Shift Work:

An Occupational Health and Safety Hazard

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I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a degree at any tertiary education institution.

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ABSTRACT
Shift work is a major feature of modern work practices. It involves individuals working at times considered unconventional for most workers, such as at night. Although the community often benefits from such work practices, shift work can be hazardous, for both the workers and the community. The thesis reviews the main problems of shift work, especially when involving night work. These are: an increased risk for accidents and errors; increased sleepiness and fatigue due to difficulties sleeping; increased health problems; and disruption to family and social life. Strategies to limit the risk associated with these hazards are also reviewed, and include using knowledge of circadian principles to plan shift schedules, sleeping schedules and meal times; planned napping; consideration of the work environment; and newer techniques such as using bright lights and melatonin. While this information is known to the research community, it has not filtered down to many shift work workplaces and thus has had little if any positive effect on actual shift work practices. For a change in shift work practices to occur, the research knowledge must become available to every shift work workplace, as must some incentive or motivation to ensure that workplaces make the necessary changes. The Occupational Health and Safety (OHS) laws provide such a framework. Considering shift work as an OHS hazard would ensure that all shift work workplaces identified the hazards of shift work, conducted a risk assessment to identify the risk associated with the hazards, and then implemented the appropriate strategies, from the hierarchy of shift work hazard control measures, for both employers and employees, to fulfil their duty of care to minimise the risks. Considering shift work as an OHS issue would ensure that the research information was used as intended – to improve the safety, performance, and quality of life of all shift workers. The present thesis reviews the shift work research and introduces an OHS perspective as a method to manage shift work effectively.
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1. INTRODUCTION

With the advent of the electric light, work time was no longer restricted to daylight hours. The industrial revolution also saw an increase in working time, including the start of around-the-clock, or 24-hour continuous operations. Today we live in a ‘24-hour society’. Society demands that certain services be available 24 hours a day, such as provision of power and telecommunications, and police, fire and health care services. Other work places which have chosen to operate 24 hours a day have long production or start up/shut down times or expensive machinery making 24-hour operations highly desirable. Many commercial services such as supermarkets, petrol stations, and some restaurants are now available 24 hours a day. While many of these services originally expanded their operations to service the shift working population many non-shift workers now take advantage of these extended opening hours. The focus of this report is not on the provision of continuous services, but rather on the shift workers themselves.

1.1 What is Shift Work?

*Shift work* involves the alternation of teams of workers each working a certain “*shift*” (the hours at work), and who usually perform the same work duties so that operations can be continued for longer than allowed by any single worker. Shift work schedules necessarily require some workers to work for periods of time that are outside the usual 7am to 7pm day time work period, however the alternating sequence of shifts usually follows a predictable and regular pattern. Shift work should therefore not be confused with *irregular working hours*, where work times vary in an unpredictable, irregular manner (Thierry and Meijman, 1994).
Many different workplace schedules can be classified as “shift work”. As there are many different shift work schedules, researchers find it useful to discuss shift schedules according to certain features used in the design of shift schedules. Kogi (2001) uses four main features to classify a shift system. These are (1) whether a person's scheduled work hours rotate or change (such as daily or weekly), or are fixed to a fairly consistent schedule (i.e. working a permanent shift type), (2) whether or not night work hours are involved, (3) whether or not the work covers the 24-hour period, and (4) whether or not weekend work is involved (Kogi, 2001). Rotating rosters can be continuous, semicontinuous, or discontinuous (Thierry and Meijman, 1994).

Continuous systems involve four (sometimes five or six) crews, and operate over the entire night period and over the entire weekend. Semicontinuous systems, or three-shift systems, involve three (sometimes four) crews, and operate over the night period, but not over the entire weekend. Discontinuous systems, or two-shift systems, involve two (sometimes three) crews, and do not operate over the entire night, or over the weekend period.

While this is a major distinction between rotating work shift scheduling systems, there are two further features used to classify rotating shift systems (Thierry and Meijman, 1994). These are the direction of the rotation, and the speed of the rotation of shifts. Shift systems can either rotate in a forward, or clockwise direction (i.e. from working a morning schedule, followed days or weeks later by working on an evening schedule, followed by a night schedule) or in a backward, or counter-clockwise direction (i.e. working first the night shift, then the evening shift, followed by the morning shift). The speed of rotation for shift schedule changes can either be fast, such as one or two days.
on a particular shift before changing, or slow, such as working five or more days on the
one shift before changing to another shift type. These shift change characteristics and
the consequences they have for the shift workers are discussed in chapter 6.

1.2 Shift Work Statistics

Prevalence rates for the number of shift workers vary among countries, and also within
countries among different work sectors. Prevalence rates can also differ depending on
the definition used for ‘shift work’ (Thierry and Meijman, 1994). According to
Swanson (1999), data collected by the US Bureau of Labor Statistics suggest that 5% of
American workers work in the evening, 4% are permanent night workers or workers
with irregular hours, and another 4% are rotating shift workers. This totals 13% of the
American workforce, and was estimated to include about 15.5 million workers. The
sectors with the higher levels of shift work were those involved with public safety (e.g.
police, fire-fighters) and transport and public utility workers.

According to the Australian Bureau of Statistics (ABS), in November 2000, there were
7,715,600 employees aged 15 years and over in Australia. Fourteen percent (1,076,
100) of these employees had worked shift work in the four weeks prior to the survey.
“Shift work” was defined by the ABS as “a system of working whereby the daily hours
of operation at the place of employment are split into at least two set work periods
(shifts), for different groups of workers” (ABS, 2000, p. 11 summary). Shift workers
were more likely to be part-time compared to full-time employees (16% vs. 13%), and
were more likely to be male rather than female in both full-time (14% male vs. 11%
female) and part-time work (17% male vs. 16% female). The industries with the
highest proportion of shift workers were ‘mining’ (37%), ‘health and community
services’ (32%) and ‘accommodation, cafes and restaurants’ (31%). The occupation 
with the highest proportion of shift workers was the ‘intermediate production and 
transport workers’ (24%), which includes intermediate plant and machine operators, 
road and rail transport drivers, and other intermediate production and transport workers 
(ABS, 2000).

1.3 Working at Night

Working at night, the work shift that schedules a worker to work through the hours of 
darkness is hard on most people because of the timing of the shift. This is because 
night shift work requires working at a time when the body’s physiology is normally 
programmed to be asleep, and sleeping at a time when the body’s physiology is 
normally programmed to be awake. This does not allow for maximally effective 
performance at work or the most efficient sleep at home, resulting in sleep restriction 
and accumulating sleep loss. The two factors involved, the circadian rhythm system 
(i.e. the circadian process) and the homeostatic need for sleep (i.e. the homeostatic 
process), which are the two main processes underlying alertness and sleep regulation, 
are discussed in the following two sections.

1.3.1 The body clock – the circadian rhythm system

Our body physiology is different at night compared to what it is like during the day. 
The change occurs even before we go to bed, as a way of preparing the body and brain 
for sleep and recuperation across the night period. The body then alters its physiology 
in the morning and across the day so that the body is ready to be active and alert during 
the daylight period. This alteration in our internal physiology occurs due to an internal, 
or endogenous body clock.
A collection of nerve cells within the brain known as the Suprachiasmatic Nucleus (SCN) is thought to be the location of the body clock, which generates internal (endogenous) biological rhythms within the body. As many of these rhythms follow a 24-hour cycle (or period), they have been called circadian ("about a day") rhythms. The body generates circadian rhythms for core body temperature, hormone secretions, urine formation, pain threshold, and blood pressure to name a few. Circadian rhythms are also generated for some behaviours and performance on many tasks, including grip strength, short-term and long-term memory, and reaction time (Aschoff and Wever, 1981; Dunne, Roche, and Hartley, 1990; Folkard and Monk, 1980; Mills, Minors, and Waterhouse, 1974; Minors and Waterhouse, 1984, 1990; Weitzman et al., 1974). Circadian rhythms are also generated for sleepiness and alertness (i.e. the sleep/wake cycle). Laboratory studies indicate that performance is impaired (Dijk, Duffy, and Czeisler, 1992; Folkard and Monk, 1979, 1985; Johnson et al., 1992; Monk et al., 1997; Rosekind et al., 1994; Tepas, Walsh, Moss, and Armstrong, 1981; Tilley, Wilkinson, Warren, Watson, and Drud, 1982) and sleepiness is increased (Carskadon and Dement, 1975, 1977; Czeisler, Weitzman, Moore-Ede, Zimmerman, and Kronauer, 1980; Folkard, Hume, Minors, Waterhouse, and Watson, 1985; Lavie, 1986; Walsh, Sugerman, and Schweitzer, 1986) during the night compared to during the day. The trough in performance and peak in sleepiness normally occurs around 0500 hours, which corresponds with the low point of the core body temperature rhythm. There is also a smaller, secondary increase in sleepiness, more reports of drowsiness, and a decrease in alertness and performance, occurring in the mid-afternoon (approximately 1300 to 1600 hours) (Åkerstedt and Gillberg, 1982; Babkoff et al. 1985, 1989; Campbell and Zulley, 1985b; Carskadon and Dement, 1979, 1987; Clodore, Foret, and
These circadian rhythms that witness biological and behavioural patterns repeating themselves in cyclic ways ‘about every 24 hours’ are mostly generated internally, being independent of external factors such as when we sleep, eat, and move about in our environment. Such external (or exogenous) factors can alter or mask the expression of the biological rhythms however, such as by changing the outward manifestations of the rhythm, such as the physiological amplitude (e.g. Wever, 1979).

The endogenous period of the body clock is actually slightly longer than 24 hours. While early research demonstrated the endogenous period to be closer to 25 hours than 24 hours (Aschoff, 1965; Wever, 1986), recent research suggests it may be nearer to 24 hours than first thought (Lavie, 2000; Wright, Hughes, Kronauer, Dijk, and Czeisler, 2001). A period longer than 24 hours means that our biological rhythms have a natural tendency to run late, or phase delay. The circadian rhythm system relies on daily environmental time cues called zeitgebers (“time givers”) to reset the internal biological clock to the external 24-hour solar clock. The most powerful zeitgeber is natural sunlight (or bright artificial light) (Czeisler, Richardson, Zimmerman, Moore-Ede, and Weitzman, 1981; Czeisler et al., 1986). Other time cues affecting the biological clock include the timing of sleep periods, physical activity, the timing of meals, and social interaction. These time cues are needed daily to reset the body clock to keep it correctly timed with the 24-hour solar clock. Without daily zeitgebers the body clock would gradually delay by up to an hour every day (Wever, 1980).
Knowledge of the zeitgebers that set the body clock is useful because keeping them constant can help maintain the timing of the circadian rhythm system, while altering the time when they occur can change the timing of the internal body clock and thus the circadian rhythm system. This can help the body cope with situations that require it to function on a different solar clock time to usual, such as when working night shift. The careful timing of sleep periods, meals, exercise, or actual exposure to sunlight, as well as the use of newer techniques such as bright light and melatonin therapy, are discussed in chapter 10 as techniques to maintain or change the timing of the body clock to help an individual cope with the demands of different shift work schedules.

Apart from this inherent tendency for the body clock to delay slightly each day with the absence of zeitgebers, the circadian system is quite resistant to change, especially abrupt changes, such as changes to work schedules or sleeping times. The body clock has a lot of physiological inertia, preferring to stay near its current timing (Quera-Salva, Defrance, Claustrat, De Lattre, and Guilleminault, 1996; Roden, Koller, Pirich, Vierhapper, and Waldhauser, 1993). Therefore, although time cues can be manipulated to change the timing of the body clock, the body clock is very slow to change and can not change completely. One exception is when people live or work in situations where the main environmental zeitgeber of sunlight is minimised, such as when working in a submarine or on North Sea oil installations in the winter (Gibbs, Hampton, Morgan, and Arendt, 2002). When we attempt to force our circadian rhythm system to change, for example by altering our work schedules, our body clock finds it somewhat easier to delay the physiological adjustments than to advance them, because the period length is longer than 24 hours. As the natural tendency of the body clock is to run late, it can
adjust to phase delays (e.g. west-ward travel, or a forward, clockwise shift rotation) more quickly than to phase advances (e.g. east-ward travel, or a backwards, counterclockwise shift rotation). The body clock has been shown to adjust by a maximum of 90 minutes per day for a phase delay and a maximum of only 60 minutes per day for a phase advance (Monk, 1990). The body temperature curve can take two to three weeks to adjust to a sleep/wake reversal (Weitzman, 1976). This concept is discussed further in chapter 6.

Circadian Rhythm Desynchronisations

As noted previously, the body’s circadian rhythm system is normally programmed for being awake and active during the day and for rest and sleep during the night. When an individual has to change the timing of their wake and sleep times, such as with night work, the new work/rest schedule no longer matches their internal body timing. For instance, when working a night shift, the worker has to be awake and active over the time that the body has programmed for sleep, while after the night shift, the worker returns home to sleep across the time that the body has programmed for being awake and active (daylight hours). The shift worker’s internal timing of the body does not match the new external timing of the work/rest environment. This mismatch between the timing of the internal body physiology and the timing of the external environment is known as inappropriate phasing or external desynchronisation (Scott, 1994; Thierry and Meijman, 1994).

This external desynchronisation is thought to be responsible for the “jet lag” that is often experienced with trans-meridian plane travel. When we engage in trans-meridian travel, we initially encounter jet lag because the timing of the internal body clock is
different from the clock time of the new location. Our body clock soon recognizes, however, that the timing of sunrise in the destination time zone has changed by some number of hours, as has the traveller’s meal and sleep schedule. Thus the body's circadian rhythm system, under direction from the body clock, begins to gradually adjust accordingly to meet the expectations of the new time zone, and the feelings of jet lag subside. This process is known as re-entrainment. The time that re-entrainment will take will depend on the size and direction of the time change (Monk, 1990; Scott, 1994).

While the body's circadian rhythm system is usually discussed as a single unit, it is important to note that each physiological variable (e.g. body temperature, specific hormones and so on) actually has its own circadian rhythm, and each of these rhythms is influenced to a different degree by endogenous and exogenous factors. When the body is receiving regular, consistent time cues, the various circadian rhythms function together in a highly synchronised manner (Aschoff, 1989). When the external timing (and time cues) changes, however, each internal circadian rhythm is affected differently. Rhythms with a large exogenous (externally driven) component adjust more rapidly than those rhythms with a large endogenous component, particularly when many exogenous factors change with the new time schedule, such as occurs with trans-meridian plane travel (Monk, 1990; Scott, 1994).

Unlike for trans-meridian plane travellers, when night shift workers change their work and sleep times, the timing of such environmental factors as light (day) and dark (night) periods, as well as schedules established by family expectations and societal demands, do not change to match their shift schedule. The night shift worker is therefore forced
to work in an environment with natural and normally expected zeitgebers that actually oppose their new work schedule. This complicates the physiological re-entrainment process because some of their circadian rhythms will follow the new sleep/wake cycle, while others will follow the unchanged but conflicting day/light cycle. Each variable’s circadian rhythm changes and alters at a different rate, taking different amounts of time to adjust to the new time schedule. In effect, each rhythm appears to have its own level of inertia, or level of resistance for change to a new time schedule. Until all the rhythms have had enough time to adjust to the new time change, the process of entrainment is incomplete and the circadian rhythm system is not working as efficiently as it normally does or is supposed to, and the individual does not feel at their best. This loss of the normal phase relationship between the components of the endogenous circadian rhythm system is known as circadian disharmony or internal desynchronisation (Comperatore and Krueger, 1990). Internal desynchronisation, or a sensitivity to desynchronisation, is thought to play a major role in the experience of shift work intolerance (Motohashi, 1992; Reinberg et al., 1989).

Chandrawanshi and Pati (2000) investigated the circadian desynchrony that occurs with shift work. Circadian rhythms of skin temperature, heart rate, and peak expiratory flow rate were studied for seven consecutive nights in six rapidly rotating factory shift workers. Results indicated that the shift workers were working under conditions of external desynchronisation, indicated by skin temperature, and also internal desynchronisation, indicated by heart rate and peak expiratory flow rate (which failed to demonstrate their typical circadian rhythms). These same workers were studied two years later, after a period of low work load, where the workers tended to sleep during the night and thus followed a diurnal work pattern. Under these conditions it was found
that the workers’ circadian rhythms were resynchronised, including the reestablishment of the circadian rhythms for heart rate and peak expiratory flow rate. These findings indicate that working night shift work can lead to circadian desynchronisation (internal and external), and that reverting to day work can resynchronise the rhythms. The importance of these two types of circadian rhythm desynchronisation for shift work schedules is addressed in chapter 6.

Knowing about the circadian rhythm system within the body can help individuals understand why they feel the way they do and also perform the way they do at certain times of the day and night, and why shift work can be hard on people. Working and feeling good at night is not simply a matter of will power or motivation. Understanding the nature and timing of the internal physiology of the body, and knowing about certain work and lifestyle strategies (for employers and employees) is useful for improving the body’s adjustment to shift work and night work. These strategies are addressed in chapter 10.

1.3.2 Sleep loss – the homeostatic need for sleep

Shift work that involves working at night, is also difficult for most people because it is usually accompanied by reduced quantities and quality of sleep. We all have a physiological need for sleep, with the average sleep need being about seven to eight hours of sleep per 24-hour period. This is the amount of sleep required by the body and brain on a long-term basis to maintain performance and alertness levels at normal levels (Balkin et al., 2000; Dinges et al., 1999; Van Dongen, Maislin, and Dinges, 1999). It is important to note that in order to obtain this amount of actual sleep time, a longer period of time in bed to sleep is required (e.g. see Balkin et al., 2000). This need for
sleep is a function of the homeostatic sleep/wake regulation process; the need for sleep increases with time awake and decreases during sleep. This physiological process is usually described as a function of time awake (i.e. increasing time awake increases the homeostatic drive for sleep), and reflects the fact that there is a certain need for sleep within each day (Borbely, 1982; Borbely and Achermann, 1992, 1999; Daan, Beersma, and Borbely, 1984; Dijk, Duffy, and Czeisler, 1992; Folkard and Åkerstedt, 1992). Decreasing the amount of sleep the body and brain have been accustomed to obtaining results in a cumulative sleep debt (Carskadon and Roth, 1991). When the amount of sleep we obtain decreases from normal, even by as little as 1.3 to 1.5 hours, our feelings of sleepiness when awake increases as does our sleep propensity (i.e. the ability to sleep) (Bonnet and Arand, 1995b; Carskadon and Dement, 1987; Harma et al., 1998; Rosenthal, Roehrs, Rosen, and Roth, 1993; Volk, Dyroff, Georgi, and Pflug, 1994), signalling that our brain and body has a need for sleep. The term sleepiness has been defined by Carskadon as the desire for, or tendency towards sleep (Dement and Carskadon, 1982). Insufficient sleep increases the likelihood that our brain will slip into sleep while we are awake, which will become more frequent and more rapid with a larger sleep debt. These episodes of sleep can be very short microsleeps (seconds), or they can last for several minutes such as by ‘nodding off’ (Torsvall et al., 1989). During these periods of sleep, which can occur without awareness, the individual looses awareness of the external environment, resulting in significant performance lapses.

It is well known that sleep restriction, of even a small amount, can lead to decrements in performance (Monk, 1997). Recent research has attempted to clarify the nature of this relationship by comparing the effect of sleep loss to that of alcohol intoxication, stimulated by the foundational work of Dawson and Reid (1997), which equated the
performance impairment due to fatigue to that of alcohol intoxication. Powell, Schechtman, Riley, Li, Troell, and Guilleminault (2001) studied the impact of the two types of sleep restriction typical for shift workers (‘acute’, by one night of total sleep deprivation, and ‘chronic’, by reducing sleep by two hours from usual per night for seven days) to that of alcohol intoxication to just below a blood alcohol concentration (BAC) of 0.10 g/dL (which is the legal limit for many US states) on day time driving performance. Driving performance was measured using a closed-course driving procedure. The results revealed a similar impact on reaction time and performance accuracy for the sleep loss (both acute and chronic sleep restriction) and alcohol conditions. Situations where obtaining sufficient sleep is difficult should therefore be a major cause for concern, as this study demonstrates that sleep restriction can be just as dangerous for performance as being intoxicated.

Apart from obtaining less sleep, shift workers are also often awake for a longer period of time than day workers are. As noted by Åkerstedt (1995b), a shift worker commencing a night shift often starts work 10 to 16 hours after waking, while an afternoon shift can start 4 to 6 hours after waking. This is compared to the usual 1 to 2 hours from waking to commencing work for a usual non-shift day worker (or shift worker on a morning shift). Night shift can therefore be accompanied by an extended period of time awake, especially when considering the end of the work period. Recent research has attempted to compare the effect that the sleep restriction and fatigue experienced in this extended wake-time situation has on performance to the well-known relationship between blood alcohol concentration (BAC) and performance. Several studies have indicated that the moderate levels of sleep restriction experienced with a long work day or working a night shift can impair performance to a similar or
greater level than the acceptable level of alcohol for safe driving or working (e.g. Rajaratnam and Arendt, 2001). According to Lamond and Dawson (1999), 17 to 19 hours of sustained wakefulness (finishing and measured at 2300 and 0100 hours) produced similar or worse levels of performance on several performance tests as a BAC of 0.05%, while 20 to 25 hours of wakefulness (finishing and measured at 0200 and 0800 hours) produced performance levels for some tasks similar to that seen with a BAC of 0.10%. Williamson and Feyer (2000) found that individuals remaining awake for 17 to 19 hours (finishing at 2300 and 0100 hours) performed at a similar level or worse than when they had a BAC of 0.05%, with the longer period awake (19 hours) producing performance similar to a BAC of 0.10%. Response speeds were slower and accuracy levels were significantly poorer for the sleep restriction compared to the alcohol condition.

As these two studies (Lamond and Dawson, 1999; Williamson and Feyer, 2000) tested participants during the night period (i.e. a day without sleep followed by a night awake with testing), the performance decrements may be partly confounded by the effect from the circadian rhythm system low point. Williamson and Feyer (2000) suggest however, that as their sleep restriction performance deficits equivalent to a BAC of 0.05% were found between 2200 and 0000 hours, which is well ahead of the circadian low point, the sleep restriction may have a deleterious effect on its own. It was suggested that the deleterious effect of sleep restriction may be exaggerated by the circadian rhythm low point during the early morning hours, producing larger performance decrements on a night shift than what may be found if performance was measured during the day time. This requires further research to test.
The results of these studies, which simulate the typical situation for many shift workers on their first night shift, together with the results of Powell and colleagues (2001), which simulate the chronic sleep restriction common for many shift workers over a series of night shifts, indicate that the extended wake times and the moderate amount of sleep restriction experienced can impair performance and compromise safety for shift workers to a similar level as the BAC levels deemed unacceptable for public safety (e.g. while driving).

After a period of sleep deprivation or sleep restriction, the body attempts to catch up on this missed sleep (the sleep debt) with what is termed a recovery sleep. Lost sleep does not need to be made up hour-for-hour. On the first recovery night, sleep may be slightly longer than usual, and will contain extra amounts of deep, slow-wave sleep (stages 3 and 4 sleep). The pressure for slow-wave sleep may preclude recovery of REM until the second night. As a rule of thumb, two consecutive nights of unrestricted sleep are usually sufficient for recovery of normal sleep architecture and waking function (Carskadon and Roth, 1991), with three nights being necessary after severe sleep restriction (Åkerstedt, Kecklund, Gillberg, Lowden, and Axelsson, 2000; Balkin et al., 2000). Shift workers usually sleep for longer than usual on their first few days off to try to recover and repay their sleep debt.

The sleep problems commonly experienced by shift workers, such as their reduced quantity and impaired quality of sleep during the day time, and the reasons behind this, such as both biological and social reasons, are discussed further in chapter 3.
1.4 The Adverse Effects of Shift Work

As the previous section indicated, working the night shift is associated with increased sleepiness and fatigue. This is due to the sleep debt that accumulates from not being able to obtain adequate good quality sleep when trying to sleep during the day, due in part to the timing of the body clock. The impact that night shift work has on the ability to obtain adequate, good quality sleep every day is a major concern for those involved with shift work. The sleep loss associated with night shift is not the only area of concern for shift workers however. Shift workers tend to experience problems in three other main areas. The first relates to their health; shift workers tend to suffer from poorer general health, including an increase in gastrointestinal and cardiovascular disorders, than non-shift workers. The second relates to their family and social life; shift workers tend to suffer from poorer family and social relationships than non-shift workers because their work times are often in conflict with societal and family expectations. The fourth area of concern, and one that is not always recognised as being an issue, is that shift workers, particularly when working at night, appear to be at an increased risk for making errors and being involved in an accident, both on and off the job, compared to non-shift workers. These four areas of concern, their increased sleepiness and fatigue, an increased risk of health related problems, an increase in family and social life difficulties, and an increased accident risk, are considered to be the main adverse effects of or major problems associated with shift work. These issues will be discussed in detail as individual chapters in part 1 of the thesis.

Despite these four main areas of concern, it must be noted that shift work is not without some advantages for many workers. Many individuals choose shift work for reasons such as: higher financial incentives than day work; the ability to combine work and
study; the provision of time off during weekdays when access to shops and services is
easier; and it allows work to be combined with family life, including the sharing of
child care responsibilities between partners (Weiss and Liss, 1988). Although such
advantages may attract some individuals to shift work initially, and may encourage
many to remain once employed, it must be emphasised that these individuals are still
subject to the same adverse effects of shift work as those individuals who must engage
in shift work as an inevitable part of their chosen career.

1.5 How to Help Shift Workers – The Occupational Health and Safety Perspective
Shift work is an integral and growing part of our modern society. Yet as addressed
above, shift work, especially when involving night work, has been associated with four
major adverse outcomes. As it is unlikely to be eliminated, something must to be done
to make shift work safer and more manageable. What can be done?

Perhaps the best way to ensure that improvements are made to shift work practices and
workplaces is to introduce an Occupational Health and Safety (OHS) framework to
shift work. Occupational Health and Safety (OHS) laws exist to ensure that all workers
are provided with a safe and healthy workplace and system of work, and are protected
at work from hazards.

Each Australian state and territory has a principal OHS Act, which specifies the
enforceable requirements for all groups of people in a workplace to ensure that all
workplaces within the state or territory are safe and healthy. Each Act has
requirements for:

promoting occupational health and safety in the workplace;
providing systems of work that are safe and without risk to health;
preventing industrial injuries and diseases;
protecting the health and safety of the public in relation to work activities;
rehabilitation and maximum recovery from incapacity of injured workers
(NOSHC, 1997, Occupational health and safety in Australia, The law – Acts
and regulations section, para. 1).

The requirements within an Act establish a ‘duty of care’ responsibility, primarily for
employers, to ensure a safe workplace. The specific rights and duties that follow from
the duty of care include:

provision and maintenance of safe plant and systems of work;
safe systems of work in connection with plant and substances;
a safe working environment and adequate welfare facilities;
information and instruction on workplace hazards and supervision of
employees in safe work;
monitoring the health of their employees and related records keeping;
employment of qualified persons to provide health and safety advice;
nomination of a senior employer representative; and
monitoring conditions at any workplace under their control and management
(NOHSC, 2002, Duty of Care section, para. 5).

Employers have a general duty of care to:

implement a systematic process of hazard identification, risk assessment, risk
control and review in the workplace;
make sure employees receive appropriate training, instruction and
supervision, including induction and ongoing training;

obtain and provide appropriate information;

consult with employees likely to be exposed to risks, and with their health
and safety representatives;

keep appropriate records (NOHSC, 1997, General duties of employers and
employees section, para. 1).

Employees have a general duty of care to:

comply, as far as they can, with all activities carried out in accordance with
the standard;

report to their employer anything that might affect the employer’s compliance
with the standard (NOHSC, 1997, General duties of employers and employees
section, para. 3).

Effective health and safety management requires the systematic identification of
hazards, assessing the risk associated with the hazard, controlling the risk, and
continual review of the situation (NOHSC, 1997), a process known as risk management
(Cross, 2000). The Standards Association of Australia has produced an Australian and
New Zealand Standard which provides guidelines for establishing and implementing
the risk management process within any organisation (AS/NZS 4360: 1999 Risk
defines ‘risk’ as “a combination of likelihood of injury or illness occurring (whether the
hazard can actually do some harm) and the consequences of its occurring (how
‘serious’ the harmful effects would be)” (NOHSC, 1997, The systematic approach, Step
2. Assessing risks section, para. 2). Risk assessments allow workplace hazards, and
therefore the need for control strategies, to be prioritised. That is, the risk is great and requires immediate attention if a hazard is highly likely to occur and/or the hazard has serious consequences. Controlling the risk means either eliminating the hazard or minimising the chance that it will harm someone (NOHSC, 1997). The risk control process must include an evaluation and continual review of the control strategies to ensure that they are being effective in controlling the risks.

A duty of care is placed on all employers, employees, and other persons who have an effect on the workplace hazards (e.g. contractors and suppliers), to ensure that everything “reasonably practicable” is done to protect the health and safety of everyone in the workplace. ‘Reasonably practicable’ allows the time, cost, and effort of various control measures to be considered along with the degree of risk posed by a hazard when deciding how to control a particular risk. The duty holder may therefore choose the most efficient control measure from a range of possibilities within the ‘hierarchy of control’. The hierarchy of control provides a number of possible risk management control options, in order of preference (NOHSC, 2002). These include:

- elimination of the hazard; its substitution with a less harmful version; its redesign; engineering controls; isolation of the hazard from people at the workplace; safe work practices; redesigning work systems; and the use of personal protective equipment by people at the workplace (NOHSC, 2002, Duty of Care section, para. 7).

As some workplace hazards are common across many workplaces, or have the potential to cause extreme injury, harm, or disease, specific regulations and codes of practice have been developed and adopted under each state/territory OHS Act, to specify the
particular duties required to control the risk associated with specific hazards. Regulations are legally binding and enforceable requirements, while codes of practice provide advice on how to fulfill the regulatory requirements. While codes of practice are not in themselves legally enforceable, they can be used as evidence in court to show whether or not legal requirements have been fulfilled (NOHSC, 2002). A code of practice:

- is designed to provide practical guidance;
- should be followed unless another solution achieves the same or better result;
- may be used in support of preventive and enforcement functions; and
- may be used to support prosecution for non-compliance (NOHSC, 1997, Occupational health and safety in Australia, The law – Acts and regulations section, para. 5).

According to the National Occupational Health and Safety Commission (NOHSC, 2002), there are no national standards or codes of practice available in Australia that deal with shift work. There are also no guidance notes or material available at a national level that relate to shift work. As the thesis will demonstrate, however, shift work is associated with numerous identifiable hazards and risks. As such, it must be considered an Occupational Health and Safety ‘hazard’. Strategies derived from sound scientific research (e.g. Folkard, 1987; Folkard et al., 1993) are needed for both employers and employees in order to make shift work safer and as manageable as possible, and to increase job satisfaction.
Overall Aim of the Thesis

The thesis will introduce an Occupational Health and Safety (OHS) perspective to shift work by systematically identifying the many hazards associated with shift work and providing the information and recommendations required to minimize or ‘control’ the hazards. Up to the present time, the health, sleep, and well-being of shift workers have not been considered an OHS issue within Australia. As the thesis will demonstrate, shift work is associated with several categories of foreseeable hazards, and as such, employers and employees must take responsibility to control or minimize the hazards where practicable. This responsibility will come from introducing the duty of care requirements under the OHS framework. The thesis will provide a systematic review of the many hazards associated with shift work and will provide strategies that can be used to reduce the risk associated with the hazards. The thesis provides a new perspective for managing shift work, which is essential to improve the safety, performance, health, and quality of life for shift workers, with consequent benefits for the community as a whole.

1.6 Overview of the Thesis

Part 1 of the thesis includes the next four chapters, and addresses the main adverse outcomes of shift work. The first of these (chapter 2) deals with the increased risk that shift workers experience for errors and accidents, both on and off the job. The next chapter, chapter 3, addresses the sleep complaints of shift workers. Chapter 4 deals with the health problems that have been associated with shift work, including theories that attempt to explain how shift work could be linked with ill-health. This chapter ends with a discussion of the main confounding factors that limit the conclusions that can be drawn from the shift work and health literature. Chapter 5 deals with the
problems experienced by shift workers in their personal, family, and social life. The impact of shift work on the partners and children of shift workers is also addressed.

Part 2 of the thesis deals with the main factors that can affect shift work tolerance. The first of these chapters considers the nature of the shift work systems themselves. Research addressing the various aspects of shift work systems, such as the timing of shifts, the speed of shift rotations, the direction of shift rotation changes, the amount of time off provided between shifts, and the length of work shifts, and the affect of these factors on shift work tolerance, is addressed in chapter 6. Chapter 7 begins a discussion of the individual characteristics and differences that may affect shift work tolerance. Factors such as age, gender, physical fitness, circadian typology, and psychological variables such as hardiness are discussed. The question of whether psychological variables can be used to predict shift work tolerance is addressed, as is the issue of whether there are circadian rhythms markers within individuals that could be used to predict shift work tolerance. Chapter 8 addresses the important issue of napping in shift work. This chapter reviews the research and covers the main considerations to ensure an effective napping strategy for shift workers. Chapter 9 addresses the research relating to specific strategies such as bright light therapy, melatonin therapy, stimulant drugs, and sedative-hypnotic drugs, and how these may or may not be useful strategies for improving shift work tolerance.

Part 3 of the thesis deals with the practical aspects of managing shift work using the OHS perspective. Chapter 10 provides the practical strategies that can be used to reduce the risks associated with shift work and thus improve the safety and personal tolerance of shift work. These are based on the previously reviewed research but now
for the first time an OHS ‘hierarchy of hazard control measures’ approach has been used to organise and prioritise the shift work coping strategies. The important role of education for shift workers is addressed in chapter 11. Chapter 12 provides a summary and conclusions for the thesis.
PART 1:

THE HAZARDS ASSOCIATED WITH SHIFT WORK
2. ACCIDENTS AND INJURY RISK

There are several sources of information to suggest that shift workers are at a greater risk of sustaining an injury or having an accident than non-shift workers, particularly when working at night. The first set of evidence comes from observations of industrial and engineering accidents, laboratory studies, and field studies looking at shift workers in real work situations, which indicate that sleepiness is increased and performance is impaired at night. This selection of evidence is discussed in the first section below.

