power may have been insufficient in regard to secondary outcome variables (e.g., physical activity level). Third both MI practitioners were extremely flexible and often participated in shift-work themselves in an attempt to meet participants for MI sessions. Nevertheless, the logistical demands on the MI practitioners and the somewhat indifferent communication often exhibited in large organisations made meeting for MI sessions extremely problematic. Which lead to a number of MI sessions being consistently rearranged. Forth, staff were often used to cover for colleagues who were absent and this would also affect MI sessions and meetings. Future, research should consider having a larger group of MI practitioners who would be accessible 24 h a day. Future research should also highlight the characteristics of non-respondents to the RCT in a bid to minimise bias and allow for some generalisations to occur. Furthermore, training of MI practitioners should follow a more rigorous structure, allowing enough time for practitioners to be assessed against a quality assurance scale (MITI scale). Therefore, ensuring the intervention implemented truly adheres to the philosophy of MI.

8.6 Future directions

The problems associated with shift-work are multi-faceted in nature and interrelate with each individual and their families. Consequently making the resultant issues related to shift-work extremely individualised and under explored. Therefore, a greater body of research examining the true issues relating to shift-work can only be gained if further 'mixed-method' studies are undertaken. This would not only reiterate the fundamental and constantly reoccurring problems of shift-work, but, involving the qualitative approaches to research would also allow for the exploration of shift-workers true thoughts and feelings related to shift-work and this would go someway to help shape future individualised heath interventions. A greater cross-section of shift-workers with a varied job content, demographic and socio-economic background also need to be studied as this would allow for true generalisations to be made, not only in relation to the key problems indicated by the shift-workers but also help researchers construct and implement a sound, effective and sustainable intervention that would truly benefit shift-workers and ultimately reduce absenteeism and increase work productivity for employers. Future, investigations should also focus on different types of physical activity, intensity, duration and realistic temporal positioning of activity with regards to both acute and chronic effects of physical activity on a shift-workers blood pressure, vigilance and performance. Furthermore, the exact mechanisms involved in any changes physical activity has on physiologic and psychological variables need to be explored and identified. Finally, additional research focusing on the implementation of individualised, non-structured/non-supervised health interventions with an aim to improve the health of shift-workers must be implemented. Researchers should consider the application and implications of such interventions from a macro (organisational) level and micro level (individual) to ensure interventions are suitable and sustainable.

Chapter 9

References and Appendices

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STANDARD SHIFTWORK INDEX

We are an independent research team engaged on a research programme looking at the problems which people may experience as a result of working shifts. We have no particular "axe to grind" within an organisation; our primary aim being to help identify and reduce the problems experienced by individual shiftworkers.

Please note that any information you provide in the questionnaire will be treated in the strictest confidence and will not be divulged to anyone. No individual will be identified in connection with any of the research findings. We are primarily concerned with the information obtained from groups of shiftworkers.

Throughout this questionnaire the terms "Morning", "Afternoon" and "Night" shifts are used. Please ignore the fact that these terms may differ from the ones used in your organisation. For example, you may call your "Morning" shift an "Early" one, while your "Afternoon" shift may be referred to as a "Late", "Evening" or "Swing" shift.

It is possible that completing this questionnaire may draw your attention to problems you experience as a result of shiftwork. If you are worried that these are serious we would advise you to contact your GP.

If there is a loose page inserted relating to your particular job, please make sure that you complete it, and return it to us together with the main questionnaire in the prepaid envelope provided. Thank you for your co-operation.

Developed and modified by the:

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1 . Your General Biographical Information

Please answer the following questions as accurately as possible. Please note that the information you give will be treated in strictest confidence.

1.1 Today's Date:

1.2 Age: ____________________

1.3 Sex: Female Male
(circle one)

1.4 What is your weight? (Kilograms)

------------ kg or ------------ Stones ....lbs

1.5 What is your height? (Metres)

-------------m or ------------ft-------- inches

1.6 Job Title:............................

1.7 Place of work:............................ (e.g. Ormskirk)

Your Domestic Situation

1.5 Are you: *(tick one)*

(a) Married/Living with a partner __________
(b) Separated/Divorced __________
(c) Widowed __________
(d) Single __________

1.6 On average, how many hours per week does your partner work in paid employment? __________ hours

1.7 What is your partner's usual work pattern?
(tick one)

(a) Daytime - no shifts __________
(b) Rotating shifts with nights __________
(c) Rotating shifts without nights __________
(d) Permanent nights __________
(e) Other .... __________
(please specify)

1.8 How many persons in your household are in each of the following age groups (excluding yourself)?

(a) 0 to 5 years __________
(b) 6 to 12 years __________
(c) 13 to 18 years __________
(d) 19 to 24 years __________
(e) 25 to 60 years __________
(f) 60 years + __________

1.9 How many of these need looking after by **you**? __________

1.10 How long have you worked in total ? __________ years

2. Your Eating Habits

2.1 How many main meals (i.e. breakfast, lunch, dinner, or any occasions where you consume a number (2 or more) items of food together) do you normally eat per day? (please tick)

	One meal per day	Two meals per day	Three meals per day	Changes from day to day
Morning shift	☐1	☐2	☐3	☐4
Afternoon shift	☐1	☐2	☐3	☐4
Night shift	☐1	☐2	☐3	☐4
Day Off	☐1	☐2	☐3	☐4

2.2 How many snacks (i.e. eating occasions were you would consume only one food item) do you normally eat per day? (please circle)