While several features of shift work systems themselves are known to affect worker performance, these will not be addressed in this chapter as they are the focus of chapter 6. These two sources of evidence have led many to conclude that as the night shift is associated with increased sleepiness and decreased performance, there must be an increased accident risk at night compared to during the day. Studies investigating the actual accident risk of shift workers, particularly at night, are limited however, and have provided mixed findings. Studies that have analysed workplace occupational injury records to determine the accident risk of shift workers at work will be discussed below. Several studies have also indicated that shift workers can be at an increased risk for an accident when driving to and from work. These studies will be addressed at the end of this chapter.

2.1 Increased Sleepiness and Decreased Performance at Night

On the night shift excessive fatigue, sleepiness, and lethargy are common (Åkerstedt, 1991). This is due mainly to the nature of the circadian rhythm system, as discussed in chapter 1.3. For a normally entrained individual (i.e. with a core body temperature minimum occurring at approximately 0500 hours), there is an endogenous increase in
sleepiness and thus decrease in alertness during the night shift. This is usually accompanied by a further increase in sleepiness resulting from the cumulative sleep debt and from staying awake for a long period of time without sleep, both of which usually accompany night shift (see chapter 1.3 for the complete discussion). While *sleepiness* encompasses the desire for, or tendency towards sleep, *fatigue* encompasses three discrete concepts; sleepiness, motivational deficits, and performance deficits (Balkin, Wesensten, Russo, and Belenky, manuscript in prep.). The types of performance deficits that result from fatigue would include forgetfulness, poor decision making, slowed reaction time, reduced vigilance, loss of situational awareness, and poor communication (Rosekind et al., 1996). Dinges (1995a) states that the main impact of sleepiness and fatigue is impaired vigilance, which can result in disaster when observable events or signals are missed.

Sleepiness and fatigue are a major concern for workplace safety, especially for night shift situations as previously discussed, and particularly because of the tendency for people to consider themselves as being at less risk from harm than others (i.e. an optimistic bias) (DeJoy, 1989; Slovic, 1987; Weinstein, 1980; Weinstein and Klein, 1996). Numerous studies, using questionnaires (Åkerstedt and Torsvall, 1978; Thiis-Evensen, 1957) and subjective rating scales (Dahlgren, 1981b; Folkard, Monk, and Lobban, 1978; Torsvall and Åkerstedt, 1987; Torsvall, Åkerstedt, Gillander, and Knutsson, 1989), reveal sleepiness to be high during the night shift. Åkerstedt, Knutsson, Westerholm, Theorell, and Alfredsson (1998) examined data from a Swedish occupational health study (n=6000) and showed that shift work was associated with an increased risk of falling asleep at work (odds ratio 1.43) compared to day workers. According to several survey studies, around half of shift workers report that they had
fallen asleep on night shift at least once (Åkerstedt et al., 1983; Coleman and Dement, 1986; Kogi and Ohta, 1975). This increased sleepiness at night could result in an accident on night shift. In fact, recent estimates have suggested that sleepiness may have contributed to a conservative 1 to 2% (Webb, 1995), or as much as up to 41% (Leger, 1994, 1995) of accidents resulting in injuries and deaths.

The circadian rhythm, with decreased alertness at night, combined with the fatigue and sleep loss that develops when working the night shift, has been suggested as the main reason why a large number of human performance errors and accidents occur during the night shift (Åkerstedt, 1988; Åkerstedt, Czeisler, Dinges, and Horne, 1994; Dinges, 1995a). Several classic studies dating back to the 1950s demonstrate that human performance such as meter readings in the gas industry (Bjerner, Holm, and Swensson, 1955), the speed of connecting calls in a telephone exchange (Browne, 1949), and the frequency of train drivers operating their safety devices (Hildebrandt, Rohmert, and Rutenfranz, 1974), was impaired during the night shift. Researchers have since studied paper mill workers, train drivers, military personnel, and truck drivers (Scott, 1994; Thierry and Meijman, 1994), and have shown that high levels of sleepiness and fatigue occur on the night shift, and is associated with more errors and accidents, particularly during the circadian nadir (roughly 0100 to 0400 hours for most normally entrained individuals). This is particularly evident under monotonous work conditions, including driving (Scott, 1994). There are numerous studies available which demonstrate that the greatest risk for a fatigue related traffic crash, including both light vehicles and trucks, occurs during the early morning pre-dawn hours when sleepiness is high (e.g. Blower and Campbell, 1998; DiMilia, 1998; Federal Motor Carrier Safety Administration, 2000; Hamelin, 1978; Horne and Reyner, 1995; Kaneko and Jovanis, 1992; Kecklund

The majority of operator fatigue-related accidents, including industrial and engineering accidents, occur in the early morning hours between 0200 to 0700 hours (e.g. Folkard, 1997; Horne and Reyner, 1995; Mitler et al., 1988; Monk, Folkard, and Wedderburn, 1996). Examples include the widely publicized nuclear power plant disasters at the Three Mile Island plant (0400 hours) and at Chernobyl (0130 hours), both of which occurred in the early morning hours (Mitler et al., 1988). The Chernobyl accident was thought to result from several factors, including poor maintenance, poor communication, confused and incomplete incident reports, and human error, which combined in the early morning hours with disastrous consequences. The pesticide disaster at Bhopal and the grounding of the oil tanker Exxon Valdez also occurred during the night (Dinges, 1995a). NASA also reports of accidents involving human error occurring at similar times within their operations (Mitler et al., 1988). There are also findings to suggest decreased performance of medical personnel working at night. A longitudinal birth register study in Sweden (Luo and Karlberg, 2001) revealed that infant mortality (especially preterm infants) was higher when birth occurred during the night shift compared to the day shift. For the period 1990 to 1995, there was a 30% increase in early neonatal mortality (relative risk 1.3) and a 70% increase in early neonatal mortality from asphyxia (relative risk 1.7) for preterm infants born during the night shift compared to during the day shift. This difference in infant mortality rate
may also reflect an endogenous difference in the capacity of infants to survive, however, and not just the performance of medical personnel on night shift.

Laboratory night shift simulation studies (e.g. Porcu, Bellatreccia, Ferrara, and Cassagrande, 1998) and field studies using EEG technology (e.g. Åkerstedt, Kecklund, and Knutsson, 1991a; Haslam, 1982; Kecklund and Åkerstedt, 1993; Rosekind et al., 1994; Torsvall and Åkerstedt, 1987) have demonstrated that night shift workers experience increased sleepiness and decreased performance during the night shift. Some workers also experience microsleeps, or periods of dozing off while on the night shift, which dramatically increase the risk for an error or accident (Åkerstedt, Torsvall, and Froberg, 1983; Kogi and Ohta, 1975; Torsvall, Åkerstedt, Gillander, and Knutsson, 1989). For instance, Åkerstedt, Kecklund, and Knutsson (1991a) recorded the subjective sleepiness and also measured objective sleepiness via ambulatory polysomnography of shift working train drivers. Subjective sleepiness increased to extreme levels during the night shift, while mean EEG alpha power density (indicating individuals were awake but with their eyes closed) increased by a moderate amount. EEG alpha activity (awake, eyes closed) and theta activity (indicating light sleep) occurred in very short bursts during the night shift, indicating the presence of microsleeps, while 5 of the 25 shift workers fell asleep for longer than these few seconds during the night. Had these drivers not been able to get up and move about or interact with colleagues when they felt the need to, which can temporarily mask sleepiness, the incidence of microsleeps and falling asleep may have been much higher (Åkerstedt et al., 1991a).
It appears that subjective and objective sleepiness is increased across the night shift, particularly in environments that are solitary and are low in stimulation.

2.2 Occupational Injury Data

While the above studies provide data to suggest that shift workers, particularly on night shift, could have an increased accident risk (as sleepiness is increased and performance is impaired during the night shift), they do not provide evidence for an accident risk *per se*, as this requires some comparison of shift worker including night shift accidents to those of non-shift workers or to day shift. As pointed out by several authors, studies addressing the actual accident risk of shift workers are quite limited, and those that are available provide conflicting evidence (e.g. Frank, 2000). For instance, some studies indicate an increased accident risk for shift workers at night, while others do not. Some show that while the frequency of accidents is similar between day and night shift, the severity of injuries is increased on the night shift compared to the day shift. Still further studies show rotating shift workers to have a higher accident risk than fixed day workers, even when not finding any increase in accident risk on the night shift. Studies investigating occupational accident risks in relation to shift work are discussed below, separated into those that did and did not find an increase in accident risk for the night shift, starting with those that found no increase for night shift.

2.2.1 Studies finding no increase in accident risk on the night shift

Novak, Smolensky, Fairchild, and Reves (1990) analysed the injury records from a chemical plant in the U.S. over a three-year period (1982 to 1985), comparing shift workers (with an eight-hour, seven-day backward rotating shift system) and non-shift workers (with a typical 40-hour week). The job requirements, work tasks, and number
of workers present during a work period were not identical between these two groups. The injury data were compared to the attendance records of workers to help determine the clock time of the injury. There was no significant difference found for the clock time of injuries, although the day shift had the highest proportion of injuries and the night shift had the lowest proportion of injuries.

Ong, Phoon, Iskandar, and Chia (1987) examined the work injuries occurring in an iron and steel mill over a five-year period (1978 to 1982) in Singapore. They found peaks in the accident risk occurring in the mid-morning and mid-afternoon, as well as during the first few hours of the night shift (2300 to 2400 hours). While there were fewer accidents reported on the night shift, the injuries that did occur on the night shift were deemed more serious than the injuries occurring on the other shifts. This increase in severity was determined because the night shift injuries required greater amounts of sick leave than day shift injuries; the average recovery time for night shift injuries was 16% higher than morning shift injuries. The work environment and conditions, including the number of workers present in the factory, were not the same between the day and night shifts.

Adams, Barlow, and Hiddlestone (1981) reported on the injury records over a five-year period (1974 to 1978) from a large steel processing plant in Australia. They did not find the expected increase in accidents for the night shift, although they did find an increase in accidents in the first few hours of the night shift (0000 hours to approximately 0230 to 0300 hours) and a sharp increase in accidents in the last few hours of the night shift (0500 hours to the end of the shift at 0700 hours). As with the
previous studies, however, the working conditions including the number of workers present were not the same between the different shifts.

Hanecke, Tiedemann, Nachreiner, and Grzech-Sukalo (1998) analysed the occupational accident records for a one-year period (1994) from the workers’ compensation board in Germany, together with the exposure data for the same population, to calculate the risk of an accident in relation to the time of day and hour at work. The accident data tended to parallel the exposure data, such that more accidents occurred during the day when there were more people working. As this study included many different work types in the analyses, there are many confounding factors that could not be controlled (e.g. the type and quantity of work to be done), thus limiting the conclusions that can be drawn from this study.

Oginski, Oginska, Pokorski, Kmita, and Gozdziela (2000) studied the work injury records (n=506) from a shift working steel plant in Poland from over a 38-year period. These authors found that the total number of injuries did not differ significantly between the three shifts, while the percentage of severe injuries (42% for the night shift, compared to 31% for the morning shift and 32% for the afternoon shifts), as well as the severity of the injuries (determined by the amount of sick leave required after the injury) was much greater on the night shift, particularly between midnight and 0500 hours. The type of work conducted during the different shifts was considered to be identical, as was the number of shift workers present, although the presence of day only workers increased the total number of workers present during the day shift.
Laundry and Lees (1991) analysed the industrial accident records (n=3423) for a 20-year period from a large manufacturing company working continuous three-shift operations. Although work tasks and production rates were similar for all shifts, the incidence of workplace injuries was significantly higher between 0800 to 1000 hours and between 1400 to 1600 hours. There was no increase in accident risk during the night shift. The number of workers present on each shift was not provided.

Together, the above studies, the majority of which do not control for exposure with respect to the number of workers present and the type of work being conducted on each shift type, suggest that there is no significant increase in accident risk for shift workers on the night shift.

2.2.2 Studies finding an increase in accident risk on the night shift

While two studies discussed above (Novak et al., 1990; Ong et al., 1987) did not find an increased risk for workers at night, they did find that rotating shift workers were at an increased risk for an accident compared to fixed day workers. Novak and colleagues (1990) indicated a slightly higher overall incident rate of injuries for shift workers compared to the non-shift workers, while Ong and colleagues (1987) found that rotating shift workers on day shift had a much higher injury risk, in fact 3.7 times the risk, than fixed shift workers on day shift.

Lauridsen and Tonnesen (1990) examined the injury records over a seven-year period (1980 to 1987) from Norwegian offshore drilling rigs. They found an increase in the total number of injuries occurring during the day time, possibly due to the increased number of workers and increased work levels during the day compared to the night.
shift. When only the drill crew were considered, however, whose numbers and workload was similar between day and night shifts, more injuries were found between 2400 and 0600 hours (approximately 25% of injuries) compared to between 1800 and 2400 hours (approximately 23% of injuries). They also found a significant increase in accident risk for the first night shift, and especially when their night shift started in their second work week.

Wojtczak-Jaroszowa and Jarosz (1987) analysed the results of work injuries from two industrial plants over a five-year period (1980 to 1984) in Ontario. Despite the workload being more intense during the day shift, the night shift was associated with an increased frequency of accidents, particularly between 0200 and 0400 hours. This was despite a decrease in work activity at this time in the plants.

Åkerstedt (1994) analysed data from the Swedish Occupational injury information system, which is a register where all Swedish occupational injuries are reported. A total of 160 000 injuries (for a working population of 4.2 million), which caused at least one day of sick leave, were analysed for the year 1990/1991. The analysis showed that the accident data followed the exposure data, that is, more accidents occurred during the day while the majority of people were at work. Åkerstedt (1994) then computed an accident risk by calculating the number of work injuries per 100 000 people at work. This accident risk calculation showed a clear time of day effect, with an increased risk occurring at night. There was double the risk of an injury in the middle of the night (2400 hours) compared to the middle of the day (1200 hours).
Levin, Oler, and Whiteside (1985) investigated the occupational injury records for a ten-year period (1971 to 1980) from a paint company in the US using a rotating shift work system. The results indicated an increased accident risk for the night shift, such that the night shift had a 25% increased accident rate compared to the day shift.

Smith and Kushida (2000) examined occupational fatality data from the National Institute for Occupational Safety and Health (NIOSH) National Traumatic Occupational Fatalities surveillance system, for the period 1980 to 1994. The analyses indicated that the risk for a fatal accident at work was 3.32 times higher during the night shift (2300 to 0700 hours) than during the day (0900 to 1700 hours).

Taken together, these studies suggest that the night shift may be associated with an increased accident risk.

2.2.3 Accident risk and confounding factors

One of the major problems when investigating the accident risk between different shifts is that there are often several differences between the shifts other than just the timing. It is often the case that work conditions are different between shift workers and non-shift workers, as well as between the different shift timings, such as day and night shifts. For instance, there are often more personnel, as well as different categories of workers present during the day compared to at night (e.g. supervisors, maintenance personnel, and visitors or clients during the day). The fact that the number and type of people differ between the shifts could have a large impact on the likelihood of an accident occurring. For example, workload can often be higher during the day because of the increased number of workers present and the presence of managers and
supervisors. Similarly, the type of work that is conducted during the day and night shifts can often be different. For instance, at some manufacturing plants long production runs are saved for the night shift, and many will save maintenance and repair work for certain shifts only (either the day or night shift depending on the workplace). In some workplaces the experience of workers may differ between the shift times, with new and less experienced staff often working the night shift while more experienced senior staff are allocated day work only, which is particularly common in the US (Thierry and Meijman, 1994).

The effect of such shift differences can be seen in a study by Smith and colleagues (1997). These authors analysed documented injury records and interviewed staff regarding the nature of worker injuries and near misses from two shift working manufacturing plants in the US. The pattern of injuries they found was consistent with the different work conditions on the three shifts. They found a higher number of injuries during the day shift, which was consistent with the higher number of staff present. The nature of the injuries also confirmed the hypothesis that an increased number of workers may lead to an increase in injuries. The day shift experienced more ‘slipped or tripped’ and ‘hit by equipment’ events, which were physical-impact events, and consistent with a crowded work environment. They also experienced more ‘bruise’ and ‘pulled muscle’ injuries, which were related to ‘moving objects that were too heavy’, and consistent with an increase in production pressure from managers and supervisors being present during the day. The night shift staff on the other hand experienced more ‘breathing problems’. This was associated with their increased exposure to chemical fumes during the night shift, consistent with the type of work
conducted on the night shift (which was the coating and painting of plastic parts, which was only performed during the night shift).

Differences in work conditions between the different shifts, such as worker numbers and work tasks, may therefore influence the accident risk of workers rather than the timing of the shifts per se. That is, fewer workers and a lower work load at night would predict fewer injuries occurring at night. This may explain some of the discrepancy in findings between studies, and the negative findings of the studies discussed initially. These studies were all affected by unequal worker numbers and/or work conditions and requirements between the day and night shifts. For instance, all of the major studies reported that more workers were present during the day compared to the night shift, including different categories of workers such as clerical, maintenance, and managerial staff being present only during the day (Adams et al., 1981; Hanecke et al., 1998; Novak et al., 1990; Oginski et al., 2000; Ong et al., 1987), and the three studies that reported specifically on the work conditions found that the working conditions, that is the type of work to be performed, was not the same between day and night shifts (Novak et al., 1990; Oginski et al., 2000; Ong et al., 1987). These differences, rather than the shift timing per se, may have contributed to the distribution of work injuries seen in these studies.

Such confounding factors must therefore be controlled when analysing data for the accident risk according to shift times. That is, data must be collected under conditions where there is an equal probability of an accident occurring at any time in the 24-hour period. There are few such studies available at present.
Smith, Folkard, and Poole (1994) conducted the first such study, where the a priori likelihood of an accident was relatively constant across the different shifts, and demonstrated a direct link between night shift and an increased accident risk. Smith and colleagues (1994) examined the injury records (n=4645 accidents) for a one-year period from a large company using a rotating shift schedule. The number of workers on each of the three shifts was the same. All workers rotated between all three shifts, including supervisory and maintenance personnel. The work performed on the three shifts was also similar. The analyses indicated that the risk of sustaining an injury at work was higher for the night shift (relative risk 1.23) compared to the morning shift (relative risk 1), with the highest risk occurring towards the end of the week of night shift (relative risk of 1.35 for last night shift compared to 1.21 for first night shift). The results also provided some evidence that the severity of accidents was increased on the night shift compared to the morning shift.

This study is thought to be the first objective study where the working conditions are considered to be relatively constant over the 24 hours, and therefore between shifts, and which demonstrates a direct link between night work and an increased accident risk (Smith, Folkard, and Poole, 1994, 1997). The results clearly indicate an increased risk for injuries on the night shift, especially towards the end of a series of night shifts.

The same authors conducted a similar study a few years later (Smith, Folkard, and Poole, 1997). This study examined the injury data collected from two similar large production engineering companies using rotating shift work schedules (with discontinuous day and night shifts and weekends off), and where the work/environmental conditions were considered constant between shifts. Relatively
constant staffing levels were maintained and all shift workers where involved with similar work tasks. The results revealed that more injuries occurred on the night shift than the day shift, however, the difference was not statistically different. The results also showed that the risk of an injury was greater at the end of the work week, especially for night shift (i.e. 6 to 7% increased injury risk at the end of a day shift week compared to a 60% increased injury risk at the end of a night shift week).

These two papers by Smith and colleagues (1994, 1997) are significant because they are thought to be the first studies where the \textit{a priori} risk of sustaining an injury was the same at all times, that is, the working conditions were constant over time. The results of these studies revealed an increased risk for sustaining an injury on the night shift, particularly after a number of night shifts. Since these studies, similar results have been found by Folkard (2002), who conducted an empirical review of the shift work literature focussing on safety, and in particular accident and injury records. Studies were only included if the \textit{a priori} risk was relatively constant across the three shifts. The results of this review indicated an increase in accident risk for the night shift of 30.6% compared to the morning shift. That is, compared to the morning shift with a relative risk of 1, the night shift had a relative risk of 1.3.

Together, the findings by Folkard and colleagues (Folkard, 2002; Smith, Folkard, and Poole, 1994, 1997) support the assertion that safety on the night shift is reduced compared to the day shift. Night shift can be hazardous for shift workers.
2.3 Shift Workers and Driving

Night shift workers may be at risk not only while at work, but also when driving to and from work, particularly when late in the evening or in the early morning hours (Lyznicki, Doege, Davis, and Williams, 1998). Marcus and Loughlin (1996) questioned medical doctors (n=70) and hospital faculty members (n=85) about their work and sleep habits, and about their driving history over the preceding few years. The doctors were ‘on call’ in the hospital every fourth night while the faculty members were rarely disturbed during the night. The results revealed that when the doctors were on call at night they obtained little sleep (2.7 hours compared to 7.2 hours when not on call), which impacted on their driving the next day (e.g. driving home from work). A total of 49% of the doctors had fallen asleep at the wheel (either when stopped at lights or while driving) compared to 13% of the faculty members. The doctors also reported a significantly higher number of vehicle accidents (25% of doctors) compared to faculty members (14% of faculty members); 45% of the doctors’ accidents occurred driving home from work compared to 27% of faculty members driving home from work.

Ninety percent of the doctors’ traffic incidents (falling asleep and accidents) occurred when driving home after being ‘on call’ during the night in the hospital. Driving home after a night on call, or essentially working a night shift, appears to be extremely hazardous.

Steele, Ma, Watson, Thomas, and Muelleman (1999) investigated the risk of a motor vehicle accident for shift-working emergency medicine residents. Emergency medicine residents (n=957) completed questionnaires asking about their driving history (crashes and near misses) in relation to the shift they had been working prior to the incident. These employees had a significantly higher rate of being involved in a crash (74%) and
near-crash (80%) after a night shift compared to following a day shift (crash 12%, near-crash 7%). Analyses also revealed that the likelihood of having a crash and/or near-crash was positively related to the number of night shifts worked, indicating that the risk of having a crash/near-crash was higher as the number of night shifts worked per month increased.

Richardson, Miner, and Czeisler (1989 to 1990) surveyed 171 rotating shift workers and 27 day workers at a manufacturing plant in the US about their work schedule, sleep quality, feelings of sleepiness and fatigue when awake, and the incidents of actual or near-miss car accidents due to sleepiness in the preceding year. A higher proportion of rotating shift workers experienced a ‘moderate to severe problem’ with poor quality sleep (52.1%) than day workers (17.1%), as well as experiencing a ‘moderate to severe’ problem with fatigue during their waking hours (44.1%) compared to the day workers (13.7%). There was also a greater percentage of rotating shift workers reporting a sleepiness related accident or near-miss in the preceding year (21.7%) compared to the day workers (7.2%).

A study by Gold et al. (1992) investigated the effect of shift work on self-reported traffic accidents and errors (including near misses) amongst nurses. For nurses working rotating shifts, the odds of ‘nodding off at the wheel while driving to or from work in the previous 12 months’ was 3.9 times the odds for nurses on the day or evening shift, and permanent night nurses were 3.6 times the odds of the nurses on day or evening shift. Statistical analyses controlling for the confounds of working at the hospital for one-year or less, being younger than 35 years, and alcohol use, revealed that the odds of an ‘accident or error’ was twice as high for rotating nurses than
day/evening nurses, while their odds of a ‘near-miss accident’ was 2.5 times higher than the day/evening nurses. It would appear from this study that rotating nurses are at a much higher risk for an accident or error while driving home from work than day/evening nurses. This is not surprising given that rotating nurses experience night shifts much more frequently than day/evening nurses, and are therefore driving home more often after a night shift, which has been associated with an increase in errors and accidents in many other work settings.

Similar results were reported by Stutts, Wilkins, and Vaughn (1999). These authors surveyed 1400 US car drivers about their sleep history and crashes. They found that shift workers were at six times the risk of a crash due to fatigue. Drivers who had less than six hours of sleep were at three times the risk of a fatigue-related crash, and drivers with less than five hours of sleep were at five times the risk of a crash due to fatigue.

These data indicate that shift workers driving home after night shift are at an increased risk for having a crash than day workers driving home. Driving home after a night shift is an occupational risk for shift workers.

2.4 Summary

It has been known for some time that sleepiness is increased and performance is decreased at night. There have been numerous industrial and workplace accidents on the night shift, often with far reaching consequences. These have suggested an increased accident risk for the night shift. Analysis of workplace injury data, which has investigated the actual accident risk for workers on night shift compared to day
workers, has provided mixed results however. Much of the discrepancy may be due to the limited control in many studies over the numerous confounding factors that occur between day and night shifts. When the confounding differences have been controlled, there does appear to be a link between night shift and an increase in accident risk. This suggests that safety on night shift is reduced. Some alarming results have also been shown regarding the safety of shift workers when driving. Studies indicate that shift workers are at an increased risk for an accident when driving, particularly when driving home after a night shift. As travelling to and from work is a necessary activity for the majority of shift workers, this issue must therefore be considered when designing shift work schedules and when addressing shift work safety issues.
3. SLEEP

Tepas and Carvalhais (1990) partition most working days into three periods; time spent in the workplace, sleep time, and time-off. Day shift workers use a sequence of sleep, followed by work, and then off-time. Afternoon/evening shift workers use the sequence of sleep, followed by off-time, and then work. Night shift workers use the same sequence as afternoon/evening workers, however, they differ in that their sleep periods are shorter and occur during the day. And of course, it is well known that many rotating shift workers change their sleep behaviour as they alternate between workdays and non-workdays or days off (Tepas and Carvalhais, 1990). Trying to sleep during the day, and alternating their sleep between the night and day, can create problems for the sleep of shift workers.

3.1 The Sleep of Shift Workers

‘Difficulties with sleep’ are found to be the most common complaint among shift workers. Data suggest that the main reason shift workers leave night shift work is because of the sleep disturbances they experience (Maasen, Meers, and Verhaegen, 1978; Rutenfranz, Knauth, and Angersbach, 1981). According to a literature review by Rutenfranz and colleagues (1981) 90% of the shift workers studied reported sleep disturbances when working shift work that involved night work. When these workers transferred to day work, less than 20% reported sleep disturbances. This dramatic decrease in sleep disturbances with the transfer to day work suggests that the earlier sleep difficulties were being influenced by the shift work rather than any inherent characteristics of the workers. Niedhammer, Lert, and Marne (1994) have also shown that the sleep disturbances reported by shift workers decrease after they transfer to day
work. While these and further research suggests that the sleep disturbances resolve after ceasing shift work, meaning that there are no long-term effects of shift work on sleep parameters (Åkerstedt and Kecklund, 1991; Webb, 1983), there is some debate about this. There is evidence that refutes this position and suggests that once transferred to day work, former shift workers may still experience sleep related problems (Dumont, Montpaisir, and Infant-Rivard, 1987, 1997).

The majority of sleep difficulties that shift workers report are due to their altered work/rest schedules. Because of the altered and often reversed sleep/wake cycle, shift workers must often sleep during the day. Circadian, environmental, and social factors combine to reduce the quantity and quality of this day sleep, causing chronic partial sleep deprivation or sleep restriction (Scott, 1994). Numerous studies demonstrate that shift workers’ day sleep is shorter in length than their night time sleep (less than six hours during the day, compared to seven or more hours when sleeping at night), therefore reducing their daily total sleep time (Pilcher et al., 2000; Tepas and Carvalhais, 1990; Tilley et al., 1982; Torsvall, Åkerstedt, and Gillberg, 1981; Torsvall et al., 1989). Day sleep also has a reduced objective quality, with reduced amounts of rapid eye movement (REM) and stage 2 sleep, a shorter REM sleep latency, and more frequent arousals, resulting in a more fragmented sleep period (Åkerstedt, Kecklund, and Knutsson, 1991b; Åkerstedt, Torsvall, and Gillberg, 1982; Dahlgren, 1981a; Foret and Benoit, 1974, 1978; Kiesswetter, 1993; Matsumoto, 1978; Scott, 1994; Tilley et al., 1982; Torsvall et al., 1981; Weitzman, Kripke, Goldmacher, McGregor, and Nogeire, 1970).
These changes in sleep length and quality during the day can be partly attributed to the phase of the circadian rhythm system at that time, which is usually set to favour sleep at night as opposed to during the day (Åkerstedt and Gillberg, 1981b). As previously discussed, core body temperature and other physiological variables (e.g. secretions of the hormones adrenaline and cortisol) are increased during the day, which is conducive for being awake and active during the day, not for sleeping during the day (e.g. Czeisler et al., 1980). The circadian rhythm is not the only influence at work affecting shift workers’ day time sleep however. There are many factors that combine to interfere with the day sleep of shift workers (Monk, 2000; Scott, 1994). Many shift workers voluntarily cut their sleep short in order to participate in personal, family, or social activities, which are primarily based on a day time schedule. Sometimes sleep time can be restricted because of the work schedule. The early start times of some morning shifts (particularly when before 0600 hours) mean that night sleep must be cut short in the morning in order to leave for work, while most shift workers find it difficult to sleep earlier than usual in the evening (Åkerstedt, 1990). Shift workers also have to contend with disturbing external factors when trying to sleep during the day, such as traffic and street sounds, phone calls, and other people including children in the house. Day sleepers are more likely to be woken by external noises, and as there are more noises and disturbances during the day, they can be woken frequently when trying to sleep.

Due to all of these factors shift workers obtain, on average, over one hour less sleep per day than day workers do (Åkerstedt, 1985). According to Scott (1994) the pattern of poor day time sleep for shift workers does not improve with an increased number of night shifts worked, nor does it improve with increased shift work experience (Tepas,
Even workers who prefer night work and appear to have reasonable coping skills report reductions in their usual sleep length (Tepas and Mahan, 1989). This chronic sleep restriction adds up across a work ‘week’ to create a significant sleep debt (Carskadon and Dement, 1981; Carskadon and Roth, 1991). This can have negative consequences for shift workers, increasing their level of sleepiness and fatigue, and negatively impacting on their performance levels and social functioning (Dinges et al., 1997; Gillberg, Kecklund, and Åkerstedt, 1994; Roth, Roehrs, and Zorick, 1982). Monk (1990) states that sleep restriction can lead directly to decrements in performance as well as to a deterioration in mood and motivation which can degrade performance further (Dinges, Kribbs, Steinberg, and Powell, 1992; Rosekind et al., 1996).

According to Dinges (1995a) increased levels of sleepiness can cause the following performance deficits: “increased periods of non-responding or delayed responding (lapses) on attention-based tasks; slowed information processing (cognitive throughput); increases in optimum reaction times; reduced accuracy of short-term memory; and accelerated decrements in performance with time-on-task” (p. 6). Such performance deficits may be due to the decreased brain activation that occurs with sleep loss (as indicated by reduced brain glucose metabolism using Positron Emission Tomography recording) in the areas needed for complex mental operations and sustained attention and alertness, such as the prefrontal cortex, medial and inferior parietal cortex, and the thalamus (Belenky et al., 1998; Thomas et al., 2000; Wu et al., 1991). These performance decrements can be especially apparent on the night shift as sleep loss exaggerates the normal circadian performance lows on the night shift, particularly for tasks requiring vigilance and sustained attention (Scott, 1994). Several studies demonstrate that people do not adapt well to a restricted sleep pattern, nor do they learn how to cope with the effects of sleep loss through experience, even though
they may think that they do (Carskadon and Dement, 1981; Webb, 1985; Webb and Levy, 1984).

Being sleepy makes it easier to fall asleep, including at inappropriate times, and especially on the night shift. *Microsleeps* can occur, which are involuntary brief periods of sleep where the brain is literally asleep; the EEG shows a brain wave pattern indicative of sleep, such as increased power density in the alpha, theta, and delta bands, and increased slow rolling eye movement activity (Torsvall and Åkerstedt, 1988). These usually occur for only a few seconds and they can occur without the individual being aware of them. Some individuals may experience slightly longer sleep episodes, such as ‘nodding off’, which may last longer than a microsleep, and which may also occur without the individual being aware of them (Torsvall et al., 1989). The frequency and duration of microsleeps increase as the ‘sleepiness’ from sleep loss increases. Nodding off and microsleeps can have disastrous consequences because during this time the individual is no longer aware of their surroundings and what is happening around them, they can no longer function in or respond appropriately to their surroundings, and there is typically no warning or control as to exactly when they will occur (Åkerstedt and Gillberg, 1990; Dinges, 1992b; Dinges and Kribbs, 1991; Johnson, 1982; Scott, 1994; Torsvall and Åkerstedt, 1988). Sleep laboratory studies have shown that people can fall asleep (as defined by the EEG) and stay asleep for a few minutes without being aware that they were asleep (Bonnet and Moore, 1982; Gastaut and Broughton, 1965, in Horne and Reyner, 1999; Rosenthal et al., 1999). According to Horne and Reyner (1999) many drivers involved in a sleep related vehicle accident will be aware of the precursory feelings of increasing sleepiness before the accident, but will genuinely have no recollection of actually having fallen asleep at the
wheel (see also Lisper, Laurell, and Van Loon, 1986). This is a serious safety hazard, both on and off the job, as these few moments of ‘unrecognised’ sleep can be enough to end in a work accident or a traffic crash while driving to and from work. It is important to note however that performance can be impaired and accidents can happen when an individual is sleepy but without the occurrence of any microsleep (Balkin et al., 2000; Dinges and Kribbs, 1991; Valley and Broughton, 1983). Sufficient, good quality sleep is essential to control fatigue and minimise sleepiness, and to perform efficiently and safely. Most shift workers struggle with this.

3.2 Complaints with Sleeping and Sleepiness in Shift Work

The effect of shift work and several individual and life-style factors (including age, smoking, alcohol consumption, and exercise) on the sleep complaints and day time sleepiness of shift workers were examined by Harma, Tenkanen, Sjoblom, Alikoski, and Heinsalmi (1998). Data were collected from 3 020 males (age range 45 to 60 years, median 52 years) via self-report questionnaires, using a cross-sectional design. The men were full time workers from either industrial or government agencies. Numerous shift schedules were in use, including two shifts, three shifts, irregular shifts, permanent days or nights, and included continuous and discontinuous schedules. The sleep complaints were categorised into four groups; ‘insomnia’, ‘sleep deprivation’, ‘day time sleepiness’, and ‘snoring’.

Of all of the predicting variables analysed, ‘shift work’ (two, three, or irregular shifts) was the most important predictor of the sleep complaints except snoring. The prevalence of sleep complaints was 39-53% insomnia, 30-45% sleep deprivation, 20-37% day time sleepiness, and 38-50% snoring, depending on the shift schedule worked.
The sleep complaints were most common for the permanent night workers and least common for the permanent day workers (Harma et al., 1998).