	One snack per day	Two snacks per day	Three snacks per day	More than three snacks per day	Changes from day to day
Morning shift	1	2	3	4	5
Afternoon shift	1	2	3	4	5
Night shift	1	2	3	4	5
Day Off	1	2	3	4	5

2.3 Over consecutive days on each shift would you say that you ate breakfast, lunch and dinner: (please tick)

	At about the same time each day	At different times each day	At the same time as your day off
Morning Shift	☐1	☐2	☐3
Afternoon Shift	☐1	☐2	☐3
Night Shift	☐1	☐2	☐3
Day Off	☐1	☐2	☐3

2.4 To what extent to do feel working a morning, afternoon or night shift interferes with your eating habits (please tick)

	Interferes Extremely	Interferes	Interferes a little	Does not interfere
Morning shift	☐ 1	☐ 2	☐ 3	☐ 4
Afternoon Shift	☐ 1	☐ 2	☐ 3	☐ 4
Night shift	☐ 1	☐ 2	☐ 3	☐ 4

2.5 In my work place I have access to: (please tick all that apply)

- Refrigerator ☐
- Microwave ☐
- Oven ☐
- Toaster ☐
- Kettle ☐
- Kitchen Utensils ☐

2.6 I would be most likely to use: (please tick all that apply)

- Refrigerator ☐
- Microwave ☐
- Oven ☐
- Toaster ☐
- Kettle ☐
- Kitchen Utensils ☐

2.7 Do you have a canteen facility at your work place Yes ☐ 1 No ☐ 2 (go to question 2.9)

2.8 How often do you use your work canteen facilities on each of your shifts? If your canteen service is not available on some of your shifts please indicate in the final columns if you would use it if it were available? (please circle)

	Almost never	**Rarely**	**Sometimes**	**Frequently**	**Almost always**	**Not open but would like to use**	**Not open but would not use anyway**
Morning shift	1	2	3	4	5	6	7
Afternoon shift	1	2	3	4	5	6	7
Night shift	1	2	3	4	5	6	7

2.9 How often do you eat takeaway foods? (please circle)

	Almost never	**Rarely**	**Sometimes**	**Frequently**	**Almost always**
Morning shifts	1	2	3	4	5
Afternoon shift	1	2	3	4	5
Night shift	1	2	3	4	5
Day off	1	2	3	4	5

2.10 How often do you use vending machines during your shifts?

	Almost never	**Rarely**	**Sometimes**	**Frequently**	**Almost always**
Morning shifts	1	2	3	4	5
Afternoon shift	1	2	3	4	5
Night shift	1	2	3	4	5

2.11 The following is a list of foods that you might buy from a vending machine. If you consume any of these please indicate this by **writing the number of times per day** on each of your shifts you would normally consume this food item in the box provided?

	Morning shift	Afternoon shift	Night shift
Carbonated drinks			
Diet carbonated drinks			
Hot caffeinated drinks e.g. tea, coffee			
Packet of crisps			
Bar chocolate			
Packet of sweets e.g. boiled or jelly sweets			
Pack of sandwiches			
Pack of biscuits			
Cake portion			

2.12 Are you satisfied with the amount of time your shifts leaves you for: (please circle)

	Not at all satisfied	Satisfied	Somewhat satisfied	Very satisfied	Extremely satisfied
Food shopping	1	2	3	4	5
Food preparation	1	2	3	4	5
Eating with family	1	2	3	4	5
Eating out	1	2	3	4	5

2.13 How satisfied are you in general with your eating habits since beginning shift work and before you started shift work? (please circle)

	Not at all satisfied	Satisfied	Somewhat satisfied	Very Satisfied	Extremely Satisfied
Before starting shift work in your career	1	2	3	4	5
Since starting shift work in your career	1	2	3	4	5

2.14 To what extent do the following statements describe your diet **before you began to work shifts**? (please tick)

	Hardly ever	Now and again	Quite often	Most of the time
Before starting shift work I made a conscious effort to eat a healthy diet	☐ 1	☐ 2	☐ 3	☐ 4
Before starting shift work I tried to keep the amount of fat I eat to a healthy amount	☐ 1	☐ 2	☐ 3	☐ 4

2.15 To what extent do the following statements describe your current diet (i.e. since starting shift work)? (please tick)

	Hardly ever	Now and again	Quite often	Most of the time
I make a conscious effort to eat a healthy diet	☐ 1	☐ 2	☐ 3	☐ 4
I try to keep the amount of fat I eat to a healthy amount	☐ 1	☐ 2	☐ 3	☐ 4

2.16 On a scale of 1 to 5 how healthy would you rate **your diet** since starting shift work and your diet prior to starting shift work?

	Very Healthy				Very Unhealthy
Before starting shift work	1	2	3	4	5
Since starting shift work	1	2	3	4	5

2.17	Before starting shift work	Since starting shift work
On average, how many cigarettes do you smoke per week?	☐	☐
On average, how many units of alcohol have you drunk per week? (e.g. 1 unit = 1/2 pint lager/bitter **or** 1 glass of wine **or** 1 measure of spirit)	☐	☐
On average, how many cups of caffeinated coffee/ tea/ have you drunk each day?	☐	☐

2.18 On a scale of 1 to 5 how would you rate **your overall health** since starting shift work and prior to starting shift work?

	Very Healthy				**Very Unhealthy**
Before starting shift work	1	2	3	4	5
Since starting shift work	1	2	3	4	5

2.19 Listed below is a number of food items, for each of your shift days and your day off, please indicate if you normally eat them by **specifying the number of portions** (based on those suggested) you would normally consume in each 24 hr period by entering a number in the space provided.