Overall, shift work was associated with increased reports of insomnia, sleep deprivation, and day time sleepiness. It would appear that this was not due to lifestyle factors, as the shift workers tended to have healthier lifestyles (e.g. more exercise and less alcohol and smoking) than the day workers. A sedentary lifestyle was the most important life-style predictor of increased sleep complaints and day time sleepiness in all groups except the three-shift shift workers (Harma et al., 1998). This aspect of physical fitness will be addressed further in chapter 7. Shift work was associated with an increase in sleep complaints and increased sleepiness for these workers.

Complimenting the study above, Barak and colleagues (1995) investigated the prevalence of sleep disorders among shift and day workers, this time in a female population. Nurses from a large hospital participated in the study by completing self-report questionnaires, providing information about their sleep and work schedules. Nurses were either counter-clockwise rotating nurses (n=131, mean age 36.9 years) or permanent day nurses (n=44, mean age 32.6 years), with at least one-year experience with their roster schedule (shift workers’ experience mean 10.9 years, day workers’ experience mean 11.3 years). Participants were divided into three groups depending on the number of sleep disturbances reported. These were ‘none’, ‘one’, and ‘more than one’ sleep disturbance reported. The particular sleep disturbances were grouped into the following categories; ‘initial insomnia’ (difficulty initiating sleep), ‘middle insomnia’ (difficulty maintaining sleep), and ‘late insomnia’ (waking earlier than desired). Sleep satisfaction was also assessed.
The shift work group reported an average main sleep duration of 6.8 hours per 24 hours. The reports of sleep disturbance were as follows: ‘none’ for 19.8%, ‘one’ for 45.8%, ‘more than one’ for 34.4%. These groups did not differ in age or frequency of shifts per week. The particular sleep disorders reported were: initial insomnia 40.5%, late insomnia 29.8%, and middle insomnia 5.1%. Unrefreshing sleep was reported by 52.7% of shift workers (Barak et al., 1995).

The day only workers reported an average sleep duration of 7.3 hours per 24 hours, which was longer than the shift work group (although not a statistically significant difference). In contrast to the shift workers, the majority of the day workers reported having ‘no’ sleep disorder (76.5%), while those that did report a sleep disorder only reported having ‘one’ (the remaining 23.5%). The sleep disorders reported were: initial insomnia 9%, late insomnia 9%, and middle insomnia 4.5%. Only 9% (two participants) of day workers reported unrefreshing sleep, compared to the 52.7% of shift workers. Age was not a significant factor in the occurrence of sleep disorders, although only 26.2% of the participants were older than 40 years (Barak et al., 1995).

The results indicated that the evening shift rather than the night shift was associated with increased sleep disturbances. This finding may be confounded, however, by the fact that the evening shift occurred after the night shift because of the counter-clockwise rotation of the roster. The negative effects from the night shift may have accumulated and combined with the negative effects of the evening shifts to increase the overall negative impact on sleep seen at that time, especially if there had been insufficient time off between the shift changes. It was also found that working more
than 4.1 shifts per week was associated with more sleep disturbances, and that greater shift work experience (more than 13.6 years) was associated with a higher frequency of multiple sleep disturbances. Overall, the results indicated that shift work was associated with increased sleep disturbances, as researchers in the past have indicated (Barak et al., 1995).

The effects of shift work on sleep were studied in a group of rapidly rotating air traffic control specialists in the US (Cruz, Della Rocco, and Hackworth, 2000). These shift workers worked a counter-clockwise rapidly rotating schedule, with no more than two or three days on a shift before changing to an earlier start time. They also had an extended period of time off between work weeks. A modified version of the National Institute for Occupational Safety and Health (NIOSH) General Health and Adjustment Questionnaire was used to assess their job history and demographics, health and mood, sleeping and eating patterns, and general lifestyle. Data from the 210 participants (79% male; average age 32 years) were analysed according to four groups; those with and without night shift, the number of early morning shifts per schedule (‘0 to 3’ or ‘4 or more’), and the shift length (8 or 9 hours). The average experience in the present job was 6.9 years. As these workers were required to undergo annual medical examinations, it was hypothesised that the health and sleep complaints reported would be lower than other shift working populations.

In general, the air traffic controllers reported themselves to be quite healthy (97% reported their health to be ‘good’ or ‘excellent’). In contrast to their health, only 39.5% reported ‘good’ or ‘excellent’ sleep patterns, with 40% indicating ‘fair’ sleep patterns. They generally reported obtaining less sleep than they prefer (obtained 6.3 hours, and
preferred 8 hours), particularly when working more morning shifts. Over half of the sample reported that sleepiness and fatigue occurred at least occasionally. Over half of the workers (55.2%) reported they felt tired or sleepy at work at least two to three times per week, with 15.2% reporting this occurred about every day. About 68% said they had felt themselves about to fall asleep (or “doze off”) at work, and 52.9% said they had taken naps at work during the last year. Most alarmingly, 32.4% of the sample reported falling asleep while driving home from work in the last six months. Interestingly, the proportion of workers who ‘took naps’ and ‘fell asleep while driving home’ was higher for those with night shifts in their schedule, while those reporting ‘dozing off at work’ were higher for those working the 9-hour shifts. These results support previous findings that shift work is associated with difficulties sleeping and thus increased sleepiness and fatigue. Unlike previous studies, however, this study found that these complaints can be found even among a group of young, very healthy shift workers.

3.3 Summary

Shift workers often complain of difficulties sleeping and not getting enough sleep, particularly when they are working the night shift. Circadian, environmental, and social factors combine to reduce the quantity and quality of their day sleep, causing sleep restriction and the accumulation of a sleep debt. This sleep debt increases their feelings of sleepiness and fatigue, which may increase the risk for errors and accidents, as discussed in the previous chapter. It has even been suggested that this long-term sleep restriction may be a contributing factor to the health and well-being complaints often reported among shift workers (Monk, 1997). The health complaints common for shift workers will be addressed in the following chapter.
To improve the performance and safety of shift workers it is important that they obtain adequate sleep, which is a minimum of seven hours sleep, but preferably 7.5 to 8 hours sleep, per 24 hours (Balkin et al., 2000; Dinges et al., 1999; Van Dongen et al., 1999); remembering that to obtain this amount of sleep, a longer period of time in bed to sleep is required. This sleep is best if obtained in one consolidated sleep period (as discussed in section 8.2.1). There are strategies that shift workers can use to improve their daytime sleep and therefore to optimise their sleep periods when working the night shift. These *sleep hygiene* strategies are given in chapter 10. If a sufficiently long sleep period is not possible, then naps can be very beneficial (Åkerstedt, Gillberg, and Torsvall, 1985; Monk, 2000). Shift workers, including night workers and rotating shift workers, report a high incidence of frequent napping (Åkerstedt, Torsvall, and Gillberg, 1989; Åkerstedt and Torsvall, 1985; Chan, Phoon, Gan, and Ngui, 1989; Rosa, 1993; Tepas et al., 1985). While naps are one way of overcoming acute sleep deprivation effects, napping to overcome chronic sleep deprivation effects is an unhelpful long-term strategy. Naps should not be relied upon as the main source of sleep, as they are the most beneficial when taken as extra sleep to a long sleep period, and are used only as a ‘top up’ before or early at work (Hartley, Buxton, Sully, and Krueger, 2001). The research investigating the appropriate use of napping is discussed in detail in chapter 8, while practical napping strategies for shift workers are provided in chapter 10.
4. HEALTH

Health and well-being are of major concern for shift workers. Numerous studies, dating back to the 1950s (Thiis-Evensen, 1958; Wyatt and Marriott, 1953) report that shift work, in particular night work, can lead to a decreased feeling of well-being and an increase of health complaints. Some research has shown that shift workers report more frequent adverse health symptoms and a higher number of health claims than day workers (Singer, Terborg, and Mayer, 1994), while many shift workers leave shift work for such health reasons (Frese and Okonek, 1984). There is some evidence to suggest that well-being (including the feelings of fatigue) may improve after leaving shift work (Äkerstedt and Torsvall, 1978; Paley and Tepas, 1994; Verhaegen, Maasen, and Meers, 1981), although this may not always be the case (Frese and Semmer, 1986; Koller, 1983; Koller, Kundi, and Cervinka, 1978). In some cases, shift workers may not realise the full extent of their suffering until after they have left the shift work situation (Spelten, Barton, and Folkard, 1993). Despite the increase in health complaints, there is some, although limited evidence to suggest that shift work does not have an adverse effect on mortality (Taylor and Pocock, 1972; Tarumi, 1997). The four main areas of health complaints among shift workers are sleep disruption, gastrointestinal (GI) disorders, cardiovascular diseases (CVD), and a deleterious impact on psychological health. Research has also suggested that women’s health may suffer with shift work. These areas will be discussed in turn, followed by a discussion of the hypothesised pathways that link shift work with ill-health. The major limitations with the research literature in this area of shift work and ill-health will also be discussed.
4.1 Sleep Disruption, Sleep Loss and Health Effects

Because of the rotation of work shifts, whether on a rotating or a permanent schedule, most shift workers endure significant sleep disruption, sleep restriction, and biological rhythm disruptions, as previously discussed. Both the quantity and the quality of sleep are affected (Naitoh, Kelly, and Englund, 1990; Tepas and Carvalhais, 1990). The most significant complaint when workers are involved with shift work is a disturbance of their sleep patterns. It is the most universal complaint in their own daily lives, as well as in their family and other relationships (Weitzman, 1976).

Rutenfranz, Knauth and Angersbach (1981), and Scott and Ladou (1990), point out that distinguishing the health problems of shift workers related to desynchronisation of biological rhythms from those due to chronic sleep restriction is generally not possible because the majority of night workers complain of both sleep disruption and sleep loss. These sleep problems of shift workers are primarily a circadian one, resulting from the disruption of the normal sleep/wake rhythm. Sleeping at a different time than normal disrupts the normal circadian REM sleep rhythm, and the rhythm of REM-nonREM patterns. Sleeping during the day also reduces the sleep length, as the phase of the body temperature rhythm is not suitable for sustaining sleep during the day, resulting in the chronic sleep restriction discussed in the previous chapter (Scott and Ladou, 1990). Even employees who have worked nights for years continue to sleep less on workdays than day workers (Tepas and Mahan, 1989).

The poor sleeping habits of shift workers are of concern not only because the resultant worker fatigue can affect on-the-job-performance and therefore workplace safety, but also because sleep disturbances and chronic sleep restriction are often associated with
poor health, a higher probability of serious medical problems, chronic illness and somatic complaints, and possibly even reduced life expectancy (Lavie et al., 1989; Moore-Ede and Richardson, 1985; Scott and Ladou, 1990). According to Naitoh and colleagues (1990) the most critical information for occupational health specialists is the health consequences of loss of several hours of sleep repeatedly every day over many days or months, that is, chronic sleep restriction. In describing and evaluating the effects of different kinds of sleep loss on the functional integrity of humans, Naitoh and colleagues (1990) discuss many factors: adrenomedullary activity (i.e. the production of two separate catecholamines, adrenaline and noradrenaline, the so called ‘stress hormones’), adrenocortical activity (i.e. the main glucocorticoid is cortisol which reflects psychological states, increasing with arousal and anticipation of stress), metabolism, haematological, and immunological changes. A brief summary of these is offered here.

As for sleep loss and adrenomedullary activity, total sleep loss of three days or less causes neither significant increases in adrenomedullary activity nor circadian disruption of the adrenaline secretion rhythm if sleep deprivation is encountered under physically and mentally non-demanding environments. When total sleep deprivation takes place with high physical activity or mental workloads, under uncomfortable ambient temperature, or when people are particularly energetic in their efforts to maintain top performance by adopting a high work pace, a significant activation of the adrenomedullary system may be reflected in increased urinary catecholamines (Naitoh et al., 1990). As for adrenocortical activity, total sleep deprivation of up to 72 hours has little affect on glucocorticoids (i.e. cortisol), and does not cause the classical non-specific stress reaction (Naitoh et al., 1990).
As for metabolism, people expend more metabolic energy during a sleepless day than during a normal 24-hour cycle. The metabolism normally slows down during sleep, and this energy conservation does not occur during sleep deprivation. Biological energy is based on the adenosine triphosphate (ATP) system and total sleep loss might be anticipated to affect ATP, although the limited research available presents unclear explanations for this hypothesis. Under some circumstances, where sustained physical activities are required (e.g. total sleep deprivation in work environments requiring constant mental alertness and physical activity), the body may convert from carbohydrates as the primary fuel for biological energy to lipids. Lipids are a preferred energy source during total sleep deprivation. As total sleep loss continues, skeletal muscles and other tissues begin to derive more energy from the use of free fatty acids. Total sleep loss of two nights or more may result in switching the main energy substrate from carbohydrates to lipids to meet energy demands, resulting in increased plasma free fatty acids, increased plasma glucose, and sluggish plasma glucose use (Naitoh et al., 1990).

There are demonstrable haematological differences in response to partial and total sleep deprivation. These responses can vary widely among individuals, as they are affected by amounts of physical activity, diet and caloric intake, and especially age. In general, total sleep deprivation changes neither the erythrocyte count nor the hematocrit level. However, a drop in plasma iron is reported with modest to moderate amounts of sleep restriction, and concern exists over the rate at which the body returns to normal plasma iron levels. For example, Levi (1972) reported total sleep deprivation of just 24 hours resulted in serum iron decreases of 26% in older participants (average age 56 years).
while iron decreased by 52% in younger participants (average age 29 years). Erythrocyte sedimentation rate of the older participants increased by 38% and that of the younger participants by 168%. Such data concern medical specialists about the body’s abilities to reclaim or remove iron from plasma to return it to the erythropoietic system to ensure adequate oxygen carrying blood cells. The existent data then suggest that the effects of sleep deprivation per se on erythrocytes remain a bit unclear. In summary, the body’s iron equilibrium may be altered during sleep deprivation, and the addition of certain drugs or other stressors may lead to anaemia (Naitoh et al., 1990).

The effects of sleep deprivation on our immunological state are also not clear. It is common belief that the stress of losing sleep causes us to be more susceptible to illness, such as catching a cold. That is, immunodeficiency is generally believed to follow stressful life changes. However, scientific data directly linking sleep loss with serious immunological changes are limited. Reduced lymphocyte stimulation ability and neutrophil phagocytosis, and gradually increasing interferon production, can be expected after 48 to 72 hours of sleep deprivation, but these changes in cell-mediated immunity are too small to be of clinical significance (Naitoh et al., 1990).

4.2 Gastrointestinal Problems
Shift workers tend to have an increased prevalence of gastrointestinal (GI) complaints including the stomach and digestive problems such as peptic ulcer disease, gastritis, colitis, and gastroduodenitis (Mazzetti di Pietralata et al, 1990; Scott and Ladou, 1990; Thierry and Meijman, 1994; Vener, Szabo, and Moore, 1989). Scott and Ladou (1990) report a US NIOSH study (Colligan et al., 1980) of almost 900 workers, which found four health factors associated with night work or rotating shifts. The strongest
association was found for constipation (especially in women), and the use of medication for stomach or digestive problems (more frequent in men). Another NIOSH study of 2 400 workers found rotating shift workers to have a significantly higher incidence of digestive problems than non-shift workers (Scott and Ladou, 1990).

According to a review by Costa (1996) between 20 to 75% of shift workers with nights, compared to 10 to 25% of day workers and shift workers without nights, experience some form of gastrointestinal distress, from minor complaints (e.g. constipation, heartburn, gas, and disturbed appetite) through to serious gastrointestinal disorders, which may develop into chronic diseases such as chronic gastritis or peptic ulcers. This finding suggests that GI disorders may be two to five times more common among shift workers who experience night shift than workers who do not work any night shifts.

Somewhat alarming results have been found when former shift workers’ GI health is considered. Aanonsen (1959) found 2.5 times as many cases of peptic ulcer disease and twice as many other GI disorders in day workers who had left shift work for health reasons than in day workers who had never done shift work. For both current and past shift workers, GI morbidity was increased by 34%. In a retrospective cohort study, Angersbach and colleagues (1980) found a higher incidence of GI disease in both current shift workers and ‘dropouts’ than in day workers who had never worked shifts. It was observed that the digestive symptoms arising during shift work may not completely resolve even after a normal schedule is resumed (Scott and Ladou, 1990).

The increase of GI complaints reported among shift workers is thought to result mostly from the mismatch which occurs with shift work between the time of food ingestion,
that is the time when meals are eaten, and the timing of the endogenous circadian rhythm of the GI system (Costa, 1997; Waterhouse, Minors, Atkinson, and Benton, 1997). For normal day/night orientated persons meal times are usually consistent across the day, and occur at appropriate phases of the GI system’s endogenous circadian rhythm. Gastric secretions, acidity, motility, and absorption exhibit a circadian rhythm; digestive ability is highest across the day and is normally reduced significantly over the night. The night period, however, is the time when night shift workers usually eat their ‘lunch’ meal. Eating at the wrong time for the body can lead to stomach upsets, nausea, peptic ulcers, constipation and more, all of which are commonly reported among shift workers. These GI upsets may be exacerbated by the type of food that shift workers eat during the night, including unhealthy vending machine food (Costa, 2001b). Night workers tend to eat fewer meals, have poorer appetites, and are less satisfied with their eating habits. Since differences in eating habits have been observed in comparisons of non-workdays with workdays for night workers and not for workers of other shifts, a causal relationship is likely (Tepas, 1990). The endogenous circadian rhythm of the digestive system interacts with the exogenous timing, quantity, and quality of meals to increase the incidence of GI symptoms among shift workers.

Scott and Ladou (1990) point out that the role of excessive alcohol or caffeine consumption in shift worker GI problems is unclear. Some early studies (conducted in the 1970s and 1980s) found alcohol consumption to be higher in shift workers, while others have not. Caffeine consumption is generally assumed to be greater on the night shift, but in some plants it has been shown to be less for experienced night workers than for day workers (Scott and Ladou, 1990). A review by Tepas (1990) suggested that
caffeine, alcohol, and drug use does not differ between day and night workers once age, gender, and shift experience are controlled. Smoking habits of shift workers may also contribute to higher rates of peptic ulcer disease, but no reliable data are readily available to demonstrate consistent patterns (Scott and Ladou, 1990).

In the past two decades there has been a significant increase in health education and a general consciousness, or awareness of the detrimental effects of alcohol, smoking, and even caffeine on overall health and performance. Good diet and nutrition information and guidance has been widely available. Worker demographics and company health policies and philosophies vary among different industries and even from plant to plant within an industry or a particular large corporation. Thus it would be instructive to conduct newer surveys to obtain more current data regarding health consequences, and the incidence of health related problems associated with shift work (G. P. Krueger, personal communication, 2001). Some strategies to help shift workers reduce the likelihood of GI upsets are provided in chapter 10.

4.3 Cardiovascular Disease Problems
Shift workers appear to have a higher risk for cardiovascular disease (CVD) compared to day workers (Äkerstedt, Knutsson, Alfredsson, and Theorell, 1984). Alfredsson, Karasek, and Theorell (1982) in a Swedish retrospective study of 334 cases and 882 controls found men with a history of myocardial infarction (MI) significantly more likely to be shift workers than non-shift workers matched for gender and age. Michel-Briand, Chopard, and Guiot (1981) reported a greater incidence of heart attacks and high blood pressure in a group of 99 former shift workers than was found with 93 former day workers. In a 15+year longitudinal study of Swedish paper mill workers,
Knutsson, Åkerstedt, Jonsson, and Orth-Gomer (1986) compared health consequences of day workers to three-shift clockwise rotation shift workers. The relative risk of ischemic heart disease (IHD) increased with increasing length of time participating in shift work, this trend continuing over twenty years. The single most important predictor of IHD was age, but the second main predictor was the duration of shift work. According to a review by Costa (1996), the research indicates a link between shift work and cardiovascular disease, including a general increase in cardiovascular complaints and ischemic heart disease, an increased risk of myocardial infarction, and an increase in some risk factors for heart disease such as hypertension in apparently otherwise healthy shift workers.

A recent meta-analysis of CVD and shift work epidemiological studies conducted by Boggild and Knutsson (1999) concluded that from the most methodologically sound studies available, shift workers, compared to day workers, have a 40% increased risk of CVD. The “most reasonable risk estimate” based on all the data reviewed was therefore a relative risk of 1.4. According to Boggild and Knutsson (1999) it is not known whether this effect of shift work on CVD is chronic or acute, or whether individuals differ in their susceptibility to the effect of shift work on CVD.

Unlike the link between GI disorders and shift work discussed above, the nature of the relationship between shift work and CVD is not well understood, and is far more complicated. Many pathways have been suggested. Boggild and Knutsson (1999) suggested that the most likely path would be through the adverse life-style factors such as smoking, a poor diet, drinking, and lack of exercise, which are thought to be higher amongst shift workers. Boggild, Suadicani, Ole Hein, and Gyntelberg (1999)
suggested the link to be through the typically lower social class of shift workers. Tenkanen, Sjoblom, and Harma (1998) suggested that shift work may aggravate the effect of adverse life-style factors on CHD risk rather than having any independent effect. Others have suggested a more direct role for shift work itself, supported by the finding of a significant relationship between working irregular hours and cardiovascular events (MI and IHD) controlling for variables such as smoking (Åkerstedt, Alfredsson, and Theorell, 1986, in Thierry and Meijman, 1994). Further support for this position may come from the finding that the change in distribution of nutrient intake from diurnal to nocturnal that occurs with night shift work (with no change in the overall 24-hour composition of nutrient intake) has been shown to alter cholesterol levels in the blood, which might increase the risk for CVD for shift workers (Lennernas, Åkerstedt, and Hambraeus, 1994). Thierry and Meijman (1994) suggested the link to be most likely a combination of factors such as stress, shift work factors (e.g. changing schedules and long work hours), and an increase in CVD life-style risk factors. Knutsson and Boggild (2000) also suggested the most likely mechanism to be a combination of circadian rhythm disturbances, behavioural changes, and social disturbances and stress, which result from shift work.

There is not enough data available at present to clearly identify the pathway between shift work and an increased risk of CVD, even though it is well known that some relationship does exist. Two pathways have been researched in recent years in an attempt to clarify the nature of the relationship between shift work and CVD. These relate firstly to blood pressure, and secondly to the functioning of the heart itself.
4.3.1 Blood pressure and hypertension

A recent study by Ohira and colleagues (2000) demonstrated that exposure to shift work can lead to long-term increases in blood pressure, which is a risk factor for CVD. Ohira and colleagues (2000) studied the effect of rapidly rotating shift work on ambulatory blood pressure and long-term blood pressure changes, controlling for confounding factors such as body mass index, alcohol consumption, physical activity, and anger expression. Ambulatory blood pressure was measured at half-hourly intervals for 24 hours on the second day shift for 27 male shift workers and 26 male day workers from the same Japanese work plant. Long-term blood pressure records were obtained from retrospective yearly surveys conducted at the workplace. Both groups had worked their current schedule for more than six months, and the mean age was 31 years.

The results showed that the shift workers had a higher systolic blood pressure than the day workers, particularly during work hours (both groups being measured during a day shift). The blood pressure variability was also higher for the shift workers. The survey results indicated that the systolic blood pressure had increased significantly over time for the shift workers. While the mechanism for this increase in blood pressure is unknown, two possible pathways were suggested. The first was an increase in sympathetic nerve activity due to the shift workers obtaining less sleep than the day workers. The second was the shift workers’ tendency to suppress hostility and anger (indicated by higher ‘anger in’ scores), which has been shown to be associated with increased sympathetic activation and increased blood pressure. Overall, the shift workers had higher blood pressure, higher variability in blood pressure, and a long-term increase in systolic blood pressure when working shift work. This finding supports
previous findings that shift work can increase the risk for cardiovascular events, including coronary heart disease.

A study by Morikawa and colleagues (1999), while supporting the above findings, has suggested that the relationship may be complicated by the age of the workers. These authors studied the blood pressure of 1 551 day (n=997) and rotating shift (n=554) workers (all males) from the same Japanese factory over a five-year period (1990 to 1995). Workers were classified according to their work type (shift or day work) and whether they had remained in or changed from their original work type after the five years. Classifications were therefore shift-shift, day-day, shift-day, or day-shift.

When the results were analysed for work type only (i.e. day or shift with no separation of age), there were no significant difference in the cumulative incidence of hypertension for day or shift workers, including those who had changed their work type in the past five years. However, when the results were analysed according to 10-year age groups (18-29, 30-39, 40-49 years), the cumulative incidence of hypertension for the 18 to 29 year old shift workers who had remained shift workers for five years (shift-shift) was 11.9%. The cumulative incidence of hypertension for the same aged workers (18-29 year olds) in the other three work type groups (day-day, day-shift, shift-day) was much lower, between 3 and 4%. The 30 to 39 year age group did not show any significant difference. Within the 40 to 49 year age group, the shift workers who had transferred to day work (shift-day) was the highest at 17.8%, followed by the 40 to 49 year old day-shift (15%), shift-shift (11%), and day-day (8.4%) workers.
When relative risk estimates for hypertension were calculated using multiple logistic regression analysis, the young shift workers (under 30 years) were found to have a significantly higher relative risk for hypertension (compared to day workers) of 3.6 (controlling for age, body mass index, systolic blood pressure, and drinking habits). The shift workers in the 30 to 39 year old age group were not at a higher risk for hypertension than similar aged day workers. The only other group to show a significantly increased risk for hypertension was the 40 to 49 year old shift workers who had transferred to day work. They had a 2.5 times higher risk than similar aged day only workers (controlling for age only). These latter findings for the over 30 year olds may reflect the “healthy worker effect” common in shift work studies, which will be addressed later in this chapter (Morikawa et al., 1999).

The results suggest that young shift workers who remain in shift work for five years are at more than three times the risk of developing hypertension than similar aged day workers. As hypertension is a risk factor for CVD, they would have an associated increased risk for CVD. This effect may not be as noticeable for the older workers as the ones unable to cope with shift work are likely to transfer to day work (the “healthy worker effect”, to be discussed later in this chapter).

The findings of the above two studies (Morikawa et al., 1999; Ohira et al., 2000) indicate a chronic or long-term effect of shift work on blood pressure and the onset of hypertension. These results suggest that there is more to the relationship between shift work and CVD than simply a change in CVD behavioural risk factors such as alcohol consumption or body mass index, as both studies found significant results for increased
blood pressure (Ohira et al., 2000) or risk for hypertension (Morikawa et al., 1999) controlling for such variables.

4.3.2 ECG measures of heart function

A recent study by Murata, Yano, and Shinozaki (1999a) investigated the cardiovascular functioning of healthy shift workers and day workers to identify whether shift workers have any abnormalities in their cardiovascular functioning which may increase their risk for CVD. The authors investigated several cardiovascular parameters from healthy day (n=115, mean age 43.8 years) and rotating shift workers (n=337, mean age 43.2 years) (all male) from the same Japanese factory. Data were collected during two consecutive annual health screenings (1996 and 1997), which are required by the Industrial Safety and Health Law in Japan. Any worker with a disorder that affected cardiovascular or nervous system functioning (e.g. diabetes mellitus) was excluded from the study. The study measures included electrocardiographic (ECG), biochemical (e.g. cholesterol, triglycerides, blood glucose, and haemoglobin), physical (e.g. body mass index and blood pressure), and questionnaire information (e.g. smoking and alcohol usage). The ECG data were used to determine the “heart-rate corrected QT interval” (QTc), which provides a measure of the electrical conduction rate of the heart. A prolonged QTc interval (≥ 440 ms 1/2) occurs when the electrical impulses in the heart are conducted more slowly than normal (i.e. a greater time interval between depolarisation and repolarization of the heart), and has been associated with an increased risk of ischemic heart disease and sudden cardiac death, and the sudden death of patients with myocardial infarction (Murata et al., 1999a).
The data revealed no difference between the day and shift workers for blood pressure, however they did differ significantly in their QTc intervals. The shift workers had a significantly prolonged QTc interval for both years studied compared to the day workers. Multiple logistic regression analyses were conducted to determine the relative risk of shift work to the prolonged QTc interval. The adjusted relative risk values (adjusted by age, working duration, body mass index, biochemical variables, and smoking habit) were 4.41 (90% CI 1.16 to 16.8) for 1996, and 8.15 (90% CI 1.31 to 50.5) for 1997. These relative risk values did not reach statistical significance however, most likely because of the small number of shift workers with prolonged QTc intervals (n=13 for both years) (Murata et al., 1999a).

In a similar study, the same authors (Murata, Yano, and Shinozaki, 1999b) compared the QTc intervals between shift and day workers, this time with a 10-year interval between the measurement periods (1986 and 1996). They found significantly longer QTc intervals for the shift workers compared to the day workers at both measurement periods. While there was no significant increase in the QTc interval for the shift workers after the ten years, the day workers had a significant decrease in their mean QTc interval length after the ten years. The authors also compared the QTc intervals of the shift and day workers who had ‘normal’ QTc intervals in the initial measurement period (1986). While there was no difference between the groups initially (1986), ten years later (1996) the shift worker group had QTc intervals that were significantly longer than the day workers, although the difference was small and the values were still within the normal range. Multiple regression analyses indicated that within the normal QTc interval cohort group, shift work was significantly related to an increased QTc interval (Murata et al., 1999b).
According to the results of these two studies by Murata and colleagues (1999a, b), shift workers tended to have statistically significant (although clinically small) prolonged QTc intervals on their ECGs compared to day workers. As only healthy participants were included in the studies, and as the analyses were conducted controlling for many confounding variables (e.g. age, smoking, and drinking), the authors considered the findings to be “robust” (p. 751, Murata et al., 1999a). The authors suggested that the prolonged QTc interval was likely due to the long-term life-style changes that occur with shift work such as a disruption of the circadian rhythms and sleep patterns, increased fatigue, and increased work stress. As stated by the authors, however, this hypothesis requires further research to clarify, including studying many different shift work settings, and studying female participants (Murata et al., 1999a, b). Although further research is required, the authors concluded “it is likely that the increased risk for IHD [ischemic heart disease] attributable to shift work may be associated with prolongation of the QTc ...” (p. 752, Murata et al., 1999a). It may be that shift work, somehow, impacts on cardiovascular functioning, such as prolonging the QTc interval of the heart, which then increases the risk for CVD such as ischaemic heart disease.

These studies, as do the previous blood pressure and hypertension studies, suggest that the effect of shift work on CV health may be independent from any of the behavioural adverse life-style risk factors such as smoking or excess body weight. This area of research certainly deserves further attention.
4.4 Shift Work, Depression, and the Antidepressive Effects of Sleep Loss

There is limited information regarding the incidence of psychopathology, such as depression, amongst shift workers (Bohle and Tilley, 1989; Cole, Loving, and Kripke, 1990). Monk (1997) states that while there are some data regarding reports of depression among shift workers, the results are mixed. While some studies indicate increased reports of depression and psychopathology among shift workers (Akinnawo, 1988; Healy, Minors, and Waterhouse, 1993), other studies suggest either no relationship (Skipper, Jung, and Coffey, 1990), or they suggest that depression may actually be lower in shift workers (Goodrich and Weaver, 1998). For instance, Skipper, Jung, and Coffey (1990) obtained self-report questionnaire information from 463 female nurses (mean age 35 years), working either a permanent shift (day, afternoon, or nights) or rotating shifts (53.6%). The results indicated no significant relationship between mental health (depression) and shift work. Goodrich and Weaver (1998) investigated the mental health of 56 workers (mean age 34 years; 23 males; 32 shift workers), and found that the self-report of depression was not higher for the shift workers than the day workers. In this study the main sleep length reported by the shift workers (mean 6.8 hours sleep) was longer than in many shift work studies (typically six hours or less), and most shift workers reported good health. This finding suggests that the increased reports of depression found in earlier studies may be associated with the decreased amounts of sleep or poorer physical health common for shift workers rather than the shift work per se, although this hypothesis requires testing. Some of the discrepancy in the shift work literature may also be due to the lack of standard diagnostic criteria for depression used in this area. The link between shift work and depression remains elusive at this time, despite the fact that depression has been linked
with circadian dysfunction in the psychiatric literature for many years (Cole et al., 1990).

The health effects of sleep deprivation are not always negative, however, as medical intervention prescribing either total sleep deprivation, or REM sleep deprivation, has been established as an antidepressant technique for some time. According to Naitoh and colleagues (1990) total sleep deprivation provides temporary relief from depression in a third to a half of endogenously depressed patients, but is less effective for patients with involutional depression. Reactively depressed patients receive greater benefit from sleep loss if they have more somatic complaints such as disturbed sleep and poor appetite, and large diurnal fluctuations in moods, as compared with few somatic complaints and poor circadian rhythm. Typically a single night of total sleep deprivation is repeated over several weeks until the desired amelioration of depression is achieved. The patients must ideally remain awake between 0400 to 0600 hours to obtain the full antidepressant benefit from sleep deprivation, as this is the time when the majority of REM sleep usually occurs. It is generally believed that total sleep deprivation assists in resynchronisation of disordered circadian rhythms and re-entrainment to the 24-hour societal rhythm, and that total sleep deprivation lowers an abnormally high arousal level in depressive people. There is also some evidence that depriving some depressives of REM sleep can help ameliorate depressive symptoms. This procedure consists of awakening patients every time they go into REM sleep for six nights, or until 30 awakenings per night are reached (REM frequency increases as deprivation accumulates). Subsequently patients are permitted a single night of uninterrupted sleep. The REM sleep deprivation procedure is repeated until the desired amelioration of depressive symptoms is obtained (Naitoh et al., 1990).
of these phenomena to shift workers in terms of the potential anti-depressive effects that partial or total sleep deprivation might have on their psychological health are not known.