For example if you consume two slices of bread during the day on which you do your evening shift you would fill in the form as follows:

		Number of portions in 24 hrs covering:			
Food Item	**Portion Size**	**Morning Shift**	**Evening Shift**	**Night Shift**	**Day Off**
White bread	1 large slice		2		

To help you to visualise some of the suggested portion sizes you may like to refer to the guidelines below. If you feel you eat less than the portion size suggested and on just one occasion in the day then you may fill in ½ or ¼ for the number of portions

fist = 1 cup

palm = 3 oz.

To make this task easier you may want to fill this in over the next few days as you experience each of your different shifts and day off. REMEMBER PLEASE **DO NOT TICK** BUT **INPUT THE NUMBER OF PORTIONS** OF EACH FOOD ITEM THAT YOU CONSUME

		Number of portions in 24 hrs:			
Food Item	**Portion Size**	**Morning Shift**	**Evening Shift**	**Night Shift**	**Day Off**
Breakfast Item					
Corn Flakes	40g medium bowl				
Frosties					
Museli					
Porridge	40g medium bowl				
Allbran					
Coco pops					
Shredded Wheat					
Other wholegrain breakfast cereal					
Other breakfast cereal					
Bread					
White bread	1 large slice (plain or toasted)				
Wholemeal bread					
Butter & Margarine					
Butter	2 tsp				
Polyunsaturated spread eg flora					

		Number of portions in 24 hrs:			
Food Item	**Portion Size**	**Morning Shift**	**Evening Shift**	**Night Shift**	**Day Off**
Hard margarine eg stork, Echo					
Biscuits					
Plain digestive	1 biscuit				
KitKat	1 two finger biscuit				
Penguin	1 biscuit				
Rich tea biscuit					
Other chocolate coated biscuit					
Other plain biscuit	1 biscuit				
Buns, Cakes & Pastries					
Danish Pastry	1 small				
Doughnut	1 medium				
Croissants	1medium				
Fruit Cake	1 piece				
Custard tart	1 slice of whole pie approx 8 "				
Sweets & Chocolate					
Milk Chocolate bar (Cadburys)	1 standard bar				
Snickers bar	1 standard bar				

		Number of portions in 24 hrs:			
Food Item	**Portion Size**	**Morning Shift**	**Evening Shift**	**Night Shift**	**Day Off**
Rolos	1 packet				
Other chocolate bar or packet of chocolates	1 bar/packet				
Jelly beans	10 sweets				
Jelly Gums eg wine gums etc	10 sweets				
Boiled sweets (eg pear drop)	1 sweet				
Sugar					
White sugar in tea or coffee etc	1 tsp				
White sugar on cereal or any other food	1 tsp				
Potatoes					
Chips	Average portion 175g				
Boiled potatoes	1/2 cup				
Baked potato	1 medium potato				
Any packet of Walkers crisps	1 packet				
Vegetables					
Baked beans	1 cup				
Green beans	1 cup				
Peas	1/2 cup				

		Number of portions in 24 hrs:			
Food Item	**Portion Size**	**Morning Shift**	**Evening Shift**	**Night Shift**	**Day Off**
Carrots	1 cup sliced				
Broccoli	1 cup of brocolli heads (florets)				
Cabbage	1/2 cup shredded cabbage				
Mixed frozen vegetables	1/2 cup				
Other vegetables	1 cup				

Fruit

Apples	1 medium				
Oranges	1 large				
Pears	1 medium				
Bananas	1 medium				
Other fresh fruit	1 medium				

Meat

Sirloin Steak	3 oz				
Lamb chop	3 oz				
Chicken breast (no skin)	3 oz				
Burgers	1 large burger with bun				
Sausages	1 sausage				

		Number of portions in 24 hrs:			
Food Item	**Portion Size**	**Morning Shift**	**Evening Shift**	**Night Shift**	**Day Off**
Cornish pasty	1 large pasty				
Sausage Roll	1 large				
Any other pasty	1 large portion				

Fish

Cod	1 fillet				
Haddock	1 fillet				
Tuna canned	1 can				
Salmon	1 fillet				
Battered or coated fish	1 fillet				

Pasta Rice & Pizza

Pasta	1 medium 128g				
White rice	1 cup				
Pizza	Whole 9" pizza				

Dairy Products

Boiled Egg	1 large				
Fried Egg					
Scrambled Egg					

		Number of portions in 24 hrs:			
Food Item	**Portion Size**	**Morning Shift**	**Evening Shift**	**Night Shift**	**Day Off**
Whole milk	1 cup				
Semi skimmed milk	1 cup				
Skimmed millk	1 cup				
Yogurt	1 cup				
Cheddar cheese	1 slice				
Cheshire Cheese	1 slice				
Other hard cheese	1 slice				
Cream cheese	1/3 small pack				
Low fat cottage cheese	1 cup				

Drinks

Carbonated soft drink (not calorie reduced)	1 can				
Water	1 cup				
Orange juice from concentrate (or other fruit juice)	1 cup				

3. Physical & Leisure Activity Questionnaire:

3.1 On a scale of 1-5 how would you rate your present level of fitness compared to other people of your age? (1 is the lowest rating and 5 is the highest rating, please circle appropriately)