4.5 Shift Work and Women

As for gender, studies have indicated that women may experience adverse health effects with shift work. Studies reviewed by Costa (1996, 1997) indicate that female shift workers have higher frequencies of perturbation of the menstrual cycle and menstrual pains than non-shift working females. There is also limited evidence that at least the general fatigue levels associated with working shift work can have detrimental effects on women’s successful pregnancy outcomes. Scott and Ladou (1990) outline several studies prior to 1990 that examined the relationship of worker fatigue and pregnancy outcomes. For instance, in a survey of over 3 400 women interviewed after giving birth, Mamalle, Laumon, and Lazar (1984) found significant relationships between high fatigue ratings and premature births, while shift work was also found to be significantly associated with an increased risk of premature births. In another study, rotating shift work was associated with low birth weight, and a significant association was found in the services sector between rotating shift work and preterm birth (McDonald et al., 1988). Axelsson, Rylander, and Molin (1989) identified an association between irregular working hours and an increased risk of low birth weight and some evidence of risk of miscarriage as well. McDonald and colleagues (1988) also found an association between rotating shift work and an increased risk of spontaneous abortion. Scott and Ladou (1990) caution that no one of these individual studies conclusively identifies shift work as a significant risk factor for expectant mothers with respect to low birth weight, preterm delivery, or spontaneous abortion,
but taken together the studies implicate rotating shift work and its attendant sleep restriction and fatigue as an added stressor during pregnancy. More recent reviews (Costa 1996, 1997) have confirmed that women who work shift work have lower rates of pregnancy and deliveries, and an increased association with preterm deliveries and/or low birth weight babies. If the woman’s job necessitates strenuous work, heavy lifting, mental stress and so forth these stressors may be amplified by the shift work stressors (Costa, 1996, 1997).

Preliminary findings from two recent studies reveal that women who work night shifts may have an increased risk for developing breast cancer. The first study (Davis, Mirick, and Stevens, 2001) interviewed 813 female breast cancer patients and 793 age-matched controls about their sleep habits, occupational history, and breast cancer risk factors. The results indicated that women who had worked the night shift during the past 10 years had an odds ratio of 1.6, indicating an increased risk for breast cancer, compared to those who had not worked night shift in the past 10 years. A dose-response pattern was found, such that those women who worked more nights per week and those who had worked nights for a longer period of time, were at the greatest risk. The second study (Schernhammer et al., 2001) examined data collected as part of the Nurses’ Health Study. Over a 10-year period (1988 to 1998), 2 441 of the nurses were diagnosed with breast cancer. The work histories of these women were compared to those who did not develop breast cancer. The results revealed that those women who had worked between 1 and 29 years with at least three night shifts a month had a relative risk of 1.08 compared to those who had not worked such a schedule. When the nurses had worked for more than 30 years with at least three nights per month the relative risk increased to 1.36 compared to those who had not worked such a schedule.
Both studies hypothesised that the link between night work and the increased risk for breast cancer was due to the abnormal suppression of melatonin secretion during a night shift (as melatonin is normally secreted at night but only in darkness) and a subsequent increase in oestrogen levels, which stimulates breast tissue growth and some cancers. Although preliminary, the findings from these two studies raise the concern that night shift work may place women at an increased risk for developing breast cancer; a potentially life-threatening condition. Further research is required to confirm the degree of risk and to clarify the nature of the relationship before any recommendations can be made.

4.6 How are Shift Work and Ill-Health Linked?

While the mechanism linking shift work and ill-health has not been firmly established, there have been several models proposed. Some of the newer theories incorporate the concept of ‘stress’, and also the concept of ‘social support’ as important factors in the shift work – health relationship. Very few empirical studies have been conducted to test these theoretical models or concepts. Some of the proposed theories are discussed here.

4.6.1 ‘Control’ / ‘Autonomy’

One hypothesis involves the concept of control. Fenwick and Tausig (2001) investigated the hypothesis that it is not just the time of work, but also the degree to which workers can ‘control’ their work times, that influence the health and family outcomes, especially for shift workers. Data were obtained from the 1992 ‘National Study of the Changing Workforce’ US survey, which consisted of telephone interviews from a random sample of 3 381 adults. Only the full-time employed adults were used
in the analysis (n=2 905). Workers were classified according to four categories of ‘work schedule’; standard day shift, regular evening or night work, other than Monday to Friday work, and rotating shift workers. ‘Work schedule control’ was measured using a single item, which asked how much control the worker had over the scheduling of their work hours. This item did not allow any distinction between those able to choose an entire shift over those only able to make minor changes to their set shifts, such as the start and finish times. Health and family outcomes were measured using a number of scales, measuring physical, psychological, and social outcomes. Variables such as ‘work type’ (professional, white-collar, blue-collar, and service work), family, and individual characteristics were controlled in the statistical analyses.

The results indicated that the type of ‘work schedule’ had very little direct effect on the physical and psychological health measures. The shifts thought to create the biggest problems for shift workers, the non-day and rotating shifts, had no affect on health and family outcomes. In contrast, the effect of ‘work schedule control’ did have a highly significant affect on physical and psychological health outcomes. The lack of work schedule control significantly increased “lack of work-home balance, burnout, distress, dissatisfaction, poor general health, and minor physical problems” (p. 1 191). The only two outcomes not affected were work-home conflict and days sick in the last three months. It appeared that the negative health and family outcomes associated with shift work were attributable to the lack of control over work schedules rather than “problems of physiological, psychological, or social adjustment to non-standard schedules” (p. 1 191). The results of this study suggest that the negative effects associated with shift work may result from a lack of control over work times rather than the work times themselves.
Barton (1994) found similar results in her study with shift working nurses. Barton investigated the impact of choosing to work the night shift on the ability to tolerate shift work. Five hundred and eighty seven nurses (530 females), including 240 on permanent night shift and 347 on rotating shifts, completed two questionnaires which gathered information on sleep, health, and social disruption. The results indicated that the nurses who had chosen to work the night shift reported better shift work tolerance than those nurses who had to engage in night work as part of their roster. The permanent night nurses who had chosen their work hours reported significantly fewer symptoms of cardiovascular disease and non-domestic disruption, while there was also a non-significant trend for fewer health, sleep, and social disruption problems in these nurses. These findings are consistent with previous work by Barton and colleagues (Barton, Smith, Totterdell, Spelten, and Folkard, 1993), which indicated that having flexibility, or control over work hours, whether choosing permanent night shift or flexible rotating shifts, was associated with better shift work tolerance, especially for psychological health and sleep disruption, compared to non-flexible fixed shift systems. It would appear that having a choice in working hours, whether permanent night shift or choosing certain rotating shifts, may influence the ability to cope with working shift work hours.

Similar results were found by Bussing (1996), who used the term ‘autonomy’ rather than ‘control’ to indicate the level of influence that workers had in choosing their own work times. Bussing investigated the degree of autonomy for work time scheduling and the impact of shift work on psychological stress, burnout, and well-being. Self-report data were collected from 297 nurses (mean age 32 years; 89% female) from a
large German hospital, whose work schedules included day work, shift work, and permanent night work.

‘Autonomy for work time scheduling’ was a strong moderating variable for the effect of different work schedules on nurses stress, burn out, and well-being. Nurses who reported a higher degree of autonomy for their work time scheduling reported better coping with shift work with regards to fatigue, monotony, psychosomatic complaints, depression, personal accomplishment, tedium, and job satisfaction. The degree of autonomy for work time scheduling may be more important for some workers rather than others, such as those with increased demands or in certain situations such as being married or having children, or those with certain social commitments or obligations. These factors would make a high degree of work time autonomy a more important variable for those individuals, and may therefore have a greater impact on the health and well-being for these individuals (Bussing, 1996). This hypothesis requires further testing, and should be taken into account in future research.

How the ability to control one’s work hours actually impacts on the health and well-being of shift workers is still unclear. One possibility is that having the ability to choose the most convenient work times can create a positive attitude towards work, which in turn may help minimise some of the negative effects of the shift work, thus enhancing the ability to tolerate shift work. A study by Morrow, McElroy, and Elliott (1994) investigated the effect of preference for work schedule on work-related attitudes. Self-report questionnaire information was obtained from 272 nurses working in the US. They found that the shift-working nurses who were working their preferred schedule of work had more favourable work-related attitudes than nurses who were not
able to work their preferred work schedule. The nurses ‘job satisfaction’ was affected less by their work preferences than their attitudes were. Of the nurses not working their preferred times, those for who this was due to self-imposed reasons (e.g. family commitments) had more positive attitudes than those for who the decision was due to organizational reasons (e.g. company finances or protocol). Having some sense of control over work times may create a positive attitude about work, which may then have a positive impact on health and well-being, and thus the ability to tolerate shift work. This hypothesis certainly deserves further research attention.

4.6.2 Stress – a stimulus-based model

A recent study by Peter, Alfredsson, Knutsson, Siegrist, and Westerholm (1999) revealed that stress in the workplace might mediate the effect of shift work on health through the CVD risk factors of hypertension and high blood lipids. Stress was measured as an “effort-reward imbalance”, that is, a ‘high cost, low gain’ condition would lead to stress. Male shift workers (n=2 288) aged between 30 and 55 years from a range of work places participated in the study. They completed a questionnaire to collect psychosocial and behavioural information, and had a clinical examination to collect blood pressure and blood lipid measurements. Stress was found to mediate the relationship between shift work and the CVD risk factors of hypertension and high blood lipids. That is, stress mediated the effect of shift work for hypertension and to a smaller extent lipid ratios, for day and late shift workers. In other words, shift work increases stress, and this stress increases the CVD risk factors, particularly hypertension. The results may be limited by a “healthy worker effect”, as the night shift workers were younger and showed a decreased rate of hypertension with increasing age, compared to the day workers (Peter et al., 1999). Overall, the results
suggest that the negative effects of shift work on health, in particular hypertension, may be mediated by a stressful work environment, and further research is needed to address this area.

A stimulus-based model of stress such as this proposes that stress results directly from certain features of the work environment. A stimulus-based model therefore proposes interventions that will improve features of the work environment, such as shift work schedules and conditions such as the lighting, noise, and temperature levels of the workplace, to reduce stress. Studies have shown that some shift work rosters and work environments are better than others for workers’ ability to tolerate shift work. Several strategies to improve shift work rosters and the work environment are discussed in chapter 10.

4.6.3 Stress – a transactional (“stress-strain”) model

An alternative view of stress is the transactional model, which utilises a ‘stress-strain’ model of stress. According to this model, stressors from the environment (e.g. work and home) or from within the individual (e.g. age) can create a negative situation or ‘stress’ for the individual (e.g. sleep disturbance or family life disturbance). This ‘stress’ is appraised by the individual, who will then choose a coping strategy to help manage the stress. The choice of coping strategy will determine how much ‘strain’ will occur. Inappropriate or inadequate coping strategies will lead to high levels of ‘strain’. This ‘strain’ can result in short-term negative effects on physical and psychological health, and if left uncontrolled, it may develop into chronic illness (e.g. potentially the gastrointestinal and cardiovascular disorders common among shift workers).
Smith and colleagues (1999) examined a shift work adaptation model based on a ‘stress-strain’ framework. The results obtained, using data modelling and path analysis, confirmed the predicted hypotheses; the shift workers who engaged in passive coping strategies (e.g. avoidance) reported more short-term negative effects such as fatigue and anxiety, which were in turn associated with the development of chronic effects such as gastrointestinal and cardiovascular complaints. Those shift workers who had inflexible sleeping habits reported more sleep complaints than those with more flexibility. These results indicate that shift work coping strategies, in particular strategies for ‘sleeping’ and dealing with ‘non-work personal disturbances’, may have important implications for the long-term health of shift workers. The authors stated that their results “strongly suggest(s) a causal link between the experience of shiftwork and the development of serious health problems” (p. 216, Smith et al., 1999). Future longitudinal research is needed however to confirm the causal link implied by this model, as this study relied on statistical analysis rather than repeated measures. A repeated measures study would provide stronger evidence for a causal relationship. Further research is also needed to test other constructs such as specific work factors (e.g. location), and to test for interactive effects, which could not be tested in this study (Smith et al., 1999).

Unlike the previous stimulus-based model of stress, this transactional model proposes that stress results not from the environment directly, but from the cognitive appraisals an individual makes in response to the environment before deciding on a coping strategy. The worker’s choice of coping strategy then impacts on their health. The transactional model therefore proposes interventions that will change the way an individual evaluates shift work, and improves the coping strategies they have available to them for dealing with shift work (Taylor et al., 1997). Employee education
programs that teach effective coping strategies for dealing with shift work and stress are therefore needed to improve shift workers’ coping skills. Several strategies for coping with shift work are discussed in chapter 10.

### 4.6.4 Social support

Social support has been investigated as a possible component in the shift work/health relationship. The role of social support in moderating the stress of shift work was studied by Schmieder and Smith (1996). It was hypothesised that the perceived social support of the shift worker could moderate, or “buffer”, the stressful outcomes of shift work. Information was collected via self-report questionnaires from shift working and non-shift working nurses (overall n=191, mean age 35 years, 96% female). Perceived social support from supervisors, co-workers, spouse, friends, and relatives was measured. The negative outcome of ‘job strain’ was measured by job satisfaction, intent-to-quit, and perceived health, while ‘job-related stress’ was measured by role ambiguity.

The statistical analyses indicated that social support in the form of non-work support had a moderating, or buffering effect, and helped to reduce the negative effects of work stress on ‘job strain’ (job satisfaction, intent-to-quit, and perceived health). Further statistical analyses indicated that social support from work also had a buffering effect, with support from supervisors buffering the effect for job satisfaction and intent-to-quit, while support from co-workers buffered the effect for job satisfaction. Those shift workers that perceived support from their supervisors and co-workers did not suffer from as much work stress, and therefore did not have such negative work attitudes as those without social support (Schmieder and Smith, 1996). Overall, the study
indicated that support from work colleagues is important for shift workers to buffer their work stress. If social support can moderate the stress of working shift work, this may be able to moderate the effect of shift work on health, by reducing stress, although this hypothesis requires further research.

Pisarski, Bohle, and Callan (1998) investigated the role of social support and coping strategies as mediating factors in the relationship between 'structural work-nonwork conflict' (i.e. when work commitments limit the time available for social commitments) and health in shift workers. One hundred and seventy two female nurses (mean age 27 years), working rapidly rotating schedules, completed questionnaires asking about psychological and physical health, structural work-nonwork conflict, coping strategies, social support, and control of shifts. The research found that social support, structural work-nonwork conflict, and coping strategies all had influences on the health and well-being of the shift workers, through various direct and mediating routes. Although the interactions found in this study were complex and further work is needed to examine the various forms of social support and coping strategies that can occur, the research highlights the need for shift workers to have effective social support and coping strategies, as having these may improve their health outcomes.

4.6.5 Summary
As has been discussed, there have been many theories proposed to explain the link between shift work and poor health. Several factors have been suggested as important variables in the relationship. These factors include characteristics of the job, the work environment, workers’ coping strategies, and the presence of social support for the worker. The choice of which theory to adopt is very important, as this will determine
the direction that intervention strategies will take, such as changes to the work environment or changes to the worker and their family. This is discussed in detail in chapter 10.

4.7 Shift Work and Health Research - Study Limitations

While there has been substantial research conducted in this area of shift work and health, the research has several limitations. These limiting or confounding factors are discussed below.

4.7.1 Methodological differences

According to Boggild and Knutsson (1999) and Costa (1996), there are several confounding factors present in the shift work and health research that may explain the many different findings among studies. These confounding factors include the differences in method of data collection used (e.g. self report to full medical examination), the definition of ‘health’ (e.g. CVD can range from mildly increased blood pressure to myocardial infarction mortality), the specific characteristics of the workers studied (e.g. age, gender, shift work experience), the definitions of ‘shift work’ (e.g. the type of shift schedule), the reference ‘day group’ used (e.g. this may confound socio-economic factors, age, work conditions, job stress, and shift work selection factors), and the kind of study design used (e.g. cross-sectional or longitudinal, retrospective or prospective, cohorts or case-reports). These factors can vary greatly among studies, and as they can significantly affect the results obtained, the overall conclusions that can be made from each study and the ability to compare studies is significantly limited.
4.7.2 The “healthy worker effect”

Another confounding factor in the shift work and health research is the “healthy worker” or “survivor” effect. This is the tendency for shift workers who feel that shift work is making them ill to leave shift work and transfer to day work. The result of this is that the population of shift workers who remain to be studied are therefore individuals who are fairly healthy and able to cope with the demands of shift work. The ‘sick’ shift workers who were unable to cope with shift work (including those for whom a demanding shift work schedule combined with other pre-existing stresses to produce or increase poor health) are no longer in the job and are therefore not included in the shift work studies. This self-selection out of shift work leaves only ‘healthy’, ‘surviving’ shift workers to study. This effect may hide the accumulation of health problems early on in shift work. As workers age and have more exposure to shift work, the health problems may become more obvious. The self-selection out of shift work may occur again for older workers as their coping strategies loose effectiveness (Ottmann, Karvonen, Schmidt, Knauth, and Rutenfranz, 1989). There may also be a “healthy worker effect” in the self-selection process of individuals who choose to apply for shift work positions initially (Knutsson and Åkerstedt, 1992). The “healthy worker effect” may limit the findings and underestimate the health risks associated with shift work (Cole et al., 1990; Frese and Okonek, 1984; Monk and Folkard, 1992; Tepas, Paley, and Popkin, 1997; Thierry and Meijman, 1994).

This “healthy worker effect” can be seen in a study conducted by Bourdouxhe and colleagues (1999). Information was collected from workers at a petroleum refinery using a number of methods, including questionnaires and interviews. Information was collected regarding sleep and fatigue, health, workload, family life, job satisfaction,
safety, and knowledge about shift work. Current shift workers (n=80) and former shift workers (now transferred to days; n=16) were included. The shift schedule was a rapidly rotating roster with 12-hour shifts. Looking at the health of the shift workers, the typical digestive, cardiovascular, and psychosocial disorders were found. An important finding, however, was that there were 40% more health complaints diagnosed (including digestive complaints, high blood pressure, asthma and allergies, back problems, and obesity) among the former shift workers than the current shift workers and day workers. While it is possible that these former shift workers started out with pre-existing conditions that were aggravated by shift work rather than the shift work on its own causing their poor health, the results highlight the importance of the selection bias, or the “healthy worker effect”, in shift work and health studies.

4.7.3 Absenteeism data

Another source of potential confounding involves the use of ‘absenteeism’ as a measure of shift worker adaptation and health (Costa, 1996; Thierry and Meijman, 1994). Thierry and Meijman (1994) state that while the duration of absenteeism of shift workers may be slightly higher than day workers, the frequency of their absenteeism is usually not, and may actually be lower than day workers. It was noted by Costa (1996) that while rotating shift workers tend to report an increase in health complaints, they are less likely to take sick leave than day workers. This finding that shift workers tend to take fewer sick days has been interpreted in several ways in the literature including: a self-selection of healthy workers starting shift work; a higher feeling of solidarity or social pressure to come to work among shift workers; easier access to day time services for shift workers thus ‘sick’ days are not required for appointments; and a tendency for shift workers to underestimate slight health complaints and to continue working while
experiencing minor health symptoms and conditions, but for which a day worker would be more likely to seek medical advice for. According to Thierry and Meijman (1994), shift workers often complain that social life disruptions are more ‘important’ or detrimental to them than the minor health or well-being problems they experience as these are considered part of the job! It is unclear whether or not this tendency to underestimate illness is related to the development of further health complaints among shift workers (Thierry and Meijmam, 1994). This tendency to take fewer sick days, and a tendency to underreport minor health complaints by shift workers may lead to the health effects of shift work being under reported in the literature.

4.7.4 Job dimensions

When examining the effect of shift work on health, an important issue must be considered, which is that the job dimensions often differ between shift work and day work positions. So apart from the different work times, the actual objective and subjective job characteristics or content can differ between day and shift work positions. While this concept has been discussed in chapter 2 in relation to shift work and accident risk, this difference is also an important factor when considering the health effects of shift work.

Blau and Lunz (1999) found that even when examining the same job type (medical technologists), there were differences in the job content between those employed in day positions and those employed in shift work positions. The permanent day staff in the study reported having ‘more enriched’ jobs, a higher level of perceived complex tasks, more professional participation, and better work satisfaction with regard to work and supervision, than evening, night, and rotating workers employed in the same job (Blau
and Lunz, 1999). These results highlight the fact that the dimensions of a job can vary between the different shift types even for workers employed in the same job position.

A recent study by Parkes (1999) also addressed this issue. Questionnaires were completed by 1320 male personnel (day workers, n=680; shift workers, n=640) working on North Sea oil and gas installations. The author found that ‘shift work’ and ‘job type’ were associated with different health outcomes; ‘shift work’ predicted gastric complaints and sleep problems, while ‘job type’ predicted musculoskeletal complaints, headaches, and work related injuries. It is therefore important to remember these differences when examining the effect of shift work, as the difference between job content may explain some of the differences found between day and shift workers rather than just the presence of shift work itself.

According to Thierry and Meijman (1994), apart from differences in job content above, shift workers on evening and night shifts are often exposed to more environmental stress at work, including increased noise, sub-optimal temperatures, poor ventilation, inadequate lighting, increased work monotony, and increased physical work demands. These factors should also be taken into account when looking at the health effects of shift work compared to day work.

As there appears to be a degree of confounding between ‘shift work’ and ‘job type’, the effect of job type must be controlled in shift work studies, especially when job type can differ significantly between day and shift work positions. The implication of this finding is that previous research demonstrating health effects from shift work may be confounded by the different job dimensions between shift and day positions. This
implication must be considered in future research, with research investigating shift work and health effects controlling for the difference in job types between shift and day work.

4.7.5 Lack of longitudinal studies

As pointed out by Åkerstedt (personal communication, 2001), a major limitation with the available shift work and health research is that there are no longitudinal studies of the effects of shift work on long-term health. All of the studies to date have been cross-sectional in design. Cross-sectional designs compare data collected at the same point in time from different populations of participants, such as some workers starting shift work and some experienced shift workers. While cross-sectional studies provide indicative information about the possible long-term effects of shift work, the results are limited to demonstrating an association between duration of shift work and poor health and do not necessarily establish a causal connection. This is because the populations may differ on some other variables other than just duration of shift work, thus making a causal interpretation of the link between shift work duration and poor health unproven.

A further problem with the cross-sectional studies is the “healthy worker effect”. That is, the long duration shift work group will have lost members who experienced adverse health effects with shift work. This may result in the adverse health effects of shift work being underestimated from cross-sectional studies. In longitudinal studies the same population of participants are studied over time, such as when workers start shift work and at several points in the future. Workers who have remained shift workers as well as those who have left shift work can therefore be followed over time. This methodology removes the possibility of extraneous differences between groups of shift
workers and the “healthy worker effect” confounding the results. Differences observed between observations can therefore be attributed to individual change rather than differences between groups.

Longitudinal studies allow for predictions to be tested, controlling for potential confounding factors, thus establishing a causal link between shift work duration and poor health rather than the correlations obtained with cross-sectional studies. Longitudinal studies are desperately needed to examine the long-term health effects of shift work.

4.8 Summary

Scott and Ladu (1990) point out that adverse health effects from shift work, such as GI and CV problems, may not show up for several years, perhaps only appearing after as many as five or more years of working shift work, or after ceasing to engage in shift work, especially night working hours. The prevalence of health complaints in shift workers may actually be underestimated, due to several reasons such as the methodological limitations of many studies, the “healthy worker effect”, or shift workers’ tendency to ignore minor health complaints and to continue working. While the link between shift work and adverse health complaints is unknown, research has uncovered several variables that may be important. These include aspects of the work itself (such as the job dimensions, the work environment, and the ability of workers to choose their own work schedule), and aspects of the workers themselves (such as their coping strategies and the amount of social support available to them). All of these variables have been shown to have an impact on the occurrence of health complaints among shift workers, while a combination of stressors may be more detrimental to the
health of shift workers than any single stressor. Improving these aspects of shift work may reduce the negative impact of shift work on health. Further research is also required to establish the causal role of the many shift work scheduling factors to be discussed in chapter 6 (such as rotation direction and the number of nights worked), as these may be important factors that can be easily modified if found to limit the negative impact of shift work on health and well-being (Boggild and Knutsson, 1999).
5. FAMILY AND SOCIAL LIFE

Disruption in social and domestic lifestyle is a major consequence of shift work. Shift workers generally find themselves disadvantaged when it comes to their ability to participate in family and social activities. Afternoon shift workers generally have to work during the time when many family and social activities are normally planned (e.g. school concerts, dinner parties). The time off from work that shift workers have can often occur on weekdays rather than on weekends and so when others are at work or school, and it can often be variable, which can make regular commitments difficult. A proportion of time off for shift workers must also be used for catching up on lost sleep, therefore requiring more sleep per night than usual, often for up to three days after the last night shift. Until the sleep debt has been repaid, shift workers can feel tired and irritable, which can reduce the quality of their time off. This includes the time that they spend with their partner or child(ren). Shift work can therefore not only reduce the amount of convenient time available to spend with family and friends, it can reduce the quality of their time off, with the chronic fatigue, tiredness, lethargy, irritability, and ill health often associated with shift work increasing the stress and tension of their personal interactions and relationships (Costa, 1997; Thierry and Meijman, 1994; Walker, 1985).

While it is generally perceived that the family and social relationship problems experienced by shift workers result from their work schedules, Colligan (1980) and Colligan and Rosa (1990) point out that at least prior to 1990 most research on the effects of shift work on family and social relations relied almost exclusively on univariate, cross-sectional, self-report surveys of male shift workers, and therefore were
subject to response bias that rarely permitted conclusions about the direction of causality. For example, from many early approaches it cannot be determined whether rotating shift work causes marital dissatisfaction, or whether unhappily married people choose rotating shifts to escape domestic strife. To some extent this may still be an issue with this area of research. There are few, if any, studies at present that can precisely identify the nature of the relationship.

Several areas of family and social life in relation to shift work have been addressed, including the impact of shift type on free time, which influences both personal and family time, and the impact of shift work on the partner and children’s lives.

5.1 Family and Social Adjustment as a Function of the Type of Shift

Colligan and Rosa (1990) reviewed the effects of shift work on worker family and social adjustment according to the type of shift worked. According to their review, one of the most comprehensive studies in this area was conducted by Mott and associates at the University of Michigan in 1965 (Mott, Mann, McLoughlin, and Warwick, 1965). Mott and colleagues surveyed 661 male shift workers (on fixed afternoon, fixed night, and rotational schedules) and their wives, about the perceived impact of work schedules on a variety of spouse and parent role activities. The responses were compared to 252 male workers on fixed day shifts, although they were unable to interview the wives of these day workers.

The results were the most positive for the permanent day shift in almost every indicator of personal and social adjustment. Permanent day workers showed the highest overall level of shift satisfaction; only 6% expressed a desire for a different work schedule.
They also indicated the highest marital satisfaction, family integration and coordination, and avoidance of domestic friction. They had the highest rate of membership in formal organizations (e.g. churches, fraternal societies, athletic clubs, and so on) and they were more likely to hold positions in these organizations than workers on other shifts. Similar results were found in a subsequent survey by Frost and Jamal (1979).

Mott and colleagues (1965) found that fixed afternoon shift workers reported more sleep and fewer health complaints than fixed night or rotating shift workers, a finding replicated by Tasto, Colligan, Skjei, and Polly (1978). With respect to family responsibilities, however, afternoon workers reported the most dissatisfaction with the amount of time available for companionship with their wives and for relaxation and diversion from household responsibilities. They also expressed concern about being unavailable to provide protection and security for their wives during the later hours of their shifts. Similarly, Wedderburn (1978) in a survey of 815 UK steel workers found 79% of the workers on an afternoon schedule felt their shift restricted their social and family life, compared to 7% of workers on a day shift.

Colligan and Rosa (1990) state that although the night shift is consistently regarded as the most disruptive of all shifts in terms of physiological adjustment and well-being, from the perspective of family and social adjustment, the fixed night shift may actually be preferred to the afternoon shift because it allows the worker to be awake and at home with the family during the morning and early evening hours (Mott et al., 1965). Relative to the afternoon and rotating shifts, the fixed night schedule affords more usable time for family and social interaction, albeit at the physiological cost of lost
sleep. Tasto and colleagues (1978) found workers on fixed night schedules were more satisfied than afternoon or rotating shift workers (but not day workers) with the amount of time they had for personal activities, running errands, sports, and other social activities. However, not enough is known about the impact of night work on the nature and quality of family life, or on the costs involved in maintaining ‘normal relationships’ for these workers.

As for rotating shift workers, Colligan and Rosa (1990) suggest these workers experience some of the best advantages and worst disadvantages of each of the fixed shifts. On day shift, the workers sleep and eat according to a diurnal schedule. They are free to socialize during the evening but are occupied at work during the daylight hours. Thus day work prohibits day time leisure activities (such as shopping, some sports like golfing, and so on). The afternoon shift also follows the normal diurnal physiological pattern and allows for a lengthened sleep period. The disadvantage of afternoon shifts is the forfeiture of those family and social activities that take place in the evening. On the night shift, the worker experiences reduced sleep and physiological asynchrony, but has time for day time and early evening activities. In terms of social and family adjustments, rotating work schedules can produce some unique problems. Mott and colleagues (1965) reported the wives of rotating shift workers complained of problems scheduling events because of their husbands’ variable schedules. Both workers and wives listed fewer friends than fixed day shift workers and reported more family friction and interference between work schedule and family activities. Men on rotating shifts also reported problems with sexual relations, finding time for companionship with their wives, and communicating with their children.
The type of shift work schedule can play an important role in determining the outcome of the shift work on family and social life adjustment.

### 5.2 Leisure Time for Shift Workers

The type of shift schedule worked can also affect the personal leisure time available to a shift worker. According to Mott and colleague’s survey (1965), night shift workers reported more usable time off compared to the other types of shift workers. The night shift workers reported more time available to help their wives with the housework than afternoon and rotating shift workers, and they reported more time for solitary personal activities such as gardening, fishing, and home maintenance than day shift workers.

Staines and Pleck (1984) used a Quality of Life Survey to ascertain that while afternoon shift workers reported having more time available for housework than day workers, they reported more conflict between their work schedule and the requirements of family life. Tasto and colleagues (1978) also reported that afternoon shift workers were unhappy with the amount of time available for participating in sports, social gatherings, and personal activities compared to day workers. These findings are consistent with the pattern of work and off times for afternoon shift workers. Much of the conflict for afternoon shift workers is due to the mismatch of their schedule with those of others, which is usually the standard day-work, afternoon-off, night-sleep routine. This source of conflict can be seen in a survey by Hornberger and Knauth (1993), who found that rotating shift workers gave the highest leisure time value ratings to the weekday evening hours and the weekend days, consistent with the day working norms of society.

Depending on when time off occurs for shift workers, differences may occur in the types of activities they engage in. The differences in leisure time activities of day and
shift workers were studied by Fischer and colleagues (1993). Questionnaires asking about leisure activities were completed by day and shift workers (mean age 35.2 years) from two Brazilian petrochemical plants. One of the plants used a weekly forward rotating schedule (at Cubatao), while the other used a rapidly rotating schedule (at Santo Andre). Both systems were continuous with a 28-day cycle, which allowed 7 days off (although scheduled differently at both plants), including one weekend off, per cycle.

Differences were found between the day and shift workers in their leisure time activities. From both plants, the day workers reported more frequent ‘breakfast’, ‘dinner’, and ‘home repairs’ than shift workers, while the shift workers from both plants reported more frequent ‘lunch’, ‘non-work transportation’, ‘home rest’, and ‘shopping’ than the day workers (Fischer et al., 1993).

Differences also occurred depending on the type of shift work schedule, particularly the number of social activities that workers were involved with. Those on weekly rotating shifts (Cubatao) had more social contact than those on rapidly rotating shifts (Santo Andre). This difference may have resulted from the different number of days off provided after the night shift with the two rosters. With the weekly roster (Cubatao) workers had four days off after night shift, while those with the rapidly rotating roster (Santo Andre) only had two days off after night shift. The fewer number of days off after night shift may not have provided workers enough time to catch up on their sleep and to spend time with family and friends, therefore their social activities had to be limited. This position is supported by the finding that ‘home rest’ and ‘naps’ were placed 6th and 7th of the 14 most frequently mentioned activities in Santo Andre
(rapidly rotating roster), while ‘home rest’ was 11th and ‘naps’ were not listed in Cubatao (weekly roster). The extra time off provided with the weekly roster (Cubatao) allowed the workers adequate time to recover from their work related fatigue and allowed adequate time to spend with family and friends (Fischer et al., 1993).

When the differences between shift and day workers were examined in more detail, it was found that the majority of activities differed between the day and shift workers at both plants (with the different shift work rosters). Only ‘staying at home’, ‘shopping’, and ‘bathing/showering’ did not differ between day and shift workers in Cubatao, while all 14 most frequently mentioned activities differed between the day and shift workers at Santo Andre (Fischer et al., 1993).

The results demonstrate that there were differences at each plant between the day and shift workers with regards to how they spend their leisure time. There were also differences in the frequency of leisure activities between the shift workers who were working different roster schedules. Working shift work as opposed to day work, and also the type of roster worked, can affect the type of activities workers choose to engage in during their time off. Further research is required to find out whether these differences indicate any sort of disadvantage to the shift workers, as the importance of the activities was not assessed in the present study (Fischer et al., 1993).

5.3 Partners

Shift work has been shown to have a negative impact on the shift workers’ family and social life, as reported by the shift worker. The impact that shift work has on the shift workers’ family, as reported by the family directly, has rarely been studied.
In the early survey study of Mott and colleagues (1965), the wives of the permanent afternoon workers felt their husbands’ work schedules interfered more than day schedules would with their own abilities to provide companionship to their husbands, and expressed the notion that evening hours should be an important time for husbands and wives to catch up on the day’s activities, share personal problems and concerns and enjoy one another’s company, but that these important times were affected by the husband’s work schedules. These wives also expressed concern about the security issue of not having husbands home in the evening and night hours. Mott and colleagues (1965) also found that while the workers on fixed night shift complained of difficulty coordinating time with their partner, the wives of these workers were even less satisfied than their husbands with the amount of time for companionship allowed by the work schedule.

A more recent study that investigated the effect of shift work on the shift workers’ partner themselves was conducted by Smith and Folkard (1993). Questionnaires were completed by 47 female partners (mean age 39.3 years) of male shift workers all from the same work site. Only two of the partners were shift workers themselves. The shift work schedule of the men was a forward rotating, continuous 5-week roster, with either seven or four nights depending on the job type within the plant. The questionnaires asked the partners how the shift work of their partner affected them personally.