1 2 3 4 5

3.2 Are you satisfied with the amount of time your shift system leaves you for: (please circle appropriately)

		Not at all Satisfied		Some-what satisfied		Very much satisfied
(a)	individual hobbies and/or sport activities	1	2	3	4	5
(b)	group/team hobbies or sport activities	1	2	3	4	5
(c)	your partner	1	2	3	4	5
(d)	your close family	1	2	3	4	5
(e)	friends and relations	1	2	3	4	5
(f)	cultural events (cinema, theatre, concert) /evenings out	1	2	3	4	5
(g)	joining social organisations	1	2	3	4	5
(h)	adult education classes	1	2	3	4	5
(i)	your children	1	2	3	4	5
(j)	going to bank or post office	1	2	3	4	5
(k)	going to dentist/doctor/chemist	1	2	3	4	5
(l)	having a tradesman do some work on your house	1	2	3	4	5
(m)	shopping (daily goods)	1	2	3	4	5
(n)	shopping (clothes, furniture, etc)	1	2	3	4	5
(o)	week-end outings	1	2	3	4	5
(p)	family outings	1	2	3	4	5
(q)	yourself	1	2	3	4	5
(r)	domestic tasks	1	2	3	4	5

3.3 In general how much does your shift system interfere with the sort of things you **would like to do** in your leisure time (e.g. sport activities, hobbies, etc.)?	1	2	3	4	5
3.4 In general how much does your shift system interfere with the **domestic things you have to do** in your time off work (e.g. domestic tasks, looking after children, etc.)?	1	2	3	4	5
3.5 In general how much does your shift system interfere with the **non-domestic things you have to do** in your time off work (e.g. going to doctor, library, bank, hairdresser, etc.)?	1	2	3	4	5

3.6 Have the last two weeks (14 days) been typical in terms of the types and amounts of your leisure time physical activity?

Yes ☐ No ☐

3.7 Please indicate from the list of physical activities below whether you have taken-part in the activity during the previous 14 days, if so how long for, how many times and what time of day you did the activity: Please see example below:

Example:

Activity	Yes	Duration (mins)	Frequency	Time of Day at start of activity
Aerobic Dancing (Intense)	√	60	3	16:00

Please complete table below as indicated as above:

Activity	Yes	Duration	Frequency	Time of Day at start of activity
Boxing (in ring, sparring, boxercise etc)				
Basketball				
Circuit training				
Hill climbing (with back pack)				
Cycling (race)				
Gardening				
Hockey				
Jogging				
Judo				
Running: 11.5 min/mile 9 min/mile 7.5 min/mile				
Soccer				
Squash				
Aerobics				
Badminton				
Ballet				
Cricket				
Cycling (leisurely, 9.4 mph) (including cycling to work)				
Dancing				
Hill climbing (no load)				
Ice skating				
Karate				
Roller skating				

Activity	Yes	Duration	Frequency	Time of Day at start of activity
Tennis				
Walking: 4.5 min/mile (including walking to and from work)				
Soccer				
Weight lifting/training				
Bowls				
Golf				
Horse riding				
Table Tennis				
Sailing				
Volleyball				
Window Cleaning				
Athletics (track & field)				
Bowling (ten pin)				
Canoing				
Caving/potholing				
Fencing				
Five-a-side Football				
Gymnastics				
Lacrosse				
Mountain Climbing				
Netball				
Recreational Swimming				
Trampolining				

3.8 In the last 14 days on how many days did you engage in housework?

------------days

3.9 During the last 2 weeks, how long on average did you spend sitting down to the nearest hour (this includes time sitting at a desk, reading, watching TV etc)?

3.10 How often in the last 14 days did you travel to a required destination by Car/Bus/Train?

3.11 Would you say that, you were more physically active before you started to work in a job that required you to work shifts?

Yes ☐ No ☐

3.12 Would you like to be more physical active?

Yes ☐ No ☐

3.13 Would you prefer to participate in physical activity/exercise:

Individually ☐ With friends/family/group ☐ Both ☐

3.14 If you had a physical activity option such as cheap gym membership, a walking club etc provided to you by your work place would you be more likely to engage and adhere to physical activity?

Yes ☐ No ☐

3.15 Do you currently adhere to a physical activity/exercise regime? (either self-imposed or tailored for you for example by a gym instructor)?

Yes ☐ No ☐

3.16 Have you ever started an exercise/physical activity programme in the past?

Yes ☐ No ☐

3.17 If you have answered yes to question 3.16 highlighted below which factors contributed to you ceasing your involvement in this programme:

a.) Time factors: ☐

b.) Did fit round my shift pattern ☐

c.) Didn't enjoy it ☐

d.) Didn't meet my needs ☐

e.) Too expensive ☐

f.) Boring ☐

g.) Social and domestic factors ☐

4. Barriers to a Healthy Lifestyle:

4.1 On a scale of 1-5 (with 1 being an important factor and 5 being not a factor at all) indicate which barriers prevent or make it hard for you to have a healthy lifestyle:

a) Time restraints	1	2	3	4	5
b) Lack of interest/motivation	1	2	3	4	5
c) Lack of knowledge/Skill	1	2	3	4	5
d) Social influence	1	2	3	4	5
e) Work influence	1	2	3	4	5
f) Lack of encouragement and support	1	2	3	4	5
g) Lack of facilities/resources	1	2	3	4	5
h) Lack of energy	1	2	3	4	5
i) Not wanting to change behaviour	1	2	3	4	5
j) Travel	1	2	3	4	5
k) Weather	1	2	3	4	5

5. Shift Pattern/Schedule/Details

		Extremely unsupp-ortive	**Fairly unsupp-ortive**	**Quite indiff-erent**	**Fairly support-ive**	**Extremely support-ive**
5.1	How does your partner feel about **you** working shifts? *(Circle one)*	1	2	3	4	5