A significant 53.3% of the partners said they were ‘fairly unhappy’ or ‘very unhappy’ with their partners’ work schedule. A high level of disruption to their lives was reported by the partners in the areas of ‘adapt life to husband’s rota’ (>65% of
partners), ‘high conflict with partner’ (>70% of partners), and ‘joint life suffers’ (>60% of partners). When asked the degree to which they had to alter their lives because of their partners’ work schedule, more than 80% said they had to keep the ‘noise levels down after nights’ (i.e. after the night shift), over 60% said they had ‘meals made/eaten at odd times’, and close to 70% said they were ‘alone during the evening’ and ‘night time’. When asked which constraints caused them concern, over 60% were concerned about being ‘alone during the evening’ and ‘night time’, over 60% were concerned about keeping ‘noise levels down after nights’, and more than 50% were concerned about the ‘meals made/eaten at odd times’. Overall, moderate to high levels of total disruption were reported by 67.6% of the partners, with the disruption to the partner being the greatest when the husband was working the night shift (Smith and Folkard, 1993).

Another study which examined the impact of shift work on family life, as revealed by the partners, was conducted by Hertz and Charlton (1989). Hertz and Charlton (1989) interviewed 44 married couples where the husband was a rotating shift worker with the security section of the U.S. Air Force. The men worked two shifts, ‘mid’ (2300 to 0700 hours) and ‘swing’ (1500 to 2300 hours) shifts, with a nine-day cycle (i.e. six work days followed by three days off). Of the 44 couples, 28 had one or more children at home.

The wives reported that their lives were affected by their husband’s shift work hours. The wives took on the major responsibility of maintaining a ‘family life’, which they did in three main ways. They continually altered the time periods in which family events/activities took place according to the husband’s shifts (which often meant
preparing extra meals), they altered the children’s routines so that the children could either spend some time with their fathers or they were kept away so the husband could sleep, and the wives suppressed their own feelings of boredom, neglect, isolation and frustration with their husband’s work schedule and changed their routine around which often meant missing out on sleep, so that they could spend some time with their husband (Hertz and Charlton, 1989). The wives’ routines were disrupted by their husbands’ shift work schedules.

It would appear from these results that while shift workers themselves report shift work interferes with their family and social life, the partners of shift workers also believe that the shift work interferes with their lives. As the above studies concentrated on female partners of shift working males only, further study is required to examine the impact of shift working females on their male partners, as the impact may be different. Further study is also required to examine the effect that different types of shift work rosters, including day work, have on the level of personal disruption experienced by the partner.

5.4 Children

The interaction of parents with their children is vital for the development of a child. As social and domestic disruption is a major consequence of shift work, it is possible that the shift work of parents may have a negative impact on their children. Although this is an important area for concern, very few studies have addressed this issue.

According to Colligan and Rosa (1990), most of the dissatisfaction associated with a fixed afternoon shift schedule is related to its impact on the parenting role. Workers on
a fixed afternoon Monday to Friday schedule (e.g. working hours such as 1400 to 2230 hours) spend five days of every week without seeing their school-age children. The children are at school in the morning and early afternoon when the worker is at home, and the children are at home in the late afternoon and early evening, when the worker is at his or her job. This can lead to fewer and more strained parent-child interactions. Mott and colleagues (1965) support this assertion, reporting that workers on fixed afternoon shifts expressed more difficulty communicating with their children than workers on any other shift. Tasto and colleagues (1978) reported similar results in a survey of 1 200 nurses and food process workers on fixed and rotating shift schedules. Afternoon shift workers were more dissatisfied with the amount of time spent with their children and reported less involvement in rearing and disciplining their children than did workers on day shifts. Tasto and colleagues (1978) found workers on fixed night schedules were more satisfied than afternoon or rotating shift workers (but not day workers) with the amount of time they had for being with their children, including child-rearing and disciplining activities.

Colligan and Rosa (1990) point out that rotating shifts can be a particular problem for parents of young children because it is difficult to find child care providers who will work the same rotating shifts as these workers. This concern for child care is often one of the reasons that shift workers, such as nurses, will commonly choose to work a fixed night shift schedule rather than a rotating schedule.

A recent study that investigated the impact of shift work on the worker’s child(ren) was conducted in the UK by Barton, Aldridge, and Smith (1998). These authors studied the effect of shift working fathers on their children. They hypothesised that the children of
shift working fathers would have increased reports of depression, lower levels of perceived competence, and more negative self-perceptions than children of day working fathers. One hundred and ninety children participated in the study, 91 had shift working fathers and 99 had day working fathers. The age of the children ranged from 8 to 11 years. The children completed two questionnaires, the Self-Perception Profile for Children, which measured global self worth and perceived competency in five areas (academic, sporting, behaviour, social acceptance, and physical appearance), and the Children’s Depression Inventory, which measured depression.

A significant main effect was found for gender and ‘overall depression’ and ‘interpersonal problems’, with girls reporting higher levels than the boys on both. A significant main effect was also found for paternal working hours and ‘perceived academic competence’, with children of day working fathers reporting higher perceived levels of academic competence than children with shift working fathers. As gender differences tend to exist for children’s perceived self-competency in many areas, the perceived competency data from the boys and girls were analysed separately (Barton et al., 1998).

Comparing the girls with shift versus day working fathers, and the boys with shift versus day working fathers, revealed significant differences for the girls only. The girls of shift working fathers reported poorer perceived academic competence and lower self-worth scores (indicated by a greater discrepancy between their perceived and ideal levels of competence) than the girls with day working fathers (Barton et al., 1998).
Comparing the sons versus daughters of shift working fathers, and the sons versus daughters of day working fathers, revealed significant differences in both groups. In the shift working father group, the girls reported greater levels of depression, lower self-worth scores (a greater discrepancy), more negative mood, more interpersonal problems, and more anhedonia than the boys. For the day working father group, the girls reported more interpersonal problems than the boys, which was the only significant difference (Barton et al., 1998).

It would appear that the daughters of shift working fathers experienced greater problems compared to daughters with day working fathers and compared to boys who have a shift working father. The daughters of shift working fathers reported poorer competencies, including academic competence, and poorer self-worth than girls with day working fathers, and they were significantly more depressed compared to the sons of shift working fathers (Barton et al., 1998).

The gender differences found in this study may have been influenced by the particular measures used in the study. Girls are thought more likely to internalise emotional difficulties, and therefore to report more symptoms like depression, whereas boys are thought more likely to externalise their emotional difficulties, and therefore respond with external signs such as conduct disorders, rather than report internalised symptoms like depression (Barton et al., 1998). Such externalising measures of emotional state were not measured in this study, thus further research is required to address this gender issue.
The differences within genders between those with shift and day working fathers was thought to be due to the increased stress and family conflict that can occur with shift work, although these variables were not measured. An increase in depression among shift working fathers could also be responsible for the differences, although paternal depression was not measured in the study. Social class was also not measured, which may be an important influence on the development of competencies, particularly academic competency. Although limited, this study does indicate some psychological differences between children who have shift working fathers compared to day working fathers, especially for girls (Barton et al., 1998). An important question that this study raises is whether there are similar differences between children when their mothers, rather than their fathers, are the shift working parent. The effect of shift working mothers on their children needs to be addressed.

5.5 Partners and Children

The question of how shift work may impact on the psychological well-being of children in the household remains elusive at this time. A recent study, which has investigated the impact of shift working men on both their spouses and children, goes some way to suggest a possible route. Pati and Chandrawanshi (2001) measured the anxiety levels (trait, state, and free-floating anxiety) and mental health status from female spouses (n=133) and children (n=263, aged 15 years and over) of shift working and day working men using self-report questionnaires.

The results indicated that free-floating anxiety (which is a generalized, non-situational anxiety) was significantly higher for both the spouses and children (with boys and girls experiencing similar levels as each other) of shift working men compared to the
spouses and children of day working men. The spouses of shift working men also reported a significantly lower mental health status compared to the spouses of day working men, while the male children with shift working fathers reported lower mental health than females with shift working fathers (Pati and Chandrawanshi, 2001).

As according to the authors, the likelihood of developing a psychological disorder is higher if a relative has the disorder, it was suggested that the higher levels of anxiety in the children of shift working fathers may be attributed to the higher levels of anxiety seen in their mothers. Whether or not this increased maternal anxiety level was due to the stress of living with their partner’s shift work lifestyle, as was hypothesised, needs investigating. Another possibility is that the shift working men had higher levels of anxiety than the day working men, and therefore had a direct effect on their child’s anxiety level, rather than an indirect effect through the increased anxiety of their spouses. As the anxiety levels of the males (day and shift workers) were not measured in this study, however, this ‘direct’ hypothesis remains untested. The manner in which shift work impacts on the anxiety levels of the spouse and particularly the child(ren) of a shift worker is still unknown. For example, it is possible that it is not the shift work of a parent per se that affects the psychological well-being of their child, but the way in which the non-shift working parent copes with the demands of the shift work family lifestyle. Further research is required to examine this complex issue.

As Pati and Chandrawanshi (2001) state, their study is a ‘novel’ study and is perhaps the first study to address such issues of psychological well-being among the spouses and particularly the children of shift workers, and therefore the results cannot be compared to any other research. There is a great need for research to assess the impact
of shift work beyond the actual shift workers themselves, focusing on the impact it has on their partners and children who live a shift work lifestyle by default.

5.6 Summary
Shift workers often report that shift work interferes with their family and social life, although solid research providing a good understanding of the many issues involved has been slight and sketchy at best. Shift workers often have a limited amount of convenient time available to spend with others, and the time they do have is often not quality time as they are often fatigued and sleepy, particularly after night shifts. While shift work in general can affect the type of leisure time activities engaged in, the particular type of shift work schedule being worked may also affect how shift workers spend their time off, particularly how much time they spend socialising with others. In fact, each type of shift can produce a set of advantages and disadvantages in terms of social satisfaction and adjustment for the worker and his or her family. The effect that shift work can have on the partner of a shift worker has begun to be addressed. Research indicates the partners of shift workers often feel that their lives are disrupted by their partners’ shift work, both emotionally and physically/practically. Possibly the most important implication of shift work and the effect it has on others is the effect that shift work may have on the children of shift workers. While this is an extremely important issue there has been very little research conducted. This area deserves immediate research attention, especially the impact of shift working mothers on their children, as there do not appear to be any studies investigating this issue, despite the fact that women have been employed in shift work positions for many years. Since in many countries around the world the make-up of work forces has changed so dramatically in the past decade or two, as have the social-cultural issues surrounding
the working populace, the research findings on these important topics seem to be rather
dated. It is time for the social-behavioural scientists to update their research and to
enlighten us further about these matters.
PART 2:

FACTORS THAT CAN AFFECT SHIFT WORK TOLERANCE
6. SHIFT WORK SCHEDULING FACTORS

Roger Rosa (2001) states that work schedule-related fatigue can result from the combination of the following factors: the “number of hours worked, the timing of work in the 24-hour day (i.e., what shift is worked), how many work shifts occur before a rest day, how many rest days are taken before a return to work, how much rest is taken between work shifts, how much rest is taken during the shift, and how variable the timing of the shift is” (p. 514). The scheduling factors of shift timing, cycle length or speed of rotation, direction of rotation, ratio of work to rest, shift length, and the predictability of work times can therefore influence the fatigue that develops from shift work, and therefore the ability of workers to tolerate shift work. As many of these factors interact, it is important to examine all features when designing or evaluating a shift work schedule. These aspects of shift work scheduling will be addressed in this chapter.

6.1 Shift Timing – Night, Morning, and Afternoon Shifts

6.1.1 Night shift

Shift timing can affect fatigue and work performance on the night shift due to three factors. These are the low point of the endogenous circadian rhythm system, sleep loss, and extended periods of wakefulness. As discussed previously, the circadian rhythm system encourages the body’s physiology to promote sleep during the night, therefore increasing sleepiness and decreasing performance. This same circadian rhythm system also makes day time sleep difficult, as the body is not normally prepared for sleep during the day, therefore reducing the amount and quality of rest that night shift
workers can obtain. These factors, the downturn in the circadian rhythm at night and the sleep loss due to inadequate day time sleep, combined with the long periods of wakefulness that can accompany working a night shift, can produce severe sleepiness and fatigue across the night shift (Åkerstedt, 1995a and b; Rosa, 2001). The greatest sleepiness and fatigue are usually experienced during the first night shift, as there is often little sleep obtained before the first night shift (Knauth et al., 1980), and also during the second half of a night shift, in the early morning hours, during the circadian rhythm low point (Thierry and Meijman, 1994). The implication of this fatigue and sleepiness for safety on the night shift has been addressed in detail in chapter 2; in short, the night shift has been associated with an increase in accident risk of about 30% compared to the morning shift (Folkard, 2002).

6.1.2 Morning and afternoon shift

Folkard (1992) makes the important point that when discussing the problems associated with shift work, the plight of the morning and afternoon shift workers should not be overlooked by the overwhelming desire to focus on the night shift workers. Day shift workers who begin work at very early start times (e.g. 0500 to 0600 hours, or sometimes even earlier) have associated early rising times and thus sleep restriction, and therefore experience sleepiness and fatigue while at work (Åkertedt, Kecklund, and Knutsson, 1991; Kecklund, Åkerstedt, and Lowden, 1997; Kecklund, Åkerstedt, Lowden, and von Heidenberg, 1994; Rosa, 2001). Early morning shift workers do not usually get adequate sleep before work because they typically go to bed at the same time as day workers despite their earlier wake up time, and if they do go to bed earlier they usually experience difficulty sleeping at that time due to the influence of the circadian rhythm system increasing their alertness in the evening hours (Åkerstedt,
Hume, Minors, Waterhouse, and Folkard, 1992; Folkard and Barton, 1993; Lavie, 1986). Folkard and Barton (1993) found that for a shift worker to get a full eight-hour sleep period before their morning shift they would have to leave home after 0800 hours. Every hour earlier that they had to leave home in order to start their morning shift was associated with 46 minutes less sleep. It has been recommended that morning and/or day shifts do not start before 0700 hours (Kecklund and Åkerstedt, 1995a; Knauth, 1993; Monk, 2000). This must be balanced, however, as a later morning start may mean later change over times for the afternoon/evening and night shift, which may not be preferred.

The afternoon shift workers (e.g. those who begin a work shift somewhere between 1400 and 1700 hours) should not be forgotten either. As discussed in chapter 5, working during the afternoon/evening hours can impact greatly on the family and social life of a worker because these hours are typically the time when social get-togethers and family interactions normally occur, therefore creating conflict and tension for the worker. Folkard (2002) has also demonstrated in his literature review, an increase in accident risk of 17.8% for the afternoon shift compared to the morning shift.

It would seem that working hours outside of the typical day time hours, including late afternoon and early evening hours, as well as early morning starting times, is associated with increased fatigue and an increased risk for an accident.

Indeed, Srithongchai and Intaranont (1996) demonstrated that mental fatigue and physical fatigue may be higher on the morning shift rather than the expected evening or night shift. Twelve male factory shift workers (four workers from three different
sections of the factory) were tested before and after their morning and evening shifts. The measures included heart rate (during the shift) and handgrip strength to assess physical fatigue, and critical flicker fusion frequency and reaction time to measure mental fatigue. The results indicated that the morning shift was more fatiguing for the workers than the evening shift (although not to statistically significant levels). The authors suggested that the higher morning shift fatigue might have resulted from the temperature fluctuations of the work environment, although this was not measured, and/or the closer supervision of staff on the morning shift compared to the evening and night shifts, which could increase mental stress. It is also likely that the morning shift worker’s higher fatigue was associated with the sleep restriction typically experienced before a morning shift, compared to the evening workers, who were able to obtain enough sleep before starting work to limit their feelings of fatigue, although this was not assessed in the study.

The timing of shifts is an important variable to consider when designing or evaluating a shift work roster. While the night shift is typically viewed as the shift associated with the greatest levels of fatigue, it is important to consider the timing of the morning and afternoon shifts, as these can also be associated with increased levels of fatigue and other complaints such as social problems associated with difficulties meeting personal and social expectations. Morning and afternoon shift workers can suffer along with night shift workers, particularly from poor shift work schedules. The practical aspects of shift work scheduling are discussed in chapter 10.
6.2 Speed of Rotation – Rapidly Rotating vs. Slow or Permanent Night Rosters?

There is a continuing debate between researchers about which is the best type of shift work roster with regard to the number of consecutive shifts worked. There are those that favour the slow roster rotations such as changing shifts every three to four weeks, and those who favour the rapid roster rotations associated with changing shifts every two to three days (Rosa, 2001). There is also a debate between those who favour a permanent night shift roster and those who favour the rapid rotation of night shift (Wedderburn, 1992; Wilkinson, 1992). The decision to favour one roster speed over the other depends primarily on the importance placed on the two main physiological consequences of each roster speed. These are (1) the problem of internal desynchronisation that occurs among the components of the circadian rhythm system when changing time schedules, and (2) the problem of external desynchronisation, where the body’s internal timing does not match the external clock time of the work schedule. If it is deemed important to avoid internal desynchronisation, then rapid rotations are favoured. A rapid rotation does not allow time for the body to adjust to night work, therefore limiting the amount of internal desynchronisation that will occur with night shift. Conversely, if external desynchronisation is seen as more important to avoid, then slow rotations are favoured. A slow rotation allows the body time for some adjustment to night work, therefore limiting the amount of external desynchronisation that will occur with night shift (Monk, 1986, 2000).

There are, of course, the intuitive counter-arguments to each position. While the rapid rotations limit the internal desynchronisation, the counter-argument is that the worker must cope with the external desynchronisation. As rapid rotations do not allow time for any circadian adjustment, the worker must work and sleep against their body clock
timing, impairing their sleep during the day, and impairing their work performance at night (Monk, 1990). For the slow rotating rosters, their aim is to limit the external desynchronisation by allowing time for circadian re-entrainment to the new work/rest schedule. While a slow rotation on nights (e.g. more than 12 nights) should, in theory, allow enough time for the circadian rhythm system to phase adjust to night work (and therefore be correctly timed for that rest/work schedule), the counter-argument is that in practice this rarely happens. This is mainly because night shift workers typically enjoy their days off by being active during the day and sleeping at night. This change to day time living on their ‘weekend’ breaks is ample time for the circadian rhythm system to revert back to a day time orientation, particularly as sunlight is a strong zeitgeber. This leads to repeated internal desynchronisation and an unmatched circadian rhythm system on the return to night shift (Rosa, 2001). The night worker on a slow rotation is therefore unlikely to receive the theoretical advantage of having their circadian rhythm system synchronised to match their work/rest schedule.

According to Monk (1990), while researchers disagree about whether rapid or slow schedules should be used, it seems that all researchers do agree that rosters which rotate weekly are the worst schedule. Workers on a weekly rotating roster with day and night shifts can find themselves in a perpetual state of flux or internal desynchronisation. Weekly time changes allow the circadian rhythm system time to start physiological re-entrainment, without allowing a sufficient amount of time for complete circadian adjustment before the timing of the shift changes and physiological re-entrainment must start again. The circadian rhythm system is therefore continually changing its timing with each weekly roster change, never having time to readjust fully to any shift timing. As well as this, the worker must also deal with the external desynchronisation
at the start of each new work week, when their circadian rhythm system is not matched to their work/rest schedule. The worker on a weekly rotating roster can therefore suffer from both types of desynchronisation on a continual, weekly basis, and can suffer greatly from the shift work. Fischer and colleagues (1997) have confirmed that shift workers on a weekly rotating roster experience significantly poorer quality sleep periods than shift workers on a rapidly rotating shift roster. Knauth and Kiesswetter (1987) reported that shift workers experienced fewer sleep difficulties when on night shift and were much happier with their roster when they changed from a weekly rotating roster to a rapidly rotating roster (83.9% voted in favour of the rapidly rotating roster). Williamson and Sanderson (1986) reported significant improvements in shift workers alertness and general well-being when their roster was changed from a weekly rotating to a rapidly rotating shift system.

It is not known at present which of the internal or external desynchronisations above has a more negative effect on human health and well-being. Until more is known about this, it has been recommended that the decision to schedule workers on either a slow or rapidly rotating roster be made based on the type of work that will be performed over the night shift (Monk, 1986, 1990; Rosa, 2001). This strategy is recommended because different performance tasks have their own circadian rhythms for best and worst performance times (determined by the biological clock), and also because different performance tasks are affected differentially by external factors such as sleep loss. This means that different tasks can be affected by the phase of the circadian rhythm system and the level of sleep debt of the worker on night shift. An important consideration when designing shift systems is therefore knowing what activities will be performed during the shift, and knowing the circadian rhythm for those performance tasks and
how much they are affected by external factors such as sleep loss before deciding on the appropriate speed of shift rotation (Folkard, Totterdell, Minors, and Waterhouse, 1993; Scott, 1994).

Many performance variables follow the temperature circadian rhythm, peaking during the day and falling during the night. Such variables include attention, concentration and vigilance; performance speed and accuracy; and manual dexterity. Examples of work tasks that use these variables include repetitive, boring tasks such as quality control and inspection, process monitoring, and driving (Monk, 1990). These tasks are therefore worse during a night shift for a diurnally oriented worker. These tasks therefore require an adapted night shift worker, so would benefit from a slow rotating roster. Tasks that involve repetitive, monotonous work (such as driving, and quality control and inspections) would therefore be suited best to a slowly rotating schedule (Monk, 2000).

The amount of cognitive load or mental effort required for a task can also affect the circadian rhythm for its performance, and should also be considered. Performance on low cognitive load tasks appear to match the temperature rhythm being poor at night, while performance on higher cognitive load tasks appear to be 180 degrees out of phase with the temperature rhythm. This means that the performance of more demanding tasks, such as stimulating versus boring work, can theoretically be maintained near or at acceptable levels earlier in the morning (i.e. the early morning pre-dawn hours) for a normally entrained individual (Scott, 1994). Complex memory functions also do not follow the body temperature rhythm. Immediate memory has been shown to be best in the morning, while working memory appears to be best around midday. Tasks with a
high cognitive load, for example running a chemical control process, or a high memory load, may therefore in theory be performed better across the night shift by a diurnally orientated worker rather than a nocturnally orientated worker (Monk, 1990). Tasks requiring a high level of cognitive capacity (a high cognitive load or high memory load) are therefore suited for a rapidly rotating roster schedule (Monk, 1997). Complex tasks are also sensitive to the effects of sleep deprivation (Wallace, 2002), and therefore may benefit from the smaller sleep debt accumulated on night shift with a rapidly rotating roster schedule (as discussed below in chapter 6.2.1). It must be borne in mind, however, that high demand jobs such as system control have shown a circadian pattern of errors (e.g. Chernobyl and Three Mile Island plant disasters both occurred in the middle of the night), suggesting caution in applying these findings.

The performance rhythms for tasks can also adjust or adapt to shift work at different rates, depending on the amount of cognitive load involved. The more complex cognitive tasks (e.g. involving maths skills and verbal reasoning) and tasks with a high memory load adjust more rapidly to a night shift routine than simple cognitive tasks (e.g. simple serial search and manual dexterity) and tasks with a low memory load (Monk, 1990; Scott, 1994). These latter tasks do not get better with increased exposure to night shift. Therefore consistent with the advice above, tasks involving a high cognitive or memory load would be suited best for a rapidly rotating roster.

As shift work scheduling according to task type is not always possible or practical, other considerations have been suggested. The research discussed below is divided into those that support the rapidly rotating position and those that favour the slow rotating, permanent night shift position.
6.2.1 Studies favouring rapidly rotating rosters

Several authors argue that as night shift is the most disruptive shift, in terms of sleep loss and increased fatigue, night shift should be avoided where possible. When this is not possible, rapidly rotating rosters should be used rather than slow rotating schedules, except in hazardous situations that require high levels of safety on the night shift, where it may be preferred to have permanent night shift workers, provided they are dedicated workers who are adjusted to night shift work (Folkard, 1989, 1992; Knauth, 1993).

Folkard (1992) argues that rapidly rotating schedules should be used where possible for three reasons. The first reason has to do with the sleep of permanent night workers. Permanent night workers have a reduced amount of sleep per day on average compared to day workers. For instance, a survey study by Tepas and colleagues (1985) demonstrated that workers on a permanent night shift reported significantly less sleep during their work week (6.82 hours per day), compared to permanent day shift workers (reporting 7.23 hours per day) (see also Bryden and Holdstock, 1973; Kripke, Cook, and Lewis, 1970; Tepas, Walsh, and Armstrong, 1981). According to Folkard (1992), the average amount of sleep for a permanent night worker on work days is typically 6.8 hours, while permanent day workers average 7.5 hours per day on work days. Folkard argues that this reduced amount of sleep for permanent night workers is not adequate on a long-term basis. He also argues that permanent night workers accumulate a greater sleep debt by their last night shift than rapidly rotating workers on their last night shift. By the last night shift in a permanent roster (of 5 consecutive night shifts) a worker can have accumulated approximately 3.9 hours of sleep debt (given 5 day sleeps of 6.72 hours) (although according to Moore-Ede, 1993, this type of calculation may
overestimate the sleep debt accumulated as there may be some partial circadian adjustment to a series of 5 night shifts, which would therefore allow more sleep to be obtained towards the end of the night shift period) compared to the last night shift in a rapidly rotating roster (of 2 night shifts), when a worker could have accumulated a sleep debt of approximately 1.7 hours (given one day sleep of 5.8 hours). So although the rapidly rotating shift worker obtains less sleep per day sleep, as the number of day sleeps required are less than the permanent night worker, the sleep debt accumulated is less for the rapidly rotating roster than the permanent roster over the whole shift cycle. Using a rapidly rotating roster minimises the amount of sleep debt accumulated from working nights, and therefore minimises the sleep deprivation experienced (see also Knauth, 1993).

The second reason for recommending rapidly rotating rosters over permanent night shift has to do with the body’s circadian rhythm system. Folkard (1992) argues that the circadian rhythm system does not adapt well to permanent night shift. He argues that the studies showing adaptation of the circadian rhythm system to night shift are confounded by the masking effects of the exogenous factors that change with the new work schedule (e.g. heart rate, urinary noradrenaline). The change in exogenous influences with night work can flatten and partly phase shift the circadian rhythm, making it appear as though the whole system has adjusted when it is merely being masked from external sources. As the circadian rhythm system seems unlikely to adapt more than only partially to night work, especially when night workers tend to ‘rotate’ to day hours on their days off, Folkard (1992) argues that it is better to keep the number of consecutive night shifts to a minimum, that is, a rapidly rotating shift schedule. This therefore enables the circadian rhythm system to remain day oriented and therefore
minimises the circadian internal desynchronisation, which may be important to limit shift work intolerance (Motohashi, 1992; Reinberg et al., 1989; see also Knauth, 1993).

The third reason Folkard (1992) provides to recommend rapidly rotating shift schedules over permanent night shift involves the performance of workers at night. Three factors affect the performance of workers on night shift. They are the endogenous circadian rhythm of many performance tasks which dip at night, the endogenous circadian rhythm of sleepiness which peaks at night (making it difficult to remain awake), and the sleep debt that accumulates over the night shift period from inadequate day time sleep. While in an ideal situation a circadian rhythm system truly adapted to permanent night shift would overcome these three factors, and therefore provide a high performance level on the night shift, complete circadian adaptation to night shift does not usually happen in the real world; the circadian rhythms of both performance and sleepiness never become completely compatible with night work. Folkard therefore argues that the highest night shift performance can be obtained by focussing on the third factor known to affect night shift performance, which is the cumulative sleep debt. To obtain the highest performance on the night shift the amount of sleep debt accumulated must be minimised. A rapidly rotating shift schedule is therefore preferred over the slow roster as the rapidly rotating roster limits the amount of sleep debt that is accumulated when working on the night shift, and thus allows for higher performance on the night shift.

Several areas of research provide support for recommending rapidly rotating shift schedules. For instance, Patkai, Åkerstedt, and Pettersson (1977) and Dahlgren (1981a) have demonstrated that permanent night shift workers do not adjust to their night shifts
with respect to at-work alertness, as they still experience the normal increases in
sleepiness during their night shift, with the peak in sleepiness occurring towards the end
of the night shift. Folkard, Monk, and Lobban (1978) found that alertness ratings of
permanent night shift workers remained diurnally orientated, showing no long-term
adjustment to their permanent night shifts. Dahlgren (1981b) also found no change in
self-rated activation at work after working three years of night shift. Foret and Benoit
(1978) demonstrated little adjustment to sleeping during the day for shift workers
working four consecutive night shifts. Tepas and Mahan (1989) have shown that the
sleep of permanent night workers decreased over their period of night shift, rather than
improving. They found that night shift workers obtained 1.1 hours less sleep
(compared to their night sleep) on their first day sleep of night shift, and this decreased
by a further 0.8 hours over their week of night shift. Åkerstedt (1985) also asserts that
the circadian rhythm of shift workers never completely adjusts to the night shift. A
review by Scott (1994) confirmed this position, concluding that the circadian rhythms
of permanent night workers never fully adjust to night work, particularly as they revert
to day life on their days off.

Monk, Folkard, and Wedderburn (1996) have revealed that shift workers can actually
prefer rapidly rotating shift rosters to weekly or slower rotations. Workers in several
industries completed questionnaires before and 6 to 12 months after changing from a
weekly rotating roster to a rapidly rotating roster. The majority of the workers (ranging
from 54% to 100%) preferred the rapidly rotating roster. Although this was a field
study, and other factors may have changed simultaneously (such as a reduction of
weekly work time), the authors concluded that the preference for the rapidly rotating
roster may have been because there was less disruption to the circadian rhythm system,
there was less sleep debt accumulated, and there were evenings off each week with the rapidly rotating roster. Having free evenings in each week allows workers to spend time with family and friends, and is an important advantage for rapidly rotating rosters (Knauth, 1993). One disadvantage with rapidly rotating rosters, however, may be access to child care, thus preference for a particular shift roster may depend on the presence and age of children.

Support for rapidly rotating rosters is also provided from studies investigating the circadian rhythm of melatonin secretion in shift workers. Melatonin is a neurohormone secreted during night time darkness during the normal sleep period (see chapter 9.2). Its secretion pattern is used as a phase marker for the endogenous circadian rhythm system. Several studies have measured the melatonin secretions from male and female permanent night workers. The majority of the permanent night shift workers studied (approximately 70%) did not show melatonin rhythms that were consistent with their sleep/wake habits. It would appear that the internal circadian rhythms of permanent night shift workers do not re-align from a normal diurnal orientation to match their work schedule (Koller et al., 1994; Quera-Salva, Defrance, Claustrat, De Lattre, and Guilleminault, 1996; Roden, Koller, Pirich, Vierhapper, and Waldhauser, 1993; Sack, Blood, and Lewy, 1992; Waldhauser, Vierhapper, and Pirich, 1986).

Perhaps the best source of support for the rapidly rotating shift work roster comes from the recent accident risk calculations by Folkard (2002). Folkard was able to compare the relative risks for an accident (including injuries) for successive night shifts from several studies by firstly determining the relative risk of each night relative to the first night within each study. These calculations could then be compared across studies.
The results indicated an increase in accident risk across successive night shifts. The risk had increased by 13% on the second night, was about 27% higher on the third night (relative risk 1.27), and was approximately 45% higher on the fourth night (relative risk 1.45). Few studies provided data for more than four consecutive night shifts. Estimates were calculated to extend the number of nights worked by fitting a linear function to the data which accounted for over 96% of the variability. These calculations revealed that the risk for each successive night shift continued to increase with each night shift so that by the seventh night shift the risk had increased by 87% (compared to the first night shift).

Using these estimates, Folkard (2002) estimated the relative risk that would exist for a shift system consisting of one to seven night shifts. These calculations revealed that compared to one single night shift (with a relative risk of 1), the relative risk for two nights was 1.07, five nights was 1.27, and the risk for seven nights was 1.43. That is, the risk increased by 7% for two nights, 27% for five nights, and approximately 43% for seven nights compared to one night shift. A block of five night shifts therefore had an approximately 20% increased risk compared to two nights shifts, while a block of seven night shifts had an approximately 36% increased risk compared to only two night shifts. The increase in risk seen with each successive night shift worked, and the increase in the risk estimates seen with longer blocks of night shifts, indicates no circadian adaptation to a slow rotating roster, and thus favours a rapidly rotating shift work system. This system would limit the risk associated with the night shift and therefore maximise the safety of workers at night.
An important point to remember when recommending rapidly rotating rosters is that as these rosters do not allow time for workers to adapt to the night-work orientation, sleepiness and fatigue can be a problem across the work period. Although the period of night shift is over fairly quickly for each particular worker, if the entire staff is on the same type of rapidly rotating roster, then all of the staff on duty will be fatigued across the night shift. This must be remembered when scheduling workers in a workplace setting. Techniques to help night shift performance are provided in chapter 10.

### 6.2.2 Studies favouring slow, or permanent night shift rosters

Research results also exist which would suggest that slowly rotating rosters, or permanent night work may be better for shift workers health, well-being, and sleep than the rapidly rotating rosters. Minors and Waterhouse (1985) found no difference for alertness ratings between nurses working less than three nights and those working more than three nights, although the nurses working more than three night shifts reported better day time sleep and general well-being. Dahlgren (1981a) also found better shift adjustment, in terms of the ability to sleep during the day, for permanent night workers than rotating shift workers. Åkerstedt, Patkai, and Dahlgren (1977) reported some short-term adjustment (i.e. slight delays in body temperature and self-rated alertness peaks) for shift workers over a week of night shift, although this slight adjustment was then lost over their week of day shifts. It was suggested that permanent night shift might facilitate more long-term adjustment to working the night shift than slow rotations.

More recently, Barton, Spelten, Totterdell, Smith, and Folkard (1995) investigated the impact of the number of consecutive night shifts worked on the health and well-being
of permanent night and rapidly rotating shift working nurses. The nurses completed the Standard Shiftwork Index, which gathered information about psychological and physical health, fatigue, social issues, attitudes toward shift work, and several sleep parameters. They found that as the number of consecutive night shifts increased, the sleep duration between night shifts increased (indicating better circadian adaptation), which subsequently predicted an increased quality of sleep. The association was much stronger for the permanent night workers than the rotating shift workers. The improved quantity and subsequent quality of sleep was a strong predictor of better psychological and physical health and less fatigue. The results suggest that allowing workers to adapt to the night orientation with a slow rotation roster may be better for the sleep and therefore indirectly better for the health and well-being of shift workers (Barton et al., 1995). This study may provide some, although limited, evidence in favour of permanent night shifts, as the increased sleep duration and subsequent sleep quality that occurred with more consecutive night shifts was associated with better physical and psychological health.

The effect of shift type has been studied by Totterdell, Spelten, Barton, Smith, and Folkard (1995). Permanent night (n=28) and rotating nurses (n=32) from large UK hospitals recorded information at the beginning and end of each day, as well as at two-hourly intervals during their work shifts. Measures included a sleep diary, mood ratings, shift workload, personal disruption, and two cognitive performance tasks (a serial choice reaction time task and a memory search task), which were all recorded using a hand-held computer. Controlling for age and shift work experience (which differed significantly between the two groups), the study found no difference for sleep or reaction times between the two groups of nurses. The rotating nurses reported lower
work satisfaction, effectiveness and physical demand ratings, and when on night shift, poorer sleep quality and mood ratings than the permanent night nurses. Overall, the results suggest that while there was no difference between permanent night and rotating shift nurses for many variables, the permanent night nurses appeared to be better off than the rotating nurses when on night shift for some variables such as work satisfaction, and night shift sleep and mood (Totterdell et al., 1995).

A recent meta-analysis investigating the effect of shift work on sleep length has suggested that slowly rotating shift schedules or permanent night shift schedules may be preferred to rapidly rotating shift schedules for sleep length (Pilcher, Lambert, and Huffcutt, 2000). Thirty-six primary studies investigating the sleep length of shift workers were included, while control data were taken from the permanent day workers category from the 1998 Ombudsman Report from the National Sleep Foundation. The results indicated that the night shift was the most disruptive for sleep, resulting in the shortest sleep lengths. On night shift, the shortest sleep times were obtained by the rapidly rotating shift workers, followed by the slowly rotating shift workers, and then the permanent night workers who obtained the most. Morning shifts also reduced sleep length for all shift workers, while evening shifts afforded longer sleep lengths than any other shift, including the permanent day workers. While longer sleep lengths were reported by the permanent night and slowly rotating workers, it was not possible to determine whether these longer sleep lengths were due to greater circadian adaptation to night shift and therefore to daytime sleeping, or whether the greater sleep lengths reflected a greater physiological need for sleep resulting from a large sleep debt accumulating across the night work period (as these workers were obtaining less sleep than the permanent day workers control group). In considering the slow rotating and
permanent night schedules, the authors concluded that slowly rotating may be preferred given that most permanent night workers rotate to ‘day shift’ on their days off, and that permanent night workers would never experience the benefits from improved sleep lengths when on day shift and the even longer sleep lengths on evening shifts. This was supported by the finding that when the shifts were collapsed within a rotating system, the rapidly rotating and permanent shift systems had an equal negative effect on sleep length, while the slowly rotating shift schedule had a smaller negative effect than both (Pilcher et al., 2000).

These studies certainly highlight the need for further research in the area of shift work scheduling, especially when considering permanent night shift. Research is needed to investigate the role of variables such as worker demographics (including age, gender, and shift work experience), and the other shift schedule features (including shift length and direction of rotation), to determine whether these variables may influence the effect of permanent night shift on a worker. Data are also needed to measure objectively the impact of permanent night shift on various sleep parameters and performance measures, as well as to identify any health or well-being effects of permanent night shift. The long-term implications of permanent night shift are not known at the present time, and research is desperately required.

6.2.3 Summary

While the debate continues on, it can be concluded from the majority of research reviewed that permanent night shift, including the slow rotating shift systems with many night shifts in a row, is the most disruptive for physiological adjustment, sleep, and well-being. Rapidly rotating shifts systems would therefore usually be preferred
and recommended over these slow systems. The three main reasons behind this recommendation were first, the finding that sleepiness and fatigue accumulates, increasing with the number of nights worked. Sleep loss appears to be greater for permanent night workers than rapidly rotating shift workers. The risk of an accident has also been shown to increase with the number of nights worked. Limiting the number of consecutive night shifts will reduce the amount of sleep debt that can accumulate and therefore help maximise the safety of workers on night shift. The second reason is the finding that permanent night shift workers, and slow rotating shift workers on their block of night shifts, typically become ‘rotating shift workers’ on their days off by staying awake during the day and sleeping at night. They therefore lose their nocturnal orientation on their days off, which has to be regained at the start of their next work period. The effect of this constant state of disruption of the circadian rhythm system on their health and well-being, which does not seem to be much different to the rapidly rotating shift workers, is unknown. The third and a major reason is the lack of knowledge about the long-term effects of working permanent nights on health and well-being. Because of these reasons, slowly rotating shift systems, and in particular permanent night shifts, are not generally recommended. As with many recommendations, however, it is important to note that differences between work places and individual workers may have an impact on the choice between rapidly and slowly rotating rosters. A dedicated night shift worker, who can maintain a night shift lifestyle on work days and days off, may perform well and cope well with a slowly rotating or permanent night shift roster. At this point in time, the choice between rapid and slowly rotating rosters may benefit from consideration of the individual workers involved.
6.3 Direction of Rotation – Backward or Forward Rotating Rosters?

An important consideration in the design of rotating shift schedules is the direction of the shift rotation. It has been suggested that forward or clockwise rotations (where day/morning shift is followed by afternoon/evening shift, which is followed by night shift) are preferred to backward or counter-clockwise rotations (where night shift is followed by afternoon/evening shift, which is followed by day/morning shifts), although as pointed out by Rosa (2001), Monk (2000), and Knauth (1993), studies actually comparing the two roster direction changes are rare. Forward rotating rosters are favoured because they match the endogenous circadian rhythm system’s tendency to run late or phase delay (Rosa, 2001). It is therefore easier for workers to delay their bedtime as required on the forward roster (i.e. creating a phase delay of the circadian rhythm system), than to advance it as required on a backward roster (i.e. requiring a phase advance of the circadian rhythm system). Delaying the start of a worker’s sleep time on the first day of shift change in the clockwise rotation actually results in the workers obtaining more sleep overall. One study in this area, by Orth-Gomer (1983) demonstrated that a change from counter-clockwise to a clockwise rotation of shifts for a four-week period improved subjective sleep quantity and quality and lowered systolic blood pressure. Czeisler, Moore-Ede, and Coleman (1982) demonstrated that changing the shift work roster from a backward to a forward rotating roster improved shift workers well-being and productivity.

A forward rotation of shifts also avoids the quick change or quick return that can occur on the backward roster, where there may be only eight hours or less off between shifts. Such a quick return limits the amount of sleep that can be obtained before returning to work (Kecklund and Åkerstedt, 1995a; Tucker, Smith, Macdonald, and Folkard, 2000),
and therefore has the potential to increase fatigue and reduce safety (Macdonald, Smith, Lowe, and Folkard, 1997). In the clockwise rotation, however, there is often 24 hours or more between shift changes, which allows time for adequate sleep between shifts. Indeed, Barton and Folkard (1993) found that workers reported more problems with physical and psychological health, sleep, and disruption to their domestic and social life, and less job satisfaction, with a backward rotation roster compared to a forward rotation roster, and that a backward roster with a quick return was the most problematic of all for the workers. Similarly, Knauth and colleagues (1983) found that shift working policemen reported backward rotating shift rosters as “unfavourable” because of the limited time off between the last afternoon shift and the first morning shift, that is, a quick return.

6.4 Shift Length - Extended Work Hours

When comparing shift schedules the length of the shifts must be considered. This is because fatigue develops according to the time of day (the circadian rhythm factor) as well as from the length of time at work (the time on task factor) (Rosa, 2001). Studies have shown that subjective sleepiness and muscular fatigue can reach higher levels in an overnight shift compared to a day shift (the circadian rhythm factor), and can also reach higher levels in a 12-hour shift compared to an 8-hour shift (the time on task factor). The greatest amounts of sleepiness and fatigue can be seen when these two factors combine; the 12-hour overnight shift. Shift length is therefore an important consideration when discussing shift work schedules, particularly as longer shift lengths are becoming more popular (such as with the compressed work week schedule), and also because many shift workers are required to work overtime in addition to their regular hours (Rosa, 1995). Fatigue can also accumulate over consecutive work days,
with long work shifts (including overtime hours) and overnight shifts accumulating the greatest amounts of fatigue. The fatigue can increase with each subsequent shift worked.

Despite this logic, Smith and colleagues (1998) state that many of the findings in this area of shift length are equivocal. As will be discussed, some studies indicate improvements in subjective well-being and other benefits with 12-hour shifts, while others do not. Studies which focus on the objective outcomes, such as performance over different shift lengths, are few and limited. It will be shown that much of the discrepancy within this literature may be due to the fact that when shift length changes, several other shift work scheduling factors (such as rotation speed) also change. As discussed previously, these factors are important in their own right, and may have influenced to varying degrees the outcomes of the studies.

6.4.1 8 versus 12 hour shifts

Early studies by Mills, Arnold, and Wood (1983) and Colligan and Tepas (1986) suggest that increasing work shift length from 8 to 12 hours did not have any detrimental effects on workers self-rated alertness at work, while work satisfaction increased. Two studies which investigated medical doctors working hours indicated that their long working hours (sometimes greater than 12 hours), which were necessarily associated with sleep loss, were associated with both objectively (Poulton, Hunt, Carpenter, and Edwards, 1978) and subjectively (Wilkinson, Tyler, and Varey, 1975) impaired performance at work. Rosa and Colligan (1987) demonstrated that 12-hour night shifts were associated with higher reports of fatigue than 8-hour night shifts. Rosa, Colligan, and Lewis (1989) demonstrated that a change from an 8-hour shift
length to a 12-hour shift length (allowing seven months for adaptation to the new roster) was associated with decreased worker performance and alertness at work. A follow-up study after 3.5 years revealed that these decrements in worker performance and alertness were still present with the 12-hour shifts compared to the 8-hour shift length (Rosa, 1991).

More recently, Iskra-Golec, Folkard, Marek, and Noworol (1996) studied the health and well-being of shift working nurses working either an 8- or 12-hour shift duration. Self-report questionnaire data were collected from two matched samples of hospital Intensive Care Unit (ICU) nurses. Participants were matched on age (mean 26 years), shift work experience (mean 5.4 years), and marital status (majority single). Both groups worked shift work that included night shifts. The nurses working the longer shifts (12 hours) reported more chronic fatigue, cognitive anxiety, and emotional exhaustion, a worse sleep quality, and increased feelings of tiredness after sleeping, despite sleeping for longer than the nurses with shorter shifts (8 hours). The build up of chronic fatigue in the nurses working 12-hour shifts was not alleviated by their increased number of rest days compared to the 8-hour shift nurses. The two groups of nurses did not differ in their general health complaints. These findings suggest that nurses, particularly those working in very demanding high stress positions such as the ICU, should not work extended shift lengths of 12 hours. If they do their levels of chronic fatigue, cognitive anxiety, emotional exhaustion, and sleep quality could be worse than nurses working for 8-hour shifts in the same position. The extra days off provided with the 12-hour shift roster were not adequate to compensate for the increased stress of working the 12-hour shifts.
Tucker, Barton, and Folkard (1996) investigated the health, well-being, and alertness levels at work of male chemical workers who were working either 8- or 12-hour shift lengths. The 12-hour shift workers (n=92) worked two shifts (day and night), while the 8-hour shift workers (n=70) worked the traditional three-shift system (morning, afternoon, and night shifts). The two groups were similar with respect to age (overall mean 42 years), marital status (majority married), number of dependents at home (overall mean 0.88), and the number of years in shift work (overall mean 17 years). Self-report questionnaires were completed by the participants to identify shift work problems relating to general health and well-being, and they completed alertness ratings at two-hourly intervals during some of their shifts.

The two groups of workers (8- and 12-hour shift lengths) did not differ significantly with respect to psychological health, gastrointestinal complaints, or reports of chronic fatigue. The two groups did differ significantly in relation to cardiovascular disease (CVD) complaints and social life disruption, the 8-hour shift workers reported more symptoms of CVD, and more disruption to their social but not domestic life. Despite the greater disruption to their social life, the workers with 8-hour shifts appeared to be more satisfied with their shift schedule, reporting that the advantages of their shift system outweighed the disadvantages (Tucker et al., 1996).

The results for ‘on shift alertness’ revealed no significant difference in the overall mean ratings between the two groups; however, there was a significant time of day factor, and a significant interaction effect between shift length and time of day. Alertness levels were lowest for both groups across the night period, reaching their lowest point at 0400 hours. At 0600 hours, the 12-hour workers reported lower alertness than the 8-
hour workers. Alertness was similar for both groups during the morning to early afternoon (0800 to 1400 hours). During the afternoon (1400 to 1800 hours), the 12-hour workers again reported lower alertness than the 8-hour workers. By 2000 hours (start of the 8-hour night shift) until 0400 hours there was no difference in alertness ratings between the two groups. While the two time periods when alertness differed between the groups (0600 hours and 1400 to 1800 hours) may be affected by the ‘time-on-task’ factor (as the 8-hour group was nearer the beginning of their shifts at both of the above times compared to the 12-hour group), such an effect was thought to be small, given that there was no difference in alertness between the two groups at 2000 hours, when the 12-hour group had just started work and the 8-hour group was nearing the end of their shift. It is also possible that the difference in morning alertness may have been attributable to the later start time for the day shift (0700 hours) for the 12-hour workers compared to the start time of the morning shift for the 8-hour shift workers (0600 hours). The difference in the afternoon alertness may have been due to the superior sleep of workers before starting their afternoon shift compared to the sleep before day shift for the 12-hour workers (Tucker et al., 1996). The results may simply reveal a differential effect for shift length at different phases of the circadian rhythm system, particularly at the low points in alertness.

Overall, the longer shift length of 12 hours did not make any difference to the workers’ psychological or GI health, while it may have lessened their CVD symptoms and social life disruption. The longer shift length did not increase the levels of chronic fatigue compared to workers with 8-hour shifts. The finding may have been due to a good schedule of work and rest days, which provided an adequate number of rest days (either two or three) to recover from the number of work days (two sometimes three). While
there was no build up of excessive fatigue with the 12-hour shift length, the workers with the 12-hour shifts did report inferior alertness at certain times at work (0600 hours and 1400 to 1800 hours). This decreased alertness may result in inferior performance, and the potential for an increase in accidents and errors with 12-hour shifts, although performance was not measured in the study. Objective performance measures for workers with 12-hour shifts need to be compared to those of workers with 8-hour shifts.

Williamson, Gower, and Clarke (1994) investigated the impact of changing from an 8-hour shift to a 12-hour shift on workers’ health, job satisfaction, and work productivity. Seventy-five computer operators completed self-report questionnaires to indicate their health and job satisfaction levels before changing and after working the new roster for seven months, while productivity was calculated from the operator errors recorded automatically by the computers. The results indicated significant improvements in health (both physical and psychological health), a non-significant trend for improved job satisfaction, and no change in the number of operator errors with the 12-hour shifts. The follow-up period in this study was only quite short (seven months), however, which may not have allowed enough time for the ‘honeymoon’ effect to wear off and for any long-term problems to develop (Williamson et al., 1994). A longer time period may have revealed different results.

A study by Mitchell and Williamson (2000) investigated the effects of a change from an 8-hour to a 12-hour compressed work week roster on work performance, health and well-being, sleep and mood, and absenteeism and accidents. Twenty-seven male workers from an electrical power station completed questionnaires (a modified Standard Shiftwork Index), diaries (indicating sleep and mood), and several
performance measures, when working the 8-hour roster, and then 10 months after the change to a 12-hour roster. Only five participants were recorded on both shift systems.

The personal preference data revealed that the 12-hour system was preferred as it allowed more free time to spend with family and friends, had fewer continuous shifts, and produced better overall health feelings. Employees working the 12-hour roster reported being more satisfied and better able to cope with their social (e.g. sports) and domestic situations (e.g. time with family). The 12-hour group reported their sleep to be deeper, of a better quality, and they felt more refreshed on waking than when working the 8-hour roster. Employees on the 12-hour roster reported fewer overall health complaints, and improved physical health (fewer headaches, less incidence of gastrointestinal symptoms, and fewer bronchial symptoms reported) than the 8-hour workers. There was no significant difference for subjective coping with sleep or work performance or for chronic fatigue or the cognitive-somatic anxiety scores. Both shift lengths produced increased feelings of fatigue and stress on the night shift compared to rest days (Mitchell and Williamson, 2000).

The results from the performance testing revealed no difference between the two groups for cognitive performance. The employees working the 12-hour rosters demonstrated faster decision times and reaction times towards the end of their shift, but they also had a higher incidence of errors towards the end of their shift compared to the beginning of their shift. This was true for both day and night shifts. The faster reactions times at the end of their shift compared to the start of the shift may reflect the workers ‘re-arousal’ response from their anticipation of finishing work. The increased
errors towards the end of the shift may be due to the accumulation of fatigue resulting from working a 12-hour shift (Mitchell and Williamson, 2000).

Looking at the study overall, from the subjective results it would appear that the 12-hour shift length was favoured as there was better subjective quality sleep, better mood, increased time for social and domestic activities and better coping with these domains, and general and physical health improvements. A major disadvantage with the 12-hour shifts, however, was the objective increase in errors seen at the end of the shift, particularly for unexpected events, which may create a serious safety risk for workers.

There are a number of limitations with this study that must be addressed. First, the study consisted of a small sample size and a very specific group of workers, which limits the generalizations of the results. Second, and importantly, the change in shift length was confounded by a change from a weekly rotating roster (the 8-hour shift) to a rapidly rotating roster (the 12-hour shift). This change is very significant, as the weekly 8-hour shift roster required seven consecutive night shifts, while the change to the rapidly rotating 12-hour shift roster decreased the number of consecutive night shifts to a maximum of three night shifts. It is quite possible that the observed changes or ‘improvements’ seen with the shift length change (from 8 to 12 hours) was the result of the change from a weekly rotating to a rapidly rotating roster, and the subsequent decrease in the number of consecutive night shifts that had to be worked. The change from the weekly rotating roster may explain some of the improvements seen in the study, rather than the change in shift length. This change in roster duration, with fewer consecutive night shifts, is a major confound in the study, seriously limiting the interpretation of this study’s results with respect to shift duration as a single variable. A third limitation with the study is that the effect of the shift change was assessed
relatively shortly after the change occurred (being only 10 months). This length of time may not be enough for the ‘honeymoon’ effect to wear off and for long-term problems to have developed. Given more time, it is possible that different results, including increased problems with the 12 hour shifts, may emerge.

Changing from an 8-hour to a 12-hour shift system was also studied by Lowden, Kecklund, Axelsson, and Åkerstedt (1998). Chemical plant employees were studied shortly before and 10 months after the change from a three shift, 8-hour schedule to a 12-hour shift length schedule. This change in shift length was also accompanied by a change to a shorter roster length (the compressed work week). All of the participants (n=34) completed questionnaires, while a smaller subgroup completed sleep diaries, two- to four-hourly sleepiness ratings, actigraphy measurements, and reaction time performance for part of the shift cycle. The results indicated that the 12-hour shift schedule was favoured over the 8-hour shift schedule. The 12-hour shift schedule produced an improved attitude towards work hours, improvement in social life (more time available for family and friends), improved sleep, and reduced fatigue after work and on days off. There was no increase in mental or physical strain, no negative effects on performance, and no increase in accidents with the change to the 12-hour shifts. Actigraphy data supported the subjective reports of improved sleep on the 12-hour shifts.

It should be noted, however, that some or potentially all of these improvements may have been due to changes other than the shift length which altered with the new roster. The original 8-hour shift schedule was poorly designed, consisting of a counter-clockwise (backward) rotation, long sequences of work days (four nights and two
afternoons), and four quick changeovers (of 8 hours only between shifts) per roster. The 12-hour roster had a maximum of three work days in a row and had more free days off, including weekends. The other factors associated with the 12-hour shift length, such as the shorter roster length (more rapid rotation), the fewer work shifts in a row, and the increase in free time (including weekends), may have been important factors in motivating the preference for the 12-hour shift length roster, rather than just the shift length on its own (Lowden et al., 1998).

Smith, Wright, Mackey, Milsop, and Yates (1998) studied shift workers from three similar work plants who originally worked slow rotating continuous 8-hour shift rosters (seven continuous shifts), and then changed their roster type. Two of the work places changed directly to a rapidly rotating 12-hour roster, while the third changed first to a rapidly rotating 8-hour shift roster for six months, and then to a rapidly rotating 12-hour shift roster. This procedure allowed the researchers to study the impact of a rapidly rotating 8-hour and 12-hour shift system on workers when both were ‘new’ rosters (groups 1 and 2 compared to the first change for group 3), and also allowed the same workers to be studied on a rapidly rotating 8- and then 12-hour shift roster (group 3). Six male shift workers participated from each work site (mean age 39 years). Workers completed self-report questionnaires before and after the roster changes, along with sleep diaries for certain weeks before and some time after the change (although the completion rate for this was very low). The work places were similar initially with regards to attitude, self-reported health, sleep quality, and the perceived impact of shift work on the workers’ lives.
Comparing the new 8-hour to the new 12-hour shift roster revealed that the workers with the new 12-hour shift rosters were more satisfied with the roster, had fewer psychological health complaints, and reported increased improvements with their family, social, and work life. The 12-hour shift was preferred and greater improvements were seen compared to the 8-hour shift change. The 12-hour shifts did not increase fatigue or decrease sleep quality (Smith et al., 1998). The workers who tried both systems did not report any improvements when they changed for the second time from the new 8-hour roster to the 12-hour roster. This latter finding was thought to be due to the characteristics of the group itself rather than the roster change, however, as this group was much less clear about why to adopt a roster change and which roster to adopt, and they were less satisfied with any roster than the workers from the other work places. There were no changes in reported sleep length for any condition (Smith et al., 1998).

Changing the roster to a rapidly rotating design (either the 8- or 12-hour shift lengths) improved roster satisfaction, improved physical and psychological circadian malaise (i.e. sleep and digestion), improved day time sleep quality, improved tiredness and fatigue, and improved the workers’ life (home, social, and work life), supporting the previous position that rapidly rotating rosters are preferred over slowly rotating rosters. As for the shift length, it would appear that the 12-hour shifts may have some subjective advantage, particularly as the reduction in the number of consecutive shifts may reduce the negative impact of shift work on family and social life (Smith et al., 1998). The results from this study are limited, however, as they are all self-report data, and from workers who strongly supported a roster change before they were introduced.
The results may also be confounded by the decrease in overtime for the workers that occurred with the roster changes (Smith et al., 1998).

While 12-hour shift lengths can often be preferred by shift workers for lifestyle reasons (i.e. greater time off), it is important to remember that a main concern regarding extended work shifts is the potential effect that the longer shifts have on fatigue, and therefore on alertness, performance, and particularly safety, including public safety. According to a review of 8- versus 12-hour shift lengths by Smith, Folkard, Tucker, and Macdonald (1998), many workplace studies which have indicated no increase in accident rates or errors with 12-hour shifts, are confounded because the changes from 8- to 12-hour shifts were accompanied by an increased awareness of safety and improved preventative safety measures within the workplaces. The long-term effect of these initiatives, that is, how long they will last, needs to be assessed.

A recent study to investigate this issue of accident rates and 12-hour shifts was conducted by Johnson and Sharit (2001). They investigated the impact of a change from 8- to 12-hour shift lengths on the occupational injury rate (the number of OHS recordable injuries per 100 workers) within a manufacturing company. According to the data analysis (spanning eight years on the 12-hour shifts), there was no significant change in the occupational injury rate when working a 12-hour work day. As the authors noted, however, the change in shift length was also associated with an increase in days off, and a reduction in the number of night shifts worked, which may have prevented any rise in injury rates. Also, those workers who were unable to cope with the 12-hour shifts were provided with alternative work arrangements within the
company, which may have left only those workers most suited to working 12-hour shifts (the ‘healthy worker effect’), which would have confounded the results.

Further evidence obtained from analyses of occupational injury records has indicated that work days longer than eight hours may indeed be associated with an increased risk of an accident. Åkerstedt (1994) analysed data from the Swedish Occupational injury information register. A total of 160,000 injuries (for a working population of 4.2 million) which caused at least one day of sick leave were analysed for the year 1990/1991. The results showed that the risk from being at work was relatively stable for the first eight hours. The risk increased dramatically from the ninth hour at work onwards to a peak at 16 hours, were the risk was trebled, and which was the maximum length of work included in the study. Hanecke and colleagues (1998) analysed the occupational accident records for one-year (1994) from the workers’ compensation board in Germany. These authors also demonstrated that the risk for an accident increased exponentially after the eighth hour at work, and was particularly pronounced when work started in the afternoon or evening hours (i.e. afternoon and night shift workers). Recent work by Folkard (2002) also supports the position that long shifts are associated with an increased risk of an accident. Folkard (2002) used mean relative risk values taken from four studies investigating the effect of time on shift to estimate the relative risk of different shift lengths. Using a relative risk of 1 for an 8-hour shift, the calculations revealed an increase in risk for a 10-hour shift of 11.6% (relative risk 1.12), and a 27.6% increased risk for a 12-hour shift (relative risk 1.28). These analyses together indicate that work shifts longer than eight hours may have serious implications for worker safety. Further research is certainly required to address this
issue, particularly when the longer work shifts are combined with the complexities of a shift work work-schedule.

Several studies indicate that 12-hour shifts, and therefore the compressed working week, may be preferred by shift workers. This is mainly for lifestyle reasons, such as the increase in days off, and a reduction in commuting time and expense. Communication between shifts can sometimes be improved with 12-hour shifts as changeover generally occurs between the same workers. The performance and safety aspects of extended shifts, such as injury data over extended work shifts, tends to suggest caution for 12-hour shifts. Another important factor to consider when comparing shift lengths is the work load. The work conducted in the majority of studies reviewed was not very physically demanding. Had it been, the results may have been different, with physical fatigue and performance decrements possibly increasing under such circumstances in the 12-hour shift schedule. Workload is an important factor when considering 12-hour shift lengths. The contribution of other scheduling factors, such as the sequencing and timing of shifts and time off, in combinations with extended work days, requires further research before firm conclusions can be drawn regarding the use of 12-hour shifts for shift workers.

6.4.2 Overtime and long weekly working hours

When discussing extended work shifts and the compressed work week, it must be noted that these working arrangements have the potential to increase the number of weekly (and thus annual) working hours for a worker. This is because these workers can often be asked to work overtime hours, or because of the extra days off due to the compressed 12-hour shifts, the workers have the opportunity to hold a second job,
which is referred to in the literature as moonlighting. The impact of long weekly working hours on the health and safety of workers, despite being an important issue, has received limited scientific attention.

Two recent reviews (Sparks, Cooper, Fried, and Shirom, 1997; Spurgeon, Harrington, and Cooper, 1997) exploring the relationship between long weekly working hours and health problems concluded that although the data was limited, there appeared to be a small but significant link between long weekly working hours and ill-health, encompassing both psychological health (such as mental stress) and physical health (in particular cardiovascular related problems). The size of the relationships found was thought to be under-representing the true strength of the relationship because of the methodological limitations when using a heterogeneous group of studies (including differing sample populations, occupations, working hours, and outcome measures used). While the precise number of safe working hours is not known from the limited data available, weekly hours of more than 50 were thought to be clearly associated with a detrimental effect on health and well-being.

The nature of the relationship between long weekly hours and ill-health is unknown at this time. There are thought to be several modifying variables, including worker attitudes and motivation, the work tasks and work environment, and the ability to choose or decline overtime work (or a second job), which may impact on the relationship in various ways. It was suggested by Sparks and colleagues (1997) that working excessive weekly hours may be linked to an increase in adverse health behaviours such as smoking and frequent alcohol consumption, lack of physical exercise, and poor dietary habits, which again would impact on a worker’s health and
well-being. It is clear from anecdotal reports that family relationships suffer with long weekly working hours, which may also affect a workers health and certainly their well-being.

With regards to performance, the studies reviewed by Spurgeon and colleagues (1997) indicated that long weekly working hours were associated with lower productivity and higher absenteeism; that is, when weekly working hours were decreased to around 40 hours per week, productivity increased and absenteeism rates decreased in several work places. The safety of workers involved with long weekly working hours, separately from shift work situations, has received surprisingly little research attention. It is clear from the shift work literature that extended working hours during the day and especially at night is associated with a higher accident risk (as discussed previously).

A major safety concern with long weekly working hours is the exposure of workers to toxic chemicals and substances. The current exposure standards for safe workplace exposure to toxic chemicals are based on an eight-hour day, 40-hour week. Apart from the length of exposure, it is known that human vulnerability to toxic substances changes across the 24-hour period, a phenomenon known as chronotoxicity, which has important implications for the health of shift workers (Brief and Scala, 1975; Kiesswetter, Seeber, Blaszkewicz, Sietmann, and Vangala, 1996; Verma, 2000). It is clear from the review by Spurgeon and colleagues (1997) that specific information regarding how to deal with this issue is lacking, and further research is desperately needed to identify if and how the safe exposure guidelines need to be amended to accommodate longer working hours, especially when involving shift work.
While there is still a great need for further information, it is clear from what is currently available that workers involved with long weekly, and therefore annual working hours, face an increased risk for adverse health and well-being problems, with the potential for performance and safety problems as well. If this position is combined with shift work, in particular night shift, the outcomes may be considerably worse. While the outcome is unknown, it would be wise to limit the number of weekly working hours to the 48 hours recommended by the International Labour Standards and the European directive 93/104/EC adopted in 1990 (Kogi, 1998; Kogi and Thurman, 1993).

6.4.3 Summary

While many workers indicate a preference for 12-hours to 8-hour shifts, many of the studies investigating shift length are confounded by other shift roster characteristics being different as well, such as rotation speed and thus the number of consecutive shifts, the scheduling of time off, weekly working hours, and so on. Future research is needed to identify the effect of shift length as a single variable. Further research is also needed to study, objectively, the effect of extended work hours on performance. Shift workers can often prefer the longer shifts because they are associated with an increased number of days off, allowing for improved family and social interaction, rather than being associated with better performance at work. Some studies have indicated that 12-hour shifts may be associated with increased fatigue and errors at work, particularly for high stress and possibly highly physical positions. The distinction between the subjective and objective outcomes of extended work hours needs to be addressed, particularly as the objective data will provide more accurate and possibly more negative results than the subjective data. Too many of the existing studies conclude that 12-hour shifts are satisfactory based solely on subjective data. Information is also required to
identify which tasks may or may not be suitable for scheduling extended work shifts, and whether any worker characteristics (e.g. age, general health) might affect the outcomes of working 12-hour shifts. Further research is also needed to investigate the long-term impact of 12-hour shifts on performance and especially health. Few such studies exist at the present time.

Recommendations have been made regarding the use of extended work days (12 hours) and compressed work weeks. These rosters are not recommended for periods greater than four days, or for night shift work, as fatigue can accumulate to high levels (Thierry and Meijman, 1994). As extended shifts or compressed working weeks can lead to increased fatigue levels, they should be carefully implemented and monitored (Knauth, 1993). Further advice on shift work scheduling is provided in chapter 10.

6.5 Time Between Shifts

Adequate time between shifts must be provided so that workers can obtain sufficient rest and sleep, as well as attend to everyday essential activities before returning to work. Quick shift changeovers, such as changing from night to afternoon/evening shifts or from afternoon/evenings to morning (common on the backward roster), only allow about eight hours between shifts. This is not enough time for workers to get adequate sleep between shifts, resulting in significant levels of fatigue on the second shift (Kecklund and Åkerstedt, 1995a; Monk, 2000).

Too many working days in a row should also be avoided as sleep loss and fatigue can build to high levels over time, decreasing performance and increasing the risk for accidents and errors towards the end of the work period (see Folkard, 2002). Working
long successions of days also means that weekends off are likely to occur only infrequently, which has negative implications for the family and social life of the worker. Working over the weekend may also have negative implications for the performance and safety of the shift worker at work, particularly when on night shift. Monk and Wagner (1989) analysed the injury data occurring on the night shift from ten US mining operations with similar work practices from over a 10-year period (n=457 night shift accidents). The shift work systems were identical across all workplaces, and involved weekly rotations of three shifts, with the seven consecutive night shifts always commencing on a Thursday night. The data analysis revealed a small reduction in injuries over the first three night shifts, followed by a massive increase in injuries (65%) on the Sunday night/Monday morning, followed by a gradual decline in injuries over the remaining three nights. As the workforce and work tasks did not change over this period, the authors suggested that the increase in injuries on the Sunday night was due to the workers’ being involved in activities during the daytime over the weekend (in keeping with their daytime oriented family and friends). The result of this was firstly that any adaptation that may have occurred in their circadian rhythms to favour the night work before the weekend was disrupted over the weekend, and secondly they had not obtained adequate sleep over the weekend before returning to work on the Sunday night (Monk and Wagner, 1989). These results highlight the importance of considering social and domestic factors, such as providing weekends off as much as possible, in shift work scheduling.

Although the precise number of consecutive days that should be worked can vary according to the work being undertaken, since World War II, it has been standard industrial and business office workplace convention to limit the number of consecutive
working days to five to seven days. This position is also supported by most shift work specialists (e.g. Koller, Kundi, and Haider, 1991, in Knauth, 1993). Time off after this work period should include at least two consecutive days free (incorporating a weekend as often as possible), although more time off (i.e. three days or more) may be required after working a series of night shifts (Kecklund and Åkerstedt, 1995a; Meijman, Thunnissen, and Vries-Griever 1990; Tepas and Mahan, 1989; Totterdell, Spelten, Smith, Barton, and Folkard, 1995). This allows time for workers to reduce their sleep debt and to recover from their work-induced fatigue, and allows them time to socialize and to enjoy their time off (Knauth, 1993). Again, the quickly rotating shift system is recommended, as it allows more frequent social contact and helps to minimise the feelings of social isolation that can be common among shift workers. When 12-hour shifts are involved, it has been recommended that at least two days off be provided between changing from the day to night shift to help limit fatigue and improved alertness levels at work (Tucker, Smith, Macdonald, and Folkard, 1999). Further guidance on shift work scheduling is provided in chapter 10.

6.6 Rest Breaks During Work

Rest breaks during a work shift are important. These help to reduce both mental and muscular fatigue build up, depending on the work being carried out. Many work places practice the standard rest breaks of one 30 to 60 minute meal break and two 10 to 15 minute tea breaks. Work that requires intense cognitive capacity (e.g. sustained attention in air traffic control) or repetitive physical work (e.g. data entry or word processing) may require more frequent, shorter rest breaks. Five to ten minutes every 30 to 60 minutes may be appropriate, depending on the task being undertaken (Dababneh, Swanson, and Shell, 2001; Kopardekar and Mital, 1994; Penn and Bootzin,
Some advice on strategies to improve alertness during breaks is provided in chapter 10.