5.2 How long have you worked in your **present** shift system? ________ years ________ months

5.3 How long **altogether** have you been working shifts? ________ years ________ months

5.4 On average, how many hours do you work each week excluding overtime? ________ hours ________ minutes

5.5 On average, how many hours **paid** overtime do you work each week? ________ hours ________ minutes

5.6 On average, how many hours unpaid overtime do you work each week, (e.g. over-run of shifts)? ________ hours ________ minutes

5.7 Do you have a second paid job in addition to your main one? *(tick one)* ________ yes ________ no

5.8 If you have taken a career break (or breaks), how long was this for in total? ________ years ________ months

Your Shift Details

5.9 On average, how long does it take you to travel to and from work (please write down your overall travelling time below)

(a) Morning Shift ________ mins ________

(b) Afternoon Shift ________ mins ________

(c) Night Shift ________ mins ________

____

5.10 Use the numbers 1 - 5 to rate **your** workload in comparison to the **average** workload of other people performing a similar job in other parts of your organisation:

Where: 1 = Extremely light
2 = Quite light
3 = About the same
4 = Quite heavy
5 = Extremely heavy
(Insert one number for each type of workload on each shift)

	Morning	Afternoon	Night
(a) Physical workload	________	________	________
(b) Mental workload	________	________	________
(c) Time pressures	________	________	________
(d) Emotional stress	________	________	________

5.11 What are your main reasons for working shifts?
(please circle one number for each)

	Not a reason for me		Partly a reason for me		Very much a reason for me
(a) It is part of the job	1	2	3	4	5
(b) It was the only job available	1	2	3	4	5
(c) More convenient for my domestic responsibilities	1	2	3	4	5
(d) Higher rates of pay	1	2	3	4	5
(e) Other .... *(please give your reasons)*	1	2	3	4	5

5.12 All other things being equal, would you prefer to give up working shifts and get a day-time job without shifts? *(circle one)*

Definitely not	Probably not	Maybe	Probably yes	Definitely yes
1	2	3	4	5

5.13 Do you feel that overall the advantages of your shift system outweigh the disadvantages

Definitely not	Probably not	Maybe	Probably yes	Definitely yes
1	2	3	4	5

5.14 The following questions relate to **general job satisfaction**, and **not** to your satisfaction with your shift system. Please circle the appropriate answer for each question.

		Disagree strongly	Disagree	Disagree slightly	Neutral	Agree slightly	Agree	Agree strongly
(a)	Generally speaking, I am very satisfied with this job	1	2	3	4	5	6	7
(b)	I frequently think of quitting this job	1	2	3	4	5	6	7
(c)	I am generally satisfied with the kind of work I do in this job	1	2	3	4	5	6	7
(d)	Most people on this job are very satisfied with the job	1	2	3	4	5	6	7
(e)	People on this job often think of quitting	1	2	3	4	5	6	7

6. Coping

Shiftwork affects many people in a variety of ways, for example in terms of their social and domestic life. Consequently shiftworkers tend to cope with the effects of shiftwork in different ways and to different degrees. Below is a list of 8 different strategies people can use to cope with problems they experience.

In relation to the different problem areas stated below, please **indicate the extent** to which you use (or have used) **each** of the coping strategies listed.

The problem areas relate to:

your **social life**	e.g. going out, visiting friends, etc.
your **domestic life**	e.g. domestic tasks, jobs around the house, childcare, etc.
the **sleep** you get	e.g. problems falling asleep, disturbed sleep, etc.
your **job**	e.g. organisation of work, job performance, etc.

It might help to actually think of an event concerning each of the areas. For sleep an example could be: difficulty with sleeping during the day, because of light and noise.

For example, to what extent do you:

- work on solving the problems in this situation, e.g. darken room. If you don't do that at all you circle 1.
- re-organise the way you look at the situation, e.g. think that it is only three more nightshifts. If you do that quite a bit you circle 4.

	Not used	**Used a little**	**Used some-what**	**Used quite a bit**	**Used a great deal**
6.1 To what extent do you use the following strategies when you have problems with your **social life** caused by working shifts?					
(a) I work on solving the problems in the situation	1	2	3	4	5
(b) I re-organize the way I look at the situation, so things don't look so bad	1	2	3	4	5
(c) I let my emotions out	1	2	3	4	5
(d) I talk to someone about how I am feeling	1	2	3	4	5
(e) I avoid thinking or doing anything about the situation	1	2	3	4	5
(f) I wish the situation would go away or somehow be over with	1	2	3	4	5
(g) I criticize myself for what is happening	1	2	3	4	5
(h) I spend more time alone	1	2	3	4	5

		Not used	Used a little	Used some-what	Used quite a bit	Used a great deal
6.2	To what extent do you use the following strategies when you have problems with your **domestic life** caused by working shifts?					
(a)	I work on solving the problems in the situation	1	2	3	4	5
(b)	I re-organize the way I look at the situation, so things don't look so bad	1	2	3	4	5
(c)	I let my emotions out	1	2	3	4	5
(d)	I talk to some-one about how I am feeling	1	2	3	4	5
(e)	I avoid thinking or doing anything about the situation	1	2	3	4	5
(f)	I wish the situation would go away or somehow be over with	1	2	3	4	5
(g)	I criticize myself for what is happening	1	2	3	4	5
(h)	I spend more time alone	1	2	3	4	5

		Not used	Used a little	Used some-what	Used quite a bit	Used a great deal
6.3	To what extent do you use the following strategies when you have problems with **your sleep** caused by working shifts?					
(a)	I work on solving the problems in the situation	1	2	3	4	5
(b)	I re-organize the way I look at the situation, so things do not look so bad	1	2	3	4	5
(c)	I let my emotions out	1	2	3	4	5
(d)	I talk to some-one about how I am feeling	1	2	3	4	5
(e)	I avoid thinking or doing anything about the situation	1	2	3	4	5
(f)	I wish the situation would go away or somehow be over with	1	2	3	4	5
(g)	I criticize myself for what is happening	1	2	3	4	5
(h)	I spend more time alone	1	2	3	4	5