### 6.7 Regularity of Start Times - Shift Work and Jet Lag

Shift work involving irregular starting times can create problems for the circadian rhythm system. Starting times that are variable can be thought of as similar to the rapid crossing of time zones that occurs with trans-meridian plane travel.

Most people will experience some form of ‘jet lag’ when they fly to a new time zone, including changes of a few hours such as experienced when flying within Australia from Perth (in the west) to Melbourne (in the east). When a passenger flies eastward from Perth to Melbourne, they experience a forward, three-hour time change. The new ‘local’ time in Melbourne is therefore three hours ahead of their body time, thus creating a three-hour phase advance for their circadian rhythm system. When they are asked to attend their important business meeting at 0900 hours (local time) in Melbourne, their body is set to function as though it was 0600 hours, a time when they would normally be asleep! Furthermore they are faced with the problem of trying to sleep three hours earlier at night than their body is set for, if they wish to obtain sufficient sleep. We know that even this small kind of time zone change is hard to make, and we cannot function at our best under such conditions.

Yet shift workers with irregular start times are exposed to similar kinds of ‘time zone changes’ every time their work hours change. When a shift worker is asked to start work three or more hours earlier in the morning than the day before, they are expected to work too early for their body time, similar to the business-person who flew from...
Perth to Melbourne. Each time shift work start times change, it is as though the worker has jumped in a plane and travelled to another new time zone, although the shift worker does not have the benefit of zeitgebers such as sunlight to set the clock in the new time zone. Changing the start times of shifts means that the body and its circadian rhythms are constantly trying to work out what ‘time zone’ it is supposed to be set to, constantly being confused with conflicting zeitgebers (e.g. morning sunlight, meal times, and sleep times). Shift start times should therefore be as consistent and regular as possible.

6.8 Twelve-Hour ‘Time Zone’ Changes and the Bimodal Circadian Rhythm System

While many human physiological processes follow a circadian cycle, with a peak and a trough once every 24 hours (Aschoff and Wever, 1981), investigations into the human sleep/wake cycle have uncovered a slightly more complicated rhythm than a simple sinusoidal rhythm. Instead of finding a rhythm of one cycle per day, researchers have found a *biphasic* rhythm with two cycles of sleepiness per day. Apart from the nocturnal increase in sleepiness, which is strongest in the early morning hours (approximately 0100 to 0400 hours), there is a smaller secondary increase in sleepiness, more reports of drowsiness, a decrease in alertness and performance, and a secondary peak of operator fatigue related accidents occurring in the early to mid-afternoon (approximately 1300 to 1600 hours) (Babkoff et al., 1985, 1989; Campbell and Zulley, 1985b; Folkard, 1997; Horne and Reyner, 1995; Lavie, 1986; Mitler, Miller, Lipsitz, Walsh, and Wylie, 1997; Richardson et al., 1982; Strogatz et al., 1987). In many cultures taking an afternoon siesta nap at this time is common practice (Dinges, 1989). Although this period is commonly referred to as the “*post-lunch dip*” in alertness, it is a
naturally occurring phenomenon, which is independent of food ingestion (Campbell, 1992).

Due to this biphasic rhythm of two cycles per day, these natural 12-hour cycles facilitate a 12-hour time zone change much more easily than a shorter or longer time change. In a 12-hour time change, the day/night periods completely reverse, which leaves the two 12-hour rhythms still partly compatible with the new time zone. The original post-lunch dip in alertness becomes positioned at the new night time sleep period, therefore facilitating sleep. The original morning wake up or ‘wake-maintenance zone’ becomes positioned at the new evening awake period, thus facilitating wakefulness at that time. The original evening ‘wake-maintenance zone’ becomes positioned at the new early morning period, therefore facilitating wakefulness at that time. The afternoon time frame is still a ‘problem’ time with a 12-hour time change (as it was in the old time zone), however, as the new afternoon period is occurring at the time of the old overnight sleep period, when sleepiness is at its highest. Sleepiness and fatigue are increased, and therefore the risk of errors or accidents will be higher at this time.

Despite this rational for 12-hour time changes, it is not acceptable to reason that 12-hour shifts would therefore be better than 8-hour shifts. The data provided earlier in this chapter detailing extended working hours and 12-hour shift lengths still provide strong evidence against working extended or 12-hour shifts.
6.9 Summary

When designing safe and satisfactory shift work schedules employers must consider several scheduling factors. These include factors such as the shift timing, the shift cycle length, the direction of shift rotations, the amount of rest time during and between shift cycles, the length of shifts, and the regularity of shift start times. Consideration must also be given to the type of work being done, and the non-work situation of the employee (e.g. domestic commitments and travel times), as this knowledge can influence the choice of several roster characteristics. Each of these factors can affect how an individual will be able to cope with shift work, and will therefore affect their performance and safety when working shift work. While there is no one single best schedule that can be recommended for all work settings, there are guidelines than can be followed to ensure that as many of the best characteristics are selected as possible. These guidelines are provided in chapter 10. Good shift work schedules are advantageous for both the worker and the company, as both safety and productivity, and shift worker satisfaction can improve with a good shift work schedule.
7. INDIVIDUAL DIFFERENCES

There are several individual difference variables that may affect shift work tolerance. These include age, gender, physical fitness, circadian type (morning type vs. evening type), ‘hardiness’, and social support (discussed in chapter 4) (e.g. Tepas et al., 1997). These variables, as well as various markers of the endogenous circadian rhythm system, have been used to try to predict those individuals that will tolerate shift work better than others. As will be shown, there is little evidence available to suggest that tolerant shift workers can be predicted before they start shift work. While these variables are important factors that may influence an individuals ability to tolerance shift work, the shift work scheduling factors discussed in the previous chapter are considered to make the greater contribution.

7.1 Age

With the percentage of workers involved in shift work increasing, and the population as a whole aging, it is inevitable that older individuals will be involved with shift work. Increasing age is thought to be associated with decreased shift work tolerance (Harma, 1993; Nachreiner, 1998; Torsvall and Åkerstedt, 1978). Shift workers sometimes become intolerant of their work schedules when they reach ages between 40 and 60 even though they have done shift work successfully for many years (Åkerstedt and Froberg, 1976; Foret, Bensimon, Benoit, and Vieux, 1981).

Harma and Ilmarinen (1999) reviewed the literature relating to shift work and the older worker. Older shift working individuals appear to be less able to cope with the demands of shift work, despite having many years of experience. This is thought to be
due to the age-related changes that occur with the circadian rhythm system and with sleep architecture. With increasing age, the circadian rhythm system tends to decrease in amplitude (i.e. it flattens), there is an increased tendency for internal desynchronisation, and due to a shortening of the period length there is an increased tendency for phase advanced rhythms, resulting in more “morningness” (Czeisler et al., 1992; Dijk, Duffy, Riel, Shanahan, and Czeisler, 1999; Harma, 1993). This latter tendency contrasts that of adolescents who, for biological and environmental reasons, typically show a phase delay in their circadian rhythm system and thus display more “eveningness” (Carskadon, 1990; Carskadon, Vieira, and Acebo, 1993; Wolfson, 1996). Sleep architecture also changes with age, with sleep becoming lighter and more fragmented on average with increasing age, resulting in an increase in sleep complaints (Bliwise, 1993). The typical sleep disruption that occurs with shift work (as discussed in chapter 3) combines in the older individual with the natural changes to their circadian rhythm system and sleep architecture, to increase the prevalence of sleep complaints among older shift working individuals. For example, researchers such as Gander and Graeber, at the NASA Ames Research Center, have studied the sleep of long-haul overseas commercial aircrews and found that the older flight crew members, especially those older than fifty years, slept less and had a poorer quality of sleep than the younger crewmen (Gander, Nguyen, Rosekind, and Connell, 1993; Graeber, Lauber, Connell, and Gander, 1986). Tepas, Duchon, and Gersten (1993) surveyed nearly 2 700 shift workers and found that the sleep length of night shift workers significantly decreased with age. Moline and colleagues (1992) found that middle-aged participants (37 to 52 years) experienced more difficulty sleeping at the wrong phase of the circadian cycle than younger participants (18 to 25 years). Older workers can also suffer more from the accumulated sleep loss that occurs with consecutive night shifts
(i.e. chronic sleep loss), being less able or slower to adapt to night shifts than younger workers (Harma, Hakola, Åkerstedt, and Laitinen, 1994). Older workers involved in shift work report more complaints of sleep disorders than older workers not working shift work (Harma and Ilmarinen, 1999).

Apart from the sleep complaints, there is also a tendency for older shift workers to suffer from more health complaints (Nachreiner, 1998; Torsvall and Åkerstedt, 1978). Gastrointestinal disorders are found among shift workers, with the highest prevalence being for those with long-term exposure, that is, the older shift workers (Harma and Ilmarinen, 1999). Aging and increased exposure to shift work is also thought to increase the risk for coronary heart disease (although the relationship between shift work and lifestyle factor changes related to the coronary heart disease risk factors is not well understood). Shift work is also thought to increase depression in the older, more experienced shift workers (Harma and Ilmarinen, 1999).

Despite these negative findings, Harma (1996) suggests that older shift workers may have some advantages over younger ones for some shift work situations. Although the older shift workers sleep worse after a night shift (i.e. when sleeping during the day), they actually sleep better before and feel better during a morning shift compared to younger workers (Åkerstedt and Torsvall, 1981). This may be due to the increased tendency for ‘morningness’ among older individuals, which allows them to sleep earlier and feel more awake earlier on than younger workers. It has also been suggested that older individuals may not be as sensitive to ‘acute’ sleep losses as younger people are, which means they may be able to cope better with a single night shift than a younger worker (Bonnet and Arand, 1989; Bonnet and Rosa, 1987; Harma et al., 1994; Monk,
Buysse, Reynolds, Jarrett, and Kupfer, 1992). Older shift workers may also have some advantage over younger shift workers with regard to better housing conditions (due to their improved economic situation), and decreased family responsibilities as their children leave home (Harma and Ilmarinen, 1999). Older shift workers are also more experienced at coping with shift work, and by this stage are self-selected to be able to cope with shift work (i.e. the “healthy worker effect”).

The above information can be used when scheduling older shift workers to minimise the negative impact of shift work. Strategies for scheduling the older shift worker are provided in chapter 10.

7.2 Gender

Gender has been suggested as an important factor effecting shift work tolerance. The main effect of gender is thought to arise for women who have children (especially young children), and the subsequent impact that children have on their sleep times, and thus their ability to tolerate shift work situations (Colligan, 1980; Gadbois, 1981). The topic of gender therefore appears to be as much or more affected by ‘social-environmental factors’ as by anything traceable to biological differences (Hakola and Harma, 1992; Hakola, Harma, and Laitinen, 1996). The differences between men and women with regard to their tolerance for shift work, although seemingly apparent, are not really very clear. In fact, the majority of research in this area has focused on comparing women with and without children, rather than comparing women and men.

Lee (1992) used questionnaires to investigate the frequency and type of sleep disturbances among working female nurses in the US. She found that for women less
than 40 years old the factor that caused the greatest sleep disturbance was the presence of children (reported as “child care responsibilities”). This was regardless of the type of shift they worked. The women working permanent nights and rotating shifts reported sleeping less than the day workers (i.e. they had a reduced sleep quantity). The presence of children for these shift working women may impair their sleep further by decreasing the quality of their sleep, by increasing the awakenings during their sleep period in order to take care of their child. In order to stay attentive to home chores and the care of their children, shift working mothers may suffer from an inadequate sleep period, with a reduced quantity and quality of sleep, causing increased sleepiness and fatigue, compared to shift working women who do not have children.

Similar results were found by Kurumatani and colleagues (1994) in a sample of Japanese female nurses. In this study the nurses with young children (mean age 2.8 years) reported sleeping less and having less free-time than the nurses without children. The nurses with children spent extra time on housework and child care, reducing the time available for free-time activities and sleeping. They were also not able to use the strategies that the childless nurses used for limiting their shift work sleep debt, which were sleeping for extra hours during the day before and after a night shift, and sleeping-in in the morning when on evening shift and on days off. The time needed for caring for their young children meant that these nurses could not obtain extra sleep when they may have needed to, particularly when on evening and night shifts.

Rotenberg, Moreno, Potela, Benedito-Silva, and Menna-Barreto (2000) studied a group of female industrial night shift workers to determine the impact of having children on their complaints related to fatigue and poor sleep, and the amount and distribution of
day time sleep. Of the 34 women included in the study, 17 had children and 26 did not. The shift working women were aged between 20 and 40 years, while the children were aged between 8 months and 19 years. All the women with children had at least one child less than 10 years old, and 65% of the women with children had only one child. The night shift roster was semi-continuous (i.e. no weekend work), with 8-hour night shifts during the week. The female workers kept daily sleep logs for 10 weeks, during which time they were contacted twice a week by researchers. They also provided information in a structured interview about their fatigue and sleep complaints.

According to the results, the two groups of women (with/without children) did not differ in the timing of their first sleep period after night shift or in their mean daily total sleep time. However, further analysis revealed that the women with children tended to have a short morning sleep followed by an afternoon sleep rather than one long sleep period, as the women without children tended to have.

While the total number of sleep and fatigue complaints did not differ between the two groups of women, closer inspection of the data revealed that the women with children reported a higher frequency of the complaints ‘difficulty falling asleep’, ‘dissatisfaction with the amount of sleep in weekdays’, and ‘increasing fatigue as the week progressed’. This latter complaint of increasing fatigue over the work week was despite these women reporting the same amount of total sleep time per day as the women without children. The difference was that the women with children obtained their sleep in two or more shorter sleep periods across the day, rather than in one consolidated sleep period beginning in the morning. The inability to obtain a long sleep period (beginning in the morning) may have resulted in the increased feelings of fatigue for the workers
with children. Despite the small sample size of the study, which may limit the
generality of findings, the results indicate that women with children may find shift
work harder to cope with than women without children, as the presence of children can
disrupt the temporal placement (and thus fragment) their diurnal sleep periods. This
may then increase their feelings of fatigue across a period of night shifts (Rotenberg et
al., 2000).

Despite the issue of gender and the impact of having children on shift working females
being an important consideration, there are very few studies addressing these issues.

7.3 Age and Gender
A study by Spelten, Totterdell, Barton, and Folkard (1995), examined the effect of age
and domestic commitments on the sleep and alertness at work of female shift workers.
A total of 572 female nurses participated in the study (mean age 33 years). Two shift
rosters were worked, a permanent night shift (n=226) and a rotating roster (n=284).
Nearly 65% of the nurses lived with a partner and 41% had ‘dependents’ that they had
to look after at home. Information regarding sleep, domestic commitments, and
alertness was collected via self-report questionnaires.

Correlation analyses indicated that increasing age was associated with a decreased
sleep duration, and a higher level of alertness at work. A high number of dependents
was associated with a decreased sleep duration for all nurses, and was associated with
increased sleep difficulties for the permanent night nurses only. High work-home
conflict was associated with increased sleep difficulties and reduced alertness for all
nurses (Spelten et al., 1995).
Regression analyses revealed that older age was associated with reduced sleep duration, but not any more sleep difficulties or reduced alertness at work. A higher number of dependents at home decreased sleep duration on the night shift for all nurses, but only affected the sleep difficulties and alertness for the permanent night nurses. Permanent night nurses had a higher alertness when older, and lower alertness with more dependents. High levels of work-home conflict also increased sleep difficulties and reduced alertness at work for the rotating nurses, but did not affect sleep duration on any shift (Spelten et al., 1995).

Similar to other studies, the results indicated that having dependents at home significantly affected the permanent night shift workers’ ability to obtain an adequate length and quality of sleep, and therefore to maintain their alertness when at work. In addition to this finding, the results also reveal that both biological (e.g. age) and social factors (e.g. dependents) should be considered when addressing the effects of shift work. Middle-aged female shift workers with domestic responsibilities may actually suffer from more sleep complaints (particularly on the night shift) than older female shift workers, who are usually thought to be at the biggest disadvantage because of their age. The study also demonstrates that ‘sleep duration’ and ‘sleep difficulties’ or ‘quality’ should be addressed separately in future studies as differences were found between these two variables (Spelten et al., 1995).

Perhaps the only study to investigate the impact of gender and age on shift work, using both male and female participants, has been conducted by Oginska, Pokorski, and Oginski (1993). These authors investigated the effect of age and gender on shift work
tolerance among 166 shift workers (male and female) matched for occupation. The women appeared to be affected more adversely by the shift work than the males, indicated by greater difficulties with sleep, greater fatigue at work, and poorer subjective health and chronic fatigue than the men. An interesting finding was what happened to the subjective health ratings around age 50; the women started to improve on their physical and psychological health measures while the men continued their downward trend. It was suggested that personal changes occurring around this age for women, such as menopausal changes, reduced childcare, or reduced domestic responsibilities, may have changed their attitudes about their work, so that they felt being at work was good for them, even shift work.

While this study supports the previous position that women may find shift work harder to tolerate than men, it is still unclear why this is so. The amount contributed by biological versus socio-cultural differences between men and women to the relationship is unknown from the present research. Further research is required to understand this relationship further. The research available to date suggests that rather than gender per se being the important variable, the presence of children and thus the child care responsibilities that mainly fall on the female, may be the more important consideration.

7.4 Physical Fitness

Physical fitness has often been suggested as a factor effecting shift work tolerance. A study by Henderson and Burt (1998) investigated the use of shift work preparation and coping strategies on the attitudes and health (physical and mental health) of shift workers. One hundred and twenty two nurses (mean age 35 years) working various
rosters participated in the study. The mean length of shift work experience was 13.9 years. Participants completed questionnaires asking how frequently they engaged in a number of shift work preparation and coping strategies (such as sleeping, eating, exercising, and socializing strategies), and about their physical health symptoms, psychological well-being, sleep problems, shift work satisfaction, and social life satisfaction.

While regression analyses indicated the main predictor of better coping and satisfaction was following more ‘socializing strategies’, the other major significant predictor of shift work coping and satisfaction was fitness level. Those shift workers who reported being physically fit reported significantly better physical health and psychological well-being than those who were unfit (Henderson and Burt, 1998). Although there was no manipulation of physical fitness in this study, the results suggest that being physically fit may enable a shift worker to cope better with shift work, resulting in fewer physical and psychological problems. Similar results were obtained by Harma, Ilmarinen, and Knauth (1988), who found that physically fit female shift workers reported lower fatigue and musculoskeletal symptoms and better sleep quality than their unfit peers. Studies using objective measures have confirmed that physically fit individuals experience less sleepiness during the night shift than unfit individuals (Harma, Ilmarinen, Knauth, Ruterfranz, and Hanninen, 1988a, 1988b). Whether the benefits from being physically fit are the same for non-shift workers as they are for shift workers needs to be examined by studying the effects of physical fitness in a control group of day workers, which has been overlooked in the majority of studies in this area. It is not clear at this time whether fitness has a main effect or an interaction effect with shift work.
A review by Harma (1996) suggested that physical fitness may play an important role in shift work tolerance as being physically fit can improve sleep quality. Both subjective and objective studies have indicated that regular physical exercise can increase sleep duration and the amount of slow-wave (deep) sleep obtained. Longitudinal studies that have manipulated physical fitness have indicated that regular, moderate physical exercise will improve physical fitness (i.e. increased VO\textsubscript{2} max. and muscle strength, and decreased resting heart rate), increase sleep length, and improve subjective fatigue and sleepiness. These beneficial effects on sleep duration and quality would be important for shift workers, as shift work is often associated with complaints about their ability to obtain enough good quality sleep (as discussed in chapter 3). Physically fit shift workers, including shift workers who have increased their physical fitness with training, have shown less general fatigue and sleepiness, longer sleep periods, and decreased musculoskeletal symptoms including back problems (Harma, 1996).

Apart from improving the sleep of shift workers, being physically fit may have an impact on some of the parameters of the circadian rhythm system, which in turn may help increase shift work tolerance (Harma et al., 1988b). Atkinson, Coldwells, Reilly, and Waterhouse (1993) found that physically fit individuals had higher amplitude circadian rhythm systems, which have been associated with increased subjective tolerance to shift work (Knauth and Harma, 1992; Reinberg et al., 1980; Reinberg, Vieux, Andlauer, and Smolensky, 1983; Wever, 1981), although recent research has begun to question this position (Vidacek et al., 1995; see chapter 7.9). Further research is required to investigate this issue.
While physical fitness has been shown to be associated with an increased tolerance for shift work the mechanism of this association remains unknown. Further research is required to examine this issue, as well as to determine the importance of physical fitness for shift workers compared to non-shift workers. Maintaining physical fitness may be more important for shift workers than non-shift workers, although such comparisons have not been made. Regular physical exercise may help to improve shift work tolerance, and advice on how to schedule this for shift workers is provided in chapter 10.

7.5 Circadian Type

One factor thought to affect shift work tolerance is related to the nature of the endogenous circadian rhythm of the individual. While the majority of individual have a circadian rhythm system that maintains an appropriate phase for the external solar clock time, some individuals tend to experience a consistent phase-advance or phase-delay of their circadian rhythm system. These differences have been externalised and measured as the circadian type of the individual. The two extremes of circadian type are the morning-type (or “larks”) and the evening-type (or “owls”).

Morning-types typically have an earlier peaking body temperature rhythm and are thought to have a shorter endogenous circadian period than evening-types. Morning-types typically report feeling more alert during the morning than during the evening, and generally retire to bed and rise in the morning earlier than evening-types (Greenwood, 1994; Harma, 1995; Horne and Ostberg, 1976; Hilliker, Muehlbach, Schweitzer, and Walsh, 1992; Kerkhof, 1985b; Kerkhof and Lancel, 1991; Kerkhof and
Van Dongen, 1996; Sexton-Radex and Harris, 1992). Morning-types perform better on logical reasoning tests around 0800 hours as opposed to 1100 hours for evening-types, and subjective alertness peaks about two hours earlier for morning-types than evening-types (Åkerstedt and Froberg, 1976; Kerkhof, 1985a). The difference in the timing of peak alertness and performance between circadian types (and the affect this has on their preferred sleep times) is one of the main reasons why adolescents, with their evening-type tendencies, may benefit from later school start times (Andrade and Menna-Baretto, 1996; Carskadon, Wolfson, Acebo, Tzischinsky, and Seifer, 1998; Mello, Louzada, and Menna-Baretto, 2001; Thorpy, Korman, Spielman, and Glovinsky, 1988).

These differences in circadian type are thought to affect the ability of the individual to cope with shift work. Several studies have found an interaction between morningness/eveningness and work schedules. Scott and Ladou (1990) give examples relating these differences to the shift work situation as: evening-types tend to adapt to night shift work more easily than morning-types; morning-types are more physically fit during the morning shift, and evening-types are more physically fit during the evening shift; and the sleep of the morning-types is more disturbed when working the night shift than it is for evening-types (Ostberg, 1973). A review by Tankova, Adan, and Buela-Casal (1994) found that permanent night shift workers were more likely to be evening-types, and permanent morning shift workers were more likely to be morning-types. Åkerstedt and Torsvall (1981) have shown morningness to be associated with poor adjustment to shift work overall (i.e. rotating shift work). If asked to work the night shift, extreme morning-type people are more apt to doze at the workplace, which could possibly constitute a safety problem. A disproportionately large number of shift work ‘dropouts’ are morning-types (Akerstedt and Froberg, 1976) as a shift in zeitgebers may
cause more interference with performance and more subjective symptoms of dysphoria for persons with an early phase of the temperature rhythm (i.e. morning-types) (Wever, 1981; Scott and Ladou, 1990).

Studies suggest that pre-existing preferences for morningness or eveningness may influence both a worker’s preference for and their ability to adapt to shift work, with evening-types being more likely to select and more able to adapt to shift work than morning-types. This may be because evening-types typically show a greater flexibility in their sleeping habits and a greater ability to overcome drowsiness than morning-types, both of which make shift work easier. Evening-types are also more likely to have a better sleep length and quality after a night shift than morning-types, and which may improve over a series of night shifts for evening types much more than for morning types (Breithaupt et al., 1978). Harma (1995) suggested that the earlier circadian phase position of morning-types would slow their adaptation to night work, which requires a delay of the circadian phase position.

A recent study by Khaleque (1999) investigated the impact of shift work on the sleep of 60 male shift workers (mean age 35 years). The results indicated that the quality of sleep across all three shifts (days, afternoons, and nights) was better for evening-type workers than morning-type workers. This finding confirms previous findings that evening-type persons may be better suited to shift work, including night shift than morning-type people. While the type of shift schedule being worked is likely to affect the preference for morningness/eveningness, long-term studies investigating this relationship are lacking (Tankova et al., 1994).
7.6 Psychological Measures

It has been suggested that two psychological dimensions which may affect shift work tolerance are *flexibility-rigidity*, which is a measure of the flexibility of an individual's sleeping habits, and *vigour-languidity*, which is a measure of an individual's ability to overcome drowsiness (Folkard, Monk, and Lobban, 1979). Several studies have indicated that these variables are correlated to shift work preference or tolerance (Costa, Lievore, Casaletti, Gaffuri, and Folkard, 1989; Iskra-Golec, 1993; Hossain and Shapiro, 1999; Humm, 1996; Steele, Ma, Watson, and Thomas, 2000). However, conflicting data do exist (Bohle and Tilley, 1998; Kaliterna, Vidacek, Prizmic, and Radosevic-Vidacek, 1995). It has been suggested that a combination of these two measures may provide a better indicator of shift work tolerance than the circadian type measure (i.e. morning type vs. evening type) discussed above (Glazner, 1991). As discussed in chapter 7.8, however, the ability of these variables to predict shift work tolerance in individuals before they experience shift work is not very clear.

The concept of *hardiness* (which is composed of commitment, challenge, and internal control) has also been suggested as a possible personality measure relevant to shift work tolerance. Hardiness has previously been related to successful coping and positive health outcomes in stressful ‘non-shift work’ work situations, therefore Wedderburn (1995) hypothesised that a hardy personality and attitude to shift work should be associated with increased shift work tolerance. Questionnaire results from shift working males (n=69) and females (n=51) indicated a small but significant correlation between a positive attitude for shift work and hardiness levels. Hardiness was also negatively correlated with reports of digestive complaints, such that those with higher hardiness scores reported fewer digestive complaints (Wedderburn, 1995).
As hardiness is a personality trait it is assumed, especially in cross-sectional studies, that the trait exists first, which then influences the attitude and health outcomes. It is possible, however, that the correlation could occur in the opposite direction, with a dislike for and negative health effects from shift work resulting in lower hardiness (i.e. less commitment and feeling out of control) (Wedderburn, 1995). This hypothesis is supported by some related, although limited findings, regarding neuroticism (also a personality characteristic), which has been shown to increase with exposure to shift work (Wedderburn, 1995), which is discussed further in chapter 7.8. A longitudinal research design is needed to address this issue of directionality.

One such longitudinal study by Bohle (1997), investigated whether the three components of hardiness (commitment, control, and challenge) could predict satisfaction with shift work. Measures were taken from 102 female student nurses (mean age 20.2 years) via questionnaires, before beginning shift work, and again after 6 and 15 months of shift work. The shift work rosters consisted of rapidly rotating, irregular two and three shift systems. The results failed to find any predictive value for hardiness and shift work tolerance for any of the shift work rosters. When using a longitudinal research design, the personality variable of hardiness was not related to shift work tolerance. While this research design is stronger than cross-sectional studies, it is only a single study. Further longitudinal research is required, which should use objective measures of shift work tolerance and health.
7.7 Complex Interactions Between Psychophysiological Variables

While the influence of several factors (such as circadian type and several psychological variables such as flexibility-rigidity) on shift workers’ health and sleep have been studied individually, it is possible that interactions between these factors may account for more variance than any on their own. Iskra-Golec, Marek, and Noworol (1995) conducted a study to investigate the interaction effects between several individual factors on shift workers’ health and sleep. Shift working nurses (n=100; mean age 26 years), working 12-hour shifts (morning and night), completed self-report questionnaires. Information was collected regarding physical and mental health, trait anxiety, chronic fatigue, and sleep complaints (the dependent variables), and morningness, flexibility, languidity, neuroticism, and extroversion (the independent variables).

The results revealed that the independent variables interacted and gave different results together than when they were analysed separately. The main predictor of ‘sleep and health complaints’ was neuroticism combined with languidity (for digestive and cardiac complaints, anxiety and chronic fatigue), followed by flexibility and extraversion (for chronic fatigue, psychological health, digestive complaints and sleep complaints between night shifts). Adding morningness did not change the relationships. It would appear from these results that the interactions between individual factors, while being rather complex, are very important to consider (Iskra-Golec et al., 1995). Further research is required to examine these interactive effects in more detail rather than focusing on individual factors separately. When individual factors are assessed on their own, important information may be missed.
7.8 Can Shift Work Tolerance be Predicted from Psychological Variables?

Although relationships have been found between some psychological variables and shift work tolerance, the nature of these relationships, including the direction of the relationships, is uncertain. Kaliterna, Vidacek, Prizmic, and Radosevic-Vidacek (1995) examined the role of various individual factors in relation to shift work tolerance using a two-stage study. The first part consisted of a cross-sectional design, which identified the various individual factors that were associated with shift work tolerance in a group of shift workers. This group consisted of 604 male shift workers (mean age 32 years) working a rapidly rotating, three shift system (mean shift work experience 9.6 years). The second part of the study used a longitudinal design to examine the variables identified in part one in a group of workers just starting shift work. This longitudinal design allowed the investigation of the predictive validity for these variables before and while working shift work. This second group consisted of 142 new male graduates (mean age 19 years) who were entering the same shift work conditions, for the first time. Of these workers, 132 were followed up after 16 months, and 109 were followed up after 39 months of working shift work. Information was collected via self-report questionnaires.

The results demonstrated that the variables associated with shift work tolerance from the cross-sectional study, while consistent with previous cross-sectional studies, did not have any ‘predictive value’ for predicting shift work tolerance when using the longitudinal approach. The predictive value of the variables were “poor or absent” (p. 146). This included the personality trait of neuroticism, previously thought to ‘predict’ shift work intolerance. It would appear that the increased neuroticism seen with intolerant shift workers in the cross-sectional studies might be a symptom of the
intolerance to shift work rather than a predictor of the intolerance. This finding contrasts with the only earlier longitudinal study conducted in this area, which showed shift workers who had left shift work in their first four years had reported significantly higher levels of “psychoneurotic complaints” at the commencement of their shift work than those who remained in shift work for four years (Meers, Maasen, and Verhaegen, 1978), although it is supported by a more recent longitudinal study (Bohle and Tilley, 1998). While the results of Kaliterna and colleagues’ study were small, they highlight the need for further longitudinal rather than cross-sectional research studies to investigate the predictive role of individual variables and shift work tolerance (Kaliterna et al., 1995).

Similar results were reported by Nachreiner (1998), who reviewed the literature regarding individual and social factors and shift work tolerance. Nachreiner identified the presence of several relationships between certain social variables (including age, gender, domestic obligations, social support, and physical fitness) and shift work tolerance. Although such relationships have been identified, there is still little known about how they work, the strengths of the relationships, and how they could be used to predict shift work tolerance. The predictive power of the relationships with social variables is unknown. None of the psychological variables reviewed by Nachreiner (1998), which included neuroticism, extroversion, morningness/eveningness, body temperature, and the newer concepts of hardiness, shift work locus of control, and coping styles, although demonstrating some ‘low and inconsistent’ associations, appeared to have any validity as predictive factors for shift work tolerance (Nachreiner, 1998).
While several psychophysiological variables, such as hardiness, neuroticism, and circadian type, have been proposed as being able to predict shift tolerance, newer research suggests that this is not the case. While associations have been found in early cross-sectional studies, according to the newer longitudinal studies, these variables do not have any predictive validity. At the present time, it would appear unwise to use psychophysiological variables to predict shift work tolerance before any involvement with shift work.

7.9 Circadian Rhythm Markers of Tolerant/Non-Tolerant Shift Workers

Various characteristics of the circadian rhythm system have been examined as possible markers of tolerant and non-tolerant shift workers. Some researchers have attempted to determine whether there are stable differences between the circadian rhythm systems of tolerant/non-tolerant shift workers, while others have attempted to determine whether there are differences between individuals in the ability of their circadian rhythm system to adapt to shift work. The ultimate aim of these types of investigations is to be able to predict before hand, based on some endogenous characteristic, who will be able to tolerate and adapt to shift work and who will not.

7.9.1 Stable differences in the circadian rhythm system

Vidacek and colleagues (1995) investigated whether there were stable differences in the circadian rhythm parameters of oral temperature and heart rate between tolerant and non-tolerant shift workers. Three groups of workers were studied, tolerant shift workers (n=29), non-tolerant shift workers (n=29), and workers who had never worked shift work (n=29) (matched by age; mean age 39.9 years). ‘Tolerant’ and ‘non-tolerant’ shift workers were derived from questionnaire information relating to sleep
quality and health (psychosomatic-digestive complaints and symptoms). The shift work consisted of a three shift, rapidly rotating roster. Participants were studied in a controlled environment for three days. Meals, lighting, ambient temperature, and activity were all controlled, and sleep was not permitted over the testing period. Measurements for oral temperature and heart rate were collected every hour for 24 hours starting on the second day.

A ‘best-fit cosine curve’ was calculated for the 24-hour temperature and heart rate data to identify the mesor, amplitude, and acrophase for both variables. The data analysis revealed no significant difference between any measure (mesor, amplitude, or acrophase) of the oral temperature or heart rate for the three groups. Although not statistically significant, there was a trend for the tolerant shift workers to have a larger amplitude oral temperature rhythm. These results are different from earlier field studies, however, which have found a significant difference in oral temperature amplitude (Knauth and Harma, 1992; Reinberg, Vieux, Ghata, Chaumont, and Laporte, 1978; Reinberg et al., 1980; Reinberg, Vieux, Andlauer, and Smolensky, 1983; Vidacek, Radosevic-Vidacek, Kaliterna, and Prizmic, 1993) and core body temperature amplitude (Wever, 1981) between tolerant and non-tolerant shift workers.