		Not used	Used a little	Used some-what	Used quite a bit	Used a great deal
6.4	To what extent do you use the following strategies when you have problems with the way you perform **your work** caused by working shifts?					
	(a) I work on solving the problems in the situation	1	2	3	4	5
	(b) I re-organize the way I look at the situation, so things do not look so bad	1	2	3	4	5
	(c) I let my emotions out	1	2	3	4	5
	(d) I talk to some-one about how I am feeling	1	2	3	4	5
	(e) I avoid thinking or doing anything about the situation	1	2	3	4	5
	(f) I wish the situation would go away or somehow be over with	1	2	3	4	5
	(g) I criticize myself for what is happening	1	2	3	4	5
	(h) I spend more time alone	1	2	3	4	5

6.5 In general, to what extent does working shifts cause you problems with:

	Never		Somewhat		Always
(a) sleep	1	2	3	4	5
(b) social life	1	2	3	4	5
(c) domestic life	1	2	3	4	5
(d) work performance	1	2	3	4	5

6.6 To what extent **do you think there are organisational** problems at your work (e.g. the way your work is organised, staffing is arranged, or management decisions are implemented)?

Not at all		Somewhat		Very much so
1	2	3	4	5

6.7 Do you find it difficult to cope with these problems?

No		Sometimes		Yes
1	2	3	4	5

7. Your Sleep and Fatigue

7.1 At what time do you normally fall asleep and wake up at the following points within your shift system? **Please note that, depending on your shift system, some of the sleeps listed may be the same as one another. If so, please indicate this by writing "same as e"; "same as g", etc.** Please use 24h time (e.g. 22:30) or clearly indicate "am" or "pm".

		FALL ASLEEP	WAKE UP
EARLY SHIFT			
(a)	Before your first morning shift	________	________
(b)	Between two successive morning shifts	________	________
(c)	After your last morning shift	________	________
LATE SHIFT			
(d)	Before your first afternoon shift	________	________
(e)	Between two successive afternoon shifts	________	________
(f)	After your last afternoon shift	________	________
NIGHT SHIFT			
(g)	Before your first night shift	________	________
(h)	Between two successive night shifts	________	________
(i)	After your last night shift	________	________
DAY OFF			
(j)	Before your first day off	________	________
(k)	Between two successive days off	________	________
(l)	After your last day off	________	________

7.2 If you normally take a nap/naps in addition to your main sleep, either at work or at home, at what time do you take it/them?

(a)	On morning shifts	from	________	to	________	and	from	________	to	________
(b)	On afternoon shifts	from	________	to	________	and	from	________	to	________
(c)	On night shifts	from	________	to	________	and	from	________	to	________
(d)	On days off	from	________	to	________	and	from	________	to	________

7.3 How many hours sleep do you feel you usually need per day, irrespective of which shift you are on?

________ hours ________ minutes

7.4 How do you feel about the amount of sleep you normally get? *(Circle one number for each)*

		Nowhere near enough	Could do with a lot more	Could do with a bit more	Get the right amount	Get plenty
(a)	Between successive morning shifts	1	2	3	4	5
(b)	Between successive afternoon shifts	1	2	3	4	5
(c)	Between successive night shifts	1	2	3	4	5
(d)	Between successive days off	1	2	3	4	5

6.5 How well do you normally sleep? *(Circle one number for each)*

		Extre-mely badly	Quite badly	Moder-ately well	Quite well	Extre-mely well
(a)	Between successive morning shifts	1	2	3	4	5
(b)	Between successive afternoon shifts	1	2	3	4	5
(c)	Between successive night shifts	1	2	3	4	5
(d)	Between successive days off	1	2	3	4	5

7.6 How rested do you normally feel after sleep? *(Circle one number for each)*

		Definite-ly not rested	Not very rested	Moder-ately rested	Quite rested	Extre-mely rested
(a)	Between successive morning shifts	1	2	3	4	5
(b)	Between successive afternoon shifts	1	2	3	4	5
(c)	Between successive night shifts	1	2	3	4	5
(d)	Between successive days off	1	2	3	4	5

7.7 Do you ever wake up earlier than you intended? *(Circle one number for each)*

		Almost never	Rarely	Some-times	Frequ-ently	Almost always
(a)	Between successive morning shifts	1	2	3	4	5
(b)	Between successive afternoon shifts	1	2	3	4	5
(c)	Between successive night shifts	1	2	3	4	5
(d)	Between successive days off	1	2	3	4	5

7.8 Do you have difficulty in falling asleep? *(Circle one number for each)*

		Almost never	Rarely	Some-times	Frequ-ently	Almost always
(a)	Between successive morning shifts	1	2	3	4	5
(b)	Between successive afternoon shifts	1	2	3	4	5
(c)	Between successive night shifts	1	2	3	4	5
(d)	Between successive days off	1	2	3	4	5

7.9 Do you take sleeping pills? *(Circle one number for each)*

		Almost never	Rarely	Some-times	Frequ-ently	Almost always
(a)	Between successive morning shifts	1	2	3	4	5
(b)	Between successive afternoon shifts	1	2	3	4	5
(c)	Between successive night shifts	1	2	3	4	5
(d)	Between successive days off	1	2	3	4	5