The lack of significant differences found by Vidacek and colleagues (1995) may be due to the well-controlled environmental conditions of the study. When the masking effects of movement, meals, and sleep were reduced in the laboratory, no significant differences were found between tolerant and non-tolerant shift workers. This study indicates that oral temperature and heart rate, when collected in well-controlled conditions, cannot be used to differentiate between tolerant and non-tolerant shift
workers. Finding no significant difference in the acrophase of the temperature rhythm between tolerant and non-tolerant shift workers adds weight to the conclusion drawn in the previous section that circadian type can not be used to predict shift work tolerance (see chapter 7.8).

It is possible that the difference between tolerant and non-tolerant shift workers may not be any difference in their circadian rhythm system per se. Rather the difference may stem from the interaction of their circadian rhythm system with any number of exogenous variables or coping strategies, or as discussed below, a difference in the ability of their circadian rhythm system to change in response to shift work.

### 7.9.2 Differences in adaptability of the circadian rhythm system

This latter issue was investigated by Hennig, Kieferdorf, Moritz, Huwe, and Netter (1998). They investigated the circadian rhythm of cortisol secretion in twenty-four nurses (18 female; mean age 27.8 years) over a series of night shifts. Cortisol was chosen because its secretion follows a pronounced circadian rhythm, and it has been shown to be affected by night shift work. The participants completed questionnaires at the start of the study and recorded information about their sleep period after each night shift. Cortisol samples were collected at three-hourly intervals across seven consecutive night shifts.

The results indicated that the circadian rhythm of cortisol secretion changed after five night shifts for 18 of the 24 participants. The cortisol secretions did not change for 6 of the participants. This difference was suggested to reflect a difference between ‘adaptors’ and ‘non-adaptors’ to shift work. The ‘non-adaptors’ were found to have a
reduced sleep duration after four nights compared to the ‘adaptors’, and were also
c charact erised by ‘behavioural stability’ and a lower ‘satisfaction with life’, which have
previously been associated with poor shift work tolerance. Unlike the previous study
by Vidacek and colleagues (1995), which attempted to find an endogenous ‘stable’
difference in the circadian rhythm system between those shift workers who could
tolerate or adapt to shift work and those who could not, this study investigated the
ability of the circadian rhythm system to adjust to or change with shift work. With this
approach, differences were found in the ability of the circadian rhythm system
(measured by the cortisol circadian rhythm) of shift workers to adapt to shift work.

A recent study by Quera-Salva and colleagues (1997) also found differences in the rate
and ability of individuals to adjust to night work, this time using melatonin as the
marker of the circadian rhythm system. Forty nurses, 20 working nights in a three-
on/two-off schedule and 20 working days in a fixed five-on/two-off schedule,
participated in the study. The participants completed sleep/wake diaries and
performance tests before and during the study, and wore wrist actigraphy monitors
during the study. Urine samples were collected at two-hourly intervals for 24 hours on
the last work day and rest day of a work cycle for each group. The study therefore
lasted for seven days for the day shift (5 days on/2 days off) and five days for the night
shift (3 nights on/2 days off). The main urinary metabolite of melatonin, 6-sulfatoxy-
melatonin, was determined through radioimmunoassay, which has a two to four-hour
delay compared to melatonin levels in the blood.

The melatonin assays revealed the day shift nurses to have a 6-sulfatoxy-melatonin
peak around 0500 hours. The night shift nurses, on their days off, had a 6-sulfatoxy-
melatonin peak around 0700 hours. On their night shifts, an average peak could not be
detected because of significant individual variations. Individual curves were therefore
analysed for the night shift data. This analysis revealed that 19 of the 20 nurses had
significant curves, with two main types being detected. Group A nurses (n=6) showed
a shift in their 6-sulfatoxy-melatonin peak, with the new peak occurring later at 1208
hours +/- 40 mins (i.e. shift work ‘adaptors’). Group B nurses, which was the larger
group (n=14), did not show any shift in their 6-sulfatoxy-melatonin peak (mean peak
0636 hours +/- 28 mins) (i.e. shift work ‘non-adaptors’). This difference when on night
shift could not be explained by lighting differences between the groups because the
lighting levels at work were monitored and were consistent for all the night nurses
(Quera-Salva et al., 1997).

Further differences were detected between the nurses. The actigraphy data revealed no
significant differences for total sleep time between the day and night A nurses
(adaptors). There were significant differences, however, between the night nurse
groups (A and B), and between the day and night B nurses (non-adaptors). The night
nurses in group A (adaptors) slept longer than those in group B (non-adaptors). All of
the nurses that fell asleep at work were night B nurses (non-adaptors). The
performance data revealed significant differences between the night nurse groups (A
and B). The night nurses in group A (adaptors) performed better than those in group B
(non-adaptors), and they also showed similar performance levels for their days off and
work days (night shift). This performance of group A night nurses (adaptors) was not
significantly different from the day nurses (who had the fastest response times and the
best memory performance). These night nurses in group A seemed more adaptable to
the night shift, performing better than the group B night nurses (non-adaptors) (Quera-Salva et al., 1997).

These data suggest that some individuals might be able to adapt more easily and quickly to a rapidly rotating day/night work roster than others. Some individuals in this study showed a quick change in their melatonin secretion peak time when on night shift. These nurses were able to sleep for a longer period of time, and they performed better during the night shift than the nurses that did not show any change in their melatonin secretion peak time. These latter nurses appeared unable to adjust to the night shift. Unlike the previous study by Hennig et al. (1998), which showed adaptation (for cortisol) after five nights, the present study detected differences between tolerant and non-tolerant shift workers after just three night shifts. Adaptation to night work may be rapid for some individuals.

Although this research highlights the important fact that some individuals seem able to adapt to night shift work more readily than others, it does not indicate what factor is responsible for this difference, or how to predict and select for this difference between individuals. As a preference for shift work was not addressed in the present study, future research could investigate whether the shift workers who easily adapted to shift work (group A) have a preference for shift work or liked it more than those workers whose physiology did not adapt to shift work (group B) (Quera-Salva et al., 1997). Future research should be conducted to investigate the role of circadian adjustability and preferences for shift work. Further research is also required to establish whether the improved performance over the night shift for group A nurses (adaptors) was due to
a circadian phase realignment process suitable for work across the night period, or due to the increased total sleep time obtained by this group.

This latter line of research suggests that rather than any overall difference in the circadian rhythm system itself between tolerant and non-tolerant shift workers, as has often been suggested in the past, there may be a difference in the ability of the circadian rhythm system of individuals to change or phase adjust to a new time schedule such as shift work. While the results at this stage are preliminary, they are encouraging, because with further research may come the development of a method to predict shift work tolerance before having to experience shift work.

7.10 Summary

Numerous individual difference variables have been suggested as factors that affect shift work tolerance. While relationships have been found between several social variables and shift work tolerance, such as age, gender, domestic responsibility, physical fitness, and social support, the ability of these to predict shift work tolerance is poor. Certain psychophysiological variables, such as circadian type and personality traits such as hardiness, have been suggested as affecting shift work tolerance. The nature of the relationship between these variables and shift work tolerance is, however, largely unknown, with their ability to predict shift work tolerance being described as “poor or absent” (p. 146, Kaliterna et al., 1995). The lack of knowledge about predictive variables may be in part due to the fact that the majority of studies within this area are cross-sectional. This means that the studies can only identify an association and not a causal relationship between variables, and they are subject to
confounding. Many variables once thought to predict shift work tolerance have since been shown, with longitudinal research, to have no predictive potential.

Recent research has focused on the idea that various markers of the endogenous circadian rhythm system may be able to identify those individuals that will be able to tolerate shift work. While differences have been found in the ability of the circadian rhythm system to change phase with night work (using cortisol and melatonin as markers), the mechanism for this difference, the role that this difference has in shift work tolerance, and the long-term impact that this has on shift workers’ health or well-being, is unknown. There have been no suggestions made at present about how this information could be used to predict shift work tolerance.

As Nachreiner (1998) states, although many relationships have been identified in the literature, there is still little known about the determinants of shift work tolerance. It may be that shift work tolerance is not due solely to personality traits or circadian rhythm differences, but could depend on behavioural or environmental factors, or a combination of all. There is not enough known about the area of individual differences and shift work tolerance to make the practice of ‘selecting’ tolerant shift workers before commencing shift work an acceptable practice at this time.
8. NAPPING FOR SHIFT WORKERS

The need for sufficient sleep is paramount. When time or circumstance does not allow a sufficient main sleep period to be obtained, napping can be an important strategy to counteract fatigue. More importantly, however, a nap can be used to supplement a main sleep period, but because of an anticipated period of extended wakefulness, such as a night shift, additional sleep would help maintain alertness and prevent fatigue from developing during the extended wake period. Napping can often therefore be an important strategy for shift workers. Napping can help increase the amount of sleep obtained in a 24-hour period, and can reduce the amount of prior wake time, both of which can improve the alertness, performance, and safety of a shift worker. A nap is oftentimes the only strategy available to shift workers, apart from stimulant drugs, to counteract fatigue.

Conventionally, naps are usually thought of as brief sleep periods, especially during the day, which are obtained to supplement, or augment sleep normally obtained at night, or perhaps to replace some sleep missed during the past few days. These types of short sleep periods are referred to in the thesis as ‘short naps’, which are an hour or less in duration. In the scientific literature of sleep researchers, however, napping has been defined by Dinges, Orne, Whitehouse, and Orne (1987) as “any sleep period <50% of a person’s average nocturnal sleep length” (pp. 313 – 314). These types of sleep periods are referred to in the thesis as ‘long naps’, which are more than one hour and can be up to three to four hours in duration. All naps can be regarded as sleep that is supplementary to an individual’s main sleep period.
A major distinction can be made between ‘maintenance’ naps, and ‘recovery’ naps. 

*Maintenance* naps are those taken to supplement the main sleep(s) already obtained during the past day or two, and before working an extended work shift or night shift. These naps are taken after a period of sufficient main sleep, which is a minimum of seven hours sleep but preferably eight hours of sleep in the previous 24 hours (which requires a longer time in bed [TIB] than this in order to achieve the sleep requirement) (Balkin et al., 2000; Dinges et al., 1999; Van Dongen et al., 1999), and before serious sleepiness and fatigue has set in. They are used to prevent substantial fatigue from accumulating and therefore to maintain alertness during extended or overnight work hours, when because of the nature of night shift (i.e. sleep loss and circadian rhythm low in alertness), some drowsiness and performance deterioration is anticipated to occur while at work. These naps can either be taken at home before leaving for a night shift, or taken early in the night shift (i.e. in the first few hours of the night shift). ‘Maintenance’ naps are usually ‘short’ naps, such as 20 to 30 minutes in duration, although the actual time in bed (TIB) required for the nap will be longer than this, such as 30 to 40 minutes, in order to allow time for sleep onset to occur and then to obtain the desired sleep duration.

A *recovery* nap, by contrast, is a nap taken when the individual is already sleepy because of insufficient sleep in the previous 24 hours, or perhaps after several days of accumulating a sleep debt. The ‘recovery’ nap is aimed at providing sufficient sleep to help make up for some of the essential sleep missed previously and to restore some alertness. The ‘recovery’ nap will likely be a ‘long’ nap, that is, probably longer than one-hour duration.
Numerous studies have been conducted to investigate the role of napping during periods of sleep loss and sleep deprivation such as shift work. These studies have helped determine the characteristics that optimise the contribution of naps to counteract fatigue. By following the principles gained from this research, napping can be a very effective coping strategy for shift workers. Naitoh and colleagues (Naitoh, 1981; Naitoh and Angus, 1989; Naitoh, Englund, and Ryman, 1982) summarized the main factors that are important for determining the effective use of naps. They are: (1) the amount of prior sleep loss, (2) the nap duration, (3) the placement of the nap within the circadian rhythm, and (4) to disperse sleep inertia the time between the nap and the next performance period. The research addressing these four areas will be discussed in this chapter.

8.1 Sleep Loss

8.1.1 Naps during a night shift
Investigations have been conducted to determine at what time during a sleep deprivation or sleep loss period a nap would be the most beneficial. Several studies have shown that a nap taken during a sleep loss period such as a night shift can lessen the fatigue felt overnight.

Matsumoto and Harada (1994) looked at the effects on worker fatigue of a night time nap taken during the night shift by comparing workers from two factories in Japan, one of which allowed workers to nap overnight (allowing them two hours TIB). They concluded that the long nap helped alleviate some of the fatigue felt by the workers. Rogers, Spencer, Stone, and Nicholson (1989) found that a short one-hour (TIB) nap
taken at 0200 hours had a limited effect in reducing the normal night time fatigue and performance decrement seen in female participants studied in the laboratory on a simulated night shift.

Sallinen, Harma, Åkerstedt, Rosa, and Lillqvist (1998) demonstrated that a short nap (one-hour TIB) taken during a night shift (at either 0100 or 0400 hours) could improve alertness during the night, as shown by improved reaction times on a two-choice visual reaction time test, compared to no nap. Physiological sleepiness, and to a lesser extent subjective sleepiness, were improved in the first half of the night shift, however, the naps were not able to overcome the increase in sleepiness (both physiological and subjective) due to the circadian rhythm system in the second half of the night shift.

Purnell, Feyer, and Herbison (2002) found that a short 20-minute nap opportunity (20 minutes TIB, taken between 0100 and 0300 hours, on two successive 12-hour night shifts) improved objective performance compared to no nap for the first of the two night shifts, while having no affect on subjective fatigue or sleepiness on either night shift.

Matsumoto and Morita (1987) compared male security guards working a night shift which allowed a long nap between 0300 and 0630 hours, with female nurses working the night shift and who were not allowed to nap. Although there were no performance data available, the results indicated that the long night time nap, averaging 3.2 hours, minimised the amount of sleep loss accumulated overnight, which would have reduced their fatigue. The sleep accumulated by the guards during their nap was enough to minimise the typical recovery style sleep required during the next full sleep period compared to the nurses. The nurses showed the classic signs of a sleep deprived
‘recovery’ sleep, such as increased total sleep time and increased slow-wave sleep activity on their next full sleep period (Matsumoto and Morita, 1987).

A recent report published by Della Rocco, Comperatore, Caldwell, and Cruz (2000) found that both a short 45-minute (TIB) nap and a long 2-hour (TIB) nap during an overnight shift were beneficial for both cognitive performance and subjective sleepiness levels compared to no nap overnight. Rosekind and colleagues (Rosekind, Gander et al., 1994; Rosekind, Graeber et al., 1994; Rosekind et al., 1995) pioneered the use of short ‘maintenance’ naps within the aviation industry, through their research with NASA. Their studies of cockpit napping showed a significantly greater benefit to pilots in terms of maintaining vigilant performance during long-haul flights with a short (40-minute TIB) night time nap compared to a short daytime nap.

Although an overnight nap has been shown to have positive effects on subsequent alertness and performance, an interesting finding was reported in a study by Minors and Waterhouse (1987). Participants were studied in the laboratory for nine days on an irregular sleep/wake schedule, with six-hour sleep periods and one-hour (TIB) nap opportunities. They found that although the naps had a slight beneficial effect on subjective fatigue, anecdotal reports from participants revealed that naps taken during the night at 0300 hours were viewed as a waste of time. Minors and Waterhouse (1987) suggested that people having a short nap overnight might not be aware of the benefits that the nap may provide to them.
8.1.2 Naps before a night shift – the ‘maintenance’ nap

The above studies suggest that an overnight nap, one taken during a night shift, can help to manage the occurrence of fatigue. While this may be true, numerous studies have demonstrated that naps taken prior to starting a night shift can be more effective than naps taken later in the night shift when fatigue has developed, and the normal hours of sleep have been lost. Naps that occur prior to a period of sleep loss have been called “prophylactic” naps by Dinges (e.g. Dinges et al., 1987), although the present author prefers the term ‘maintenance’ naps. A number of napping studies have suggested that ‘maintenance’ (or prophylactic) naps, or at least naps that occur before a significant amount of sleep loss has occurred, will be more beneficial than a nap taken during the sleep loss period.

Hayashi, Watanabe, and Hori (1999) studied the effects of a short 20-minute (TIB) ‘maintenance’ afternoon nap (1400 hours) on subsequent daytime functioning. They found that the nap helped to improve daytime self-rated sleepiness and performance levels on a variety of tasks, including logical reasoning, mathematical calculations, and auditory vigilance. Although some measures did not differ between the nap and no nap conditions (such as reaction time), there were no negative effects found for the napping group. Bonnet and Arand (1995a) found that a long four-hour (TIB) ‘maintenance’ nap before a 24-hour period of wakefulness improved participants’ performance levels overnight, maintaining them near baseline levels, while four shorter one-hour (TIB) naps during the night had a detrimental effect on participants’ performance levels overnight, possibly due to continuous sleep inertia from each short nap. The long ‘maintenance’ nap was much more beneficial than a similar amount of sleep placed
during the sleep loss period. Work by Nicholson and colleagues (1985) has looked at the effects of a long four-hour (TIB) nap placed in the evening prior to an extended period of wakefulness overnight. Results suggested that the evening ‘maintenance’ nap helped to improve performance levels, particularly over the early morning hours when performance levels are naturally low, compared to a no nap condition. The ‘maintenance’ nap was beneficial for subsequent overnight performance.

The effect of a long three-hour (TIB) late afternoon nap on overnight sleepiness/alertness levels was studied by Sugerman and Walsh (1989). Objective measures of sleepiness/alertness (such as the Multiple Sleep Latency Test (MSLT), where participants are given the opportunity to nap while the time that it takes for them to fall asleep is measured, and the Maintenance of Wakefulness Test, which measures the participants’ ability to remain awake while sitting in a comfortable chair in a dimly lit room) revealed that the ‘maintenance’ nap improved the participants’ ability to remain awake and alert across the night. Although the circadian early morning decline in performance was evident in both conditions, the alertness levels remained higher in the participants that had been able to take a ‘maintenance’ nap. A review of shift work studies by Bonnet (1990) summarized results from four studies that compared morning performance after an overnight awake either with or without a ‘maintenance’ nap. The results clearly indicated that a ‘maintenance’ nap, varying from one to four hours, helped to minimise the amount of morning performance decrement after the night awake. Rosekind and colleagues (Rosekind, Gander et al., 1994; Rosekind, Graeber et al., 1994; Rosekind et al., 1995) found that short 40-minute (TIB) ‘maintenance’ naps were of benefit to pilots during long-haul flights, reducing their levels of fatigue and
improving their flight performance. Details of their work are discussed in chapter 8.5.2.

A report published recently by the US Department of Transport Federal Highway Administration (USDOT FHWA, 1999) investigated the effect of a long three-hour (TIB) afternoon nap on overnight performance with long-haul truck drivers. The results indicated that the ‘maintenance’ nap, which averaged 2.35 hours of sleep time, was beneficial for their overnight alertness and performance compared to a no nap group. It was also found that unscheduled naps (lasting one to two hours), which occurred due to excessive fatigue from sleep loss (ie ‘recovery’ naps), did not provide much benefit for the participants. The ‘maintenance’ naps provided much greater improvements for alertness and performance than naps occurring after a significant sleep debt had been accumulated. Nevertheless the unplanned nap taken because of excessive fatigue did provide some benefit.

Several authors have investigated the scheduling of naps during prolonged periods awake to determine the best timing for a nap during that period. The effects of ‘maintenance’ naps over a 52-hour continuous operation were studied by Bonnet (1991). Participants were allocated to a group not allowed a nap, or to a group allowed a two, four, or eight-hour (TIB) ‘sleep period’ type nap. Performance and alertness measures (using the MSLT) were then conducted over the following 52 hours awake. Results indicated that a ‘maintenance’ nap was beneficial for improving performance and alertness over the first 24 hours compared to no nap, and that the longer the sleep period the more improved the performance and alertness levels. None of the sleep conditions could maintain performance over the last 24 hours. Bonnet (1991)
concluded that a ‘maintenance’ nap before a night shift could help to improve overnight performance.

Dinges and colleagues (1987) studied the effects of a nap placed at various points during an otherwise 56-hour sleep deprivation period. A long two-hour (TIB) nap was placed either at the circadian peak or trough in alertness after varying hours of prior wakefulness. They found that the timing of the nap within the sleep deprivation period was very important, as the naps taken early on, before any substantial sleep loss had been accumulated, produced the best and longest lasting performance benefits. These were the naps taken after only 6 or 18 hours of prior wake time, and therefore were ‘prophylactic’ or ‘maintenance’ naps. These ‘maintenance’ naps produced the best results despite being shorter and being composed of lighter sleep than the naps that occurred after more sleep loss.

Similar results were reported by Dinges, Whitehouse, Orne, and Orne (1988), who allowed a long two-hour (TIB) nap at various stages during an otherwise 54-hour period of sleep deprivation, following a normal night of sleep. They concluded that although a two-hour nap anywhere provided some benefits, the early ‘prophylactic’ or ‘maintenance’ naps provided the best improvements for performance, lasting for several hours. It is interesting to note from this study that the naps did not help the participants’ mood ratings or their fatigue ratings even though their objective performance measures improved with the naps. This also suggests that individuals may be unaware of the benefits afforded to them by the naps (Dinges et al., 1988).
8.1.3 Summary

While it has been shown that an overnight nap can help to relieve some of the fatigue felt during a night shift, a ‘maintenance’ nap, taken before the sleep loss of night shift, is more beneficial. ‘Maintenance’ naps can enhance alertness levels and therefore improve the performance of workers during a period of sleep loss such as a night shift, even though they may not always be aware of these benefits. While a strategy of napping to maintain alertness before fatigue develops (the ‘maintenance’ nap) is a more effective strategy in terms of maintaining performance than one that tries to recover alertness after fatigue and sleepiness has already set in (the ‘recovery’ nap), it is recognized, however, that if an insufficient main sleep period has been obtained, then a ‘recovery’ type nap would be preferred compared to no nap in order to increase the amount of sleep to seven and a half hours per 24-hour day. Sometimes a ‘recovery’ nap is the only option available to a shift worker.

8.2 Nap Duration

Several studies have been conducted to investigate the effect of nap length and its recuperative value. Krueger (1989; 1991) has stated that naps can be helpful in maintaining performance during sleep loss conditions, and that at least four to five hours of uninterrupted sleep should be obtained every 24 hours to maintain performance levels near normal. This type of ‘nap’, however, was the only sleep period allowed in these studies, and could therefore resemble a short normal sleep period rather than the type of ‘maintenance’ naps discussed earlier, which are extras to the normal sleep period. The distinction between a ‘sleep’ period and a ‘nap’ period, and their durations, is therefore important to discuss.
8.2.1 “Sleep Period” length

Several studies have investigated the recuperative value of different length sleep periods. Most of these studies are based on the ‘continuity theory of sleep’. This theory states that consolidated, uninterrupted sleep (preferably that obtained over a longer period of time, of about four hours) has a higher recuperative value than fragmented sleep, as fragmented sleep does not allow the brain to go through the normal cyclical pattern of sleep stages (each sleep cycle averages 90 minutes for an adult) (Naitoh and Angus, 1987).

Bonnet (1991) examined the effect of varying length sleep periods (two, four, and eight hours TIB) on performance and alertness over an extended period of sustained wakefulness. Bonnet found a dose-response relationship between the length of the sleep period and the improvements seen in performance and alertness. That is, the eight-hour sleep period provided the best improvements, followed by the four and then the two-hour sleep periods. Similar results were obtained by Bonnet, Gomez, Wirth, and Arand (1995), who again found that eight-hour (TIB) sleep periods were more beneficial to their participants than four-hour or two-hour sleep periods. The results from these two studies suggest that the longer the sleep period the better the subsequent performance compared to a shorter sleep period.

The effect of a long consolidated sleep period versus several shorter sleep periods was studied by Mullaney and colleagues (Mullaney, Kripke, Fleck, and Johnson, 1983; Mullaney, Fleck, Okudaira, and Kripke, 1985). Mullaney and colleagues (1983) compared six one-hour (TIB) naps to a one six-hour (TIB) sleep during a 42-hour
period of otherwise continuous work. They found that the group allowed the longer sleep period performed better during the wake period than the group allowed the shorter naps. This was possibly due to the fact that the participants allowed the longer sleep period would have been able to obtain more sleep overall than those sleeping in several shorter periods, as each short nap would have included a period of wake time before falling asleep. A similar, larger study by Mullaney and colleagues (1985) confirmed the previous findings that a six-hour (TIB) continuous sleep period was better for sustaining performance than six one-hour (TIB) naps during a 42-hour period otherwise awake, particularly during the last 18 hours of the experiment. These results suggest that obtaining sleep in a consolidated block is more beneficial than the sleep fragmented into shorter nap periods for helping to maintain performance.

Studies investigating shorter sleep lengths have produced mixed results. A study by Bonnet and Arand (1995a) found that overnight performance was maintained near baseline levels with a long four-hour (TIB) afternoon nap, while four short one-hour (TIB) naps were detrimental, reducing the performance levels of the participants. Webb (1985, 1987) found inconsistent results between participants allowed two two-hour (TIB) long naps or one four-hour (TIB) long nap during 72 hours of otherwise sleep deprivation. Research by Haslam (1985) found no significant difference in performance between participants allowed one long four-hour (TIB) nap and four short one-hour (TIB) naps following 23 hours of sleep deprivation. These studies only investigated a maximum of four-hour naps, however, and results may have differed if longer sleep periods were studied.
Although some inconsistency exists in the literature, the results suggest that sleep in longer, uninterrupted periods, such as the nocturnal sleep period, may have a more recuperative benefit than sleep that has been broken down into several shorter periods, such as napping across the day and night. A review by Naitoh and Angus (1989) concluded that at least four to five hours of uninterrupted sleep per night was needed to maintain performance levels near baseline levels. These results are consistent with the concept of “core” and “optional” sleep put forward by Horne (1988), and also the concept of “anchor sleep” proposed by Minors and Waterhouse (1981, 1983).

**Core Sleep**

Horne (1988, 1991) reviewed numerous sleep restriction studies and came to the conclusion that individuals could cope and maintain adequate levels of functioning if they were allowed five to six hours of uninterrupted sleep per night. This amount of sleep he therefore termed “core” sleep, as it was thought to be the minimum amount of sleep a person must obtain in order to function at any reasonable level during the day. Horne then proposed that the extra amount of sleep that is normally obtained in an eight-hour sleep period would therefore be “optional” sleep. This is the sleep that the body may be able to do without, but with which people do feel more alert and are better able to cope with the pressures of the day (Horne, 1988, 1991).

Recent research has indicated that Horne may have underestimated the minimum amount of sleep that the body requires. Research has shown that six hours sleep may not be an adequate amount of sleep on a long-term basis to maintain performance and alertness levels. Dinges and colleagues (Dinges et al., 1999; Van Dongen, Maislin, and Dinges, 1999) have demonstrated that significant neurobehavioural performance
decrements occurred when participants’ sleep was restricted to six hours in bed per
night over a 14-day period, compared to participants experiencing eight hours in bed
per night over the same period. Neurobehavioural performance measures included
vigilance type tasks, a digit symbol substitution task, a memory task, several subjective
sleepiness questionnaires, and the POMS mood states questionnaire. The performance
of participants experiencing six hours in bed per night deteriorated across the 14-day
period such that by day five of the restricted sleep regime the performance levels were
equivalent to participants who had one night of total sleep deprivation. After day six of
the restricted sleep regime, 23% of the participants experienced an uncontrolled sleep
attack. Although the sleep lengths were represented as time in bed, the sleep efficiency
for the six-hour group was reported to be high (Dinges et al., 1999). These results
indicate that six hours in bed, therefore obtaining somewhat less sleep than that, on a
chronic basis, but even as short as one to two weeks, can create a sleep debt that can
significantly impair daytime alertness and neurobehavioural functioning.

This finding is confirmed by the recent work of Balkin and colleagues (2000). Balkin
analysed the performance of 66 truck drivers on a variety of tasks over 14.5 days in the
laboratory. Following three days of training on the tasks with 8 hours in bed overnight,
subjects were tested for seven days following either 3, 5, 7 or 9 hours in bed. This was
followed by four days of 8 hours in bed during which time subjects continued to be
tested. Tests included the Walter Reed Performance Assessment Battery, and the
Dinges Psychomotor Vigilance Test (PVT).

The groups allowed 3, 5, 7 and 9 hours in bed averaged 2.87, 4.66, 6.28 and 7.93 hours
of sleep over the seven day trial. There were systematic differences in performance of
the groups related to their hours of sleep. Even a slight reduction in sleep to 6.28 hours was accompanied by a measurable decline on PVT performance maintained over the seven days, with no adaptation to the restricted sleep. It was apparent from this study that to maintain unimpaired performance the participants required almost 8 hrs of sleep (7.93 h), which is considerably more than the minimum of six hours proposed by Horne.

Returning to the work of Dinges and colleagues (Dinges et al., 1999; Van Dongen et al., 1999), the performance results obtained by these authors become more alarming when the subjective experience reported by the participants is considered. The subjective sleepiness reports did not follow the decrements of the objective neurobehavioural performance measures; that is, the participants believed they were adapting to the restricted sleep pattern, while the objective performance measures indicated otherwise. This suggests that an individual who restricts their sleep to six hours in bed per night for as little as one week may not recognise the decrease in neurobehavioural performance that can occur with that degree of sleep restriction. Such an individual may be operating in a state of compromised fitness, without being aware of the risk they pose to themselves and others.

It seems that the amount of ‘core’ sleep, or the minimum sleep length that the body requires on a long-term basis (longer than one week) to maintain performance and alertness, is greater than the six hours proposed by Horne (Dinges et al., 1999; Van Dongen et al., 1999). In fact, according to Balkin and colleagues (2000), the minimum sleep length required for unimpaired performance was about seven and a half hours; a
reduction to six and a half hours of sleep was accompanied by some performance impairment.

*Anchor Sleep*

Another benefit of longer sleep periods is that a longer sleep period placed at the correct circadian phase can act as an “anchor sleep”, which can stabilize the internal circadian rhythm system (Minors and Waterhouse, 1981). Several classic studies by Minors and Waterhouse (1981, 1983) discovered that a regular four-hour sleep period placed at the circadian trough time (early morning hours) can stabilize the internal circadian rhythm system, maintaining its normal 24-hour pattern at the correct external clock time. Without this ‘anchor’ period, the sleepiness/alertness rhythm can drift out of phase, or out of its normal position referenced to clock time. Minors and Waterhouse (1983) suggested that lengthening this period to greater than four hours would produce even better results. Recent work by Motohashi and Takano (1993) has led to similar conclusions. They looked at the effects of a long four-hour (TIB) night time nap in ambulance personnel working a 24-hour shift. They found that naps of four or more hours duration helped to ‘anchor’, or stabilize the internal circadian rhythm system.

Taken together, these studies suggest that the best sleep pattern may be a period of sleep longer than six hours taken in the early morning hours. This consolidated sleep period will have a high recuperative value and will help to stabilize the circadian rhythm system. A ‘maintenance’ nap, or a short supplemental sleep taken in addition to this main night time sleep period, can also be helpful for improving alertness and
performance, particularly over a subsequent sleep loss period, such as a night shift.

The duration of these naps is discussed next.

8.2.2 “Nap” length

It is well known that fragmented sleep, or sleep interrupted by the presence of continual arousals, reduces the restorative or recuperative value of the sleep period for subsequent performance and alertness levels. For instance, Stepanski, Lamphere, Badia, Zorick, and Roth (1984) and Levine, Roehrs, Stepanski, Zorick, and Roth (1987) fragmented the sleep of participants across a night, and found that the fragmented sleep (i.e. interrupted periodically with arousals), either naturally (Stepanski et al., 1984) or experimentally (Levine et al., 1987) was less recuperative in the sense of restoral of full alertness than an undisturbed sleep period of the same total time.

To determine the minimum length of consolidated sleep time required to have a restorative effect, and thus the minimum length of a nap, Bonnet (1986a, 1986b) investigated the effect of fragmenting sleep periods at different time intervals. After disrupting the sleep of participants at various intervals (1 minute, 10 minutes, and 2.5 hours), Bonnet found that sleep periods longer than ten minutes had more recuperative value than sleep of a shorter length. It was concluded that continuous sleep periods longer than ten minutes would be required for the sleep to have a recuperative effect. These results suggest that the very minimum length of a nap taken to help reduce fatigue should be at least ten minutes (Bonnet, 1986a, 1986b). Stampi (1989) also found that naps longer than ten minutes were required by sailors during solo or double-handed ocean yacht races in order to be effective (mean nap lengths of 20 minutes to 1-hour).
Several studies investigated the effects of varying length naps longer than ten minutes and their effect on performance and alertness levels. Lumley, Roesrs, Zorick, Lamphere, and Roth (1986) compared the alerting effects of naps of four different lengths (15, 30, 60, and 120 minutes TIB) after sleep loss (one night of total sleep deprivation) and found that a nap length of 60 minutes produced the highest alertness levels measured eight hours later, although these were not to baseline levels. Extending the nap length to two hours (120 minutes) did not produce any better results than the 60-minute nap. It was suggested that this was because the 120-minute nap was more fragmented, with many more awakenings and shifts to light stage 1 sleep than the 60-minute nap, therefore reducing its recuperative effects.

Taub, Tanguay, and Clarkson (1976) compared the effects of a short 30-minute (TIB) nap to a long 2-hour (TIB) nap on performance and mood. It was found that both nap lengths improved performance and mood ratings, with no difference between the two nap lengths. Similar results were obtained by Taub (1977) and Taub, Tanguay, and Rosa (1977), who found a limited difference in the amount of performance, arousal or mood improvement seen with either a short 30-minute (TIB) nap or a long 2-hour (TIB) nap. These results suggest that a short 30-minute nap opportunity may be just as beneficial in terms of improving performance and arousal levels as a longer nap. Indeed, several other authors have indicated that a short daytime nap, from 15 to 30 minutes (TIB), can improve alertness and performance after a night of mild to moderate sleep restriction (approximately 4 hours nocturnal sleep) (Gillberg, Kecklund, Axelsson, and Åkerstedt, 1996; Takahashi and Arito, 2000; Tietzel and Lack, 2001).
In contrast to these findings by Taub, a recent report by Della Rocco and colleagues (2000) found a difference in the benefits gained from two different length naps. They found that while a 45-minute (TIB) overnight nap helped to improve the night time performance, a longer 2-hour (TIB) overnight nap produced greater performance improvements and more consistent improvements than the shorter nap. These naps were overnight naps, however, and not ‘maintenance