7.10 Do you use alcohol to help you to sleep? *(Circle one number for each)*

		Almost never	Rarely	Some-times	Frequ-ently	Almost always
(a)	Between successive morning shifts	1	2	3	4	5
(b)	Between successive afternoon shifts	1	2	3	4	5
(c)	Between successive night shifts	1	2	3	4	5
(d)	Between successive days off	1	2	3	4	5

7.11 Do you ever feel tired on: *(Circle one number for each)*

		Almost never	Rarely	Some-times	Frequ-ently	Almost always
(a)	Morning shifts	1	2	3	4	5
(b)	Afternoon shifts	1	2	3	4	5
(c)	Night shifts	1	2	3	4	5
(d)	Days off	1	2	3	4	5

7.12 The following items relate to how tired or energetic **you generally feel**, irrespective of whether you have had enough sleep or have been working very hard. Some people appear to "suffer" from permanent tiredness, even on rest days and holidays, while others seem to have limitless energy. Please indicate the degree to which the following statements apply to your own normal feelings. *(Circle one number for each).*

		Not at all		Some-what		Very much so
(a)	I generally feel I have plenty of energy	1	2	3	4	5
(b)	I usually feel drained	1	2	3	4	5
(c)	I generally feel quite active	1	2	3	4	5
(d)	I feel tired most of the time	1	2	3	4	5
(e)	I generally feel full of vigour	1	2	3	4	5
(f)	I usually feel rather lethargic	1	2	3	4	5
(g)	I generally feel alert	1	2	3	4	5
(h)	I often feel exhausted	1	2	3	4	5
(i)	I usually feel lively	1	2	3	4	5
(j)	I feel weary much of the time	1	2	3	4	5

8. Your Health and Well-Being

8.1 Please indicate how frequently you experience the following, by circling the appropriate number:

		Almost never	Quite seldom	Quite often	Almost always
(a)	How often is your appetite disturbed?	1	2	3	4
(b)	How often do you have to watch what you eat to avoid stomach upsets?	1	2	3	4
(c)	How often do you feel nauseous?	1	2	3	4
(d)	How often do you suffer from heartburn or stomach-ache?	1	2	3	4
(e)	How often do you complain of digestion difficulties?	1	2	3	4
(f)	How often do you suffer from bloated stomach or flatulence?	1	2	3	4
(g)	How often do you suffer from pain in your abdomen?	1	2	3	4
(h)	How often do you suffer from constipation or diarrhoea?	1	2	3	4
(i)	How often do you suffer from heart palpitations?	1	2	3	4

(j)	How often do you suffer from aches and pains in your chest?	1	2	3	4
(k)	How often do you suffer from dizziness?	1	2	3	4
(l)	How often do you suffer from sudden rushes of blood to your head?	1	2	3	4
(m)	Do you suffer from shortness of breath when climbing the stairs normally?	1	2	3	4
(n)	How often have you been told that you have high blood pressure?	1	2	3	4
(o)	Have you ever been aware of your heart beating irregularly?	1	2	3	4
(p)	Do you suffer from swollen feet?	1	2	3	4
(q)	How often do you feel "tight" in your chest?	1	2	3	4
(r)	Do you feel you have put on too much weight since beginning shiftwork?	1	2	3	4
(s)	Do you feel you have lost too much weight since beginning shiftwork?	1	2	3	4

8.2 Have you suffered from any of the following (diagnosed by your doctor)?

		Before starting shiftwork	**Since starting shiftwork**	**Never**
(a)	Chronic back pain	....	....	....
(b)	Gastritis, duodenitis	....	....	....
(c)	Gastric or duodenal ulcer	....	....	....
(d)	Gall stones	....	....	....
(e)	Colitis	....	....	....
(f)	Sinusitis, tonsillitis	....	....	....
(g)	Bronchial asthma	....	....	....
(h)	Angina	....	....	....
(i)	Severe heart attack (myocardial infarction)	....	....	....
(j)	High blood pressure	....	....	....
(k)	Cardiac arrhythmias	....	....	....
(l)	Hypercholesterolaemia	....	....	....
(m)	Diabetes	....	....	....
(n)	Cystitis	....	....	....
(o)	Kidney stones	....	....	....
(p)	Eczema	....	....	....
(q)	Chronic anxiety	....	....	....
(r)	Depression	....	....	....

(s)	Arthritis	....	....	....
(t)	Haemorrhoids	....	....	....
(u)	Varicose veins	....	....	....
(v)	Anaemia	....	....	....
(w)	Headaches	....	....	....
(x)	Others	....	....	....
	....	....	....	....

8.3 Have you taken any of the following medications for prolonged periods (more than three months)?

		Before starting shiftwork	**Since starting shifwork**	**Never**
(a)	Tranquillizers	....	....	....
(b)	Sleeping tablets	....	....	....
(c)	Anti-depressants	....	....	....
(d)	Antacids	....	....	....
(e)	Antispasmodics	....	....	....
(f)	Laxatives	....	....	....
(g)	Drugs to control high blood pressure	....	....	....
(h)	Diuretics	....	....	....
(i)	Heart medicines	....	....	....
(j)	Vasodilators	....	....	....
(k)	Bronchodilators	....	....	....
(l)	Vitamins, tonics	....	....	....
(m)	Pain killers	....	....	....
(n)	Steroids	....	....	....
(o)	Anti-inflammatory medicines	....	....	....
(p)	Hormones (except contraceptive pills)	....	....	....
(q)	Others	....	....	....
	....	....	....	....

8.4 If appropriate, and you are not taking a birth control pill, has your menstrual cycle been:

		Extremely irregular	**Fairly irregular**	**Fairly regular**	**Extremely regular**
(a)	Before starting shiftwork	1	2	3	4
(b)	Since starting shiftwork	1	2	3	4

8.5 The following questions deal with **how you have felt in general over the past few weeks.** Please circle the most appropriate answer for each question. Remember to concentrate on present and recent complaints, not those that you have had in the distant past.

Have you recently:

(a)	been able to concentrate on what you are doing?	Better than usual	Same as usual	Less than usual	Much less than usual
(b)	lost much sleep over worry?	Not at all	No more than usual	Rather more than usual	Much more than usual
(c)	felt that you are playing a useful part in things?	More so than usual	Same as usual	Less than usual	Much less than usual
(d)	felt capable of making decisions about things?	More so than usual	Same as usual	Less than usual	Much less than usual
(e)	felt constantly under strain?	Not at all	No more than usual	Rather more than usual	Much more than usual
(f)	felt you could not overcome your difficulties?	Not at all	No more than usual	Rather more than usual	Much more than usual
(g)	been able to enjoy your normal day to day activities?	More so than usual	Same as usual	Less than usual	Much less than usual
(h)	been able to face up to your problems?	More so than usual	Same as usual	Less than usual	Much less than usual
(i)	been feeling unhappy and depressed?	Not at all	No more than usual	Rather more than usual	Much more than usual
(j)	been losing confidence in yourself?	Not at all	No more than usual	Rather more than usual	Much more than usual
(k)	been thinking of yourself as a worthless person?	Not at all	No more than usual	Rather more than usual	Much more than usual
(l)	been feeling reasonably happy all things considered?	More so than usual	About the same	Less so than usual	Much less than usual

8.6 Below are listed some descriptions of **symptoms of anxiety.**

Please indicate the degree to which you **generally** or **typically** experience the symptom when **you are feeling anxious.**

		Not at all		**Some-what**		**Very much so**
(a)	I perspire	1	2	3	4	5
(b)	My heart beats faster	1	2	3	4	5
(c)	I worry too much over something that doesn't really matter	1	2	3	4	5
(d)	I feel jittery in my body	1	2	2	4	5
(e)	I imagine terrifying scenes	1	2	3	4	5
(f)	I get diarrhoea	1	2	3	4	5
(g)	I can't keep anxiety provoking pictures out of my mind	1	2	3	4	5
(h)	I feel tense in my stomach	1	2	3	4	5
(i)	Some unimportant thought runs through my mind and bothers me	1	2	3	4	5
(j)	I nervously pace	1	2	3	4	5
(k)	I feel like I am losing out on things because I can't make up my mind soon enough	1	2	3	4	5
(l)	I feel physically immobilised	1	2	3	4	5
(m)	I can't keep anxiety provoking thoughts out of my mind	1	2	3	4	5
(n)	I find it difficult to concentrate because of uncontrollable thoughts	1	2	3	4	5

9. The type of person you are

9.1 Please answer the following items according to your own preferences and not what you may be forced to do by your work schedule. For each question, circle the alternative that best indicates your preference relative to that of most people. When answering the questions, please refer only to your main sleep period, not to any nap or short sleep.

	Much later than most people	**A little later than most people**	**About the same as most people**	**A little earlier than most people**	**Much earlier than most people**
a. When would you prefer to take an important 3-h examination?	1	2	3	4	5
b. When would you prefer to get up?	1	2	3	4	5
c. When would you prefer to do some difficult mental work which needs full concentration?	1	2	3	4	5
d. When would you prefer to get up if you had a day off and nothing to do?	1	2	3	4	5
e. When would you prefer to have an important interview at which you need to be at your best?	1	2	3	4	5
f. When would you prefer to eat breakfast?	1	2	3	4	5
g. When would you prefer to exercise/engage in physical activity?	1	2	3	4	5

9.2 The following questions are concerned with your daily habits and preferences. Please indicate what you prefer to do, or can do, and not what you may be forced to do due to work commitments. Please work through the questions as quickly as possible.

	Almost never	**Seldom**	**Sometimes**	**Usually**	**Almost always**
a. Do you tend to need more sleep than other people?	1	2	3	4	5
b. If you had to do a certain job in the middle of the night do you think you could do it almost as easily as at a more normal time of day?	1	2	3	4	5
c. Do you find it difficult to 'wake up' properly if you are awoken at an unusual time?	1	2	3	4	5
d. Do you enjoy working at unusual times of the day or night?	1	2	3	4	5
e. If you go to bed very late do you need to sleep in the following morning?	1	2	3	4	5
f. If you have a lot to do can you stay up late to finish it off without feeling too tired?	1	2	3	4	5
g. Do you feel sleepy for a while after waking in the morning?	1	2	3	4	5
h. Do you find it as easy to work late at night as earlier in the day?	1	2	3	4	5

	Almost never	Seldom	Sometimes	Usually	Almost always
i. If you have to get up very early one morning do you tend to feel tired all day?	1	2	3	4	5
j. Would you be just as happy to do something in the middle of the night as during the day?	1	2	3	4	5
k. Do you rely on an alarm clock, or someone else, to wake you up in the morning?	1	2	3	4	5
l. Do you enjoy exercise/physical activity?	1	2	3	4	5
m. Do you enjoy exercise/physical activity at unusual times of the day?	1	2	3	4	5
n. If you go to bed very late would you feel too tired to engage in any physical activity/exercise the following day?	1	2	3	4	5
o. If you have to get up very early one morning would you tend to feel too tired to participate in physical activity/exercise during that day?	1	2	3	4	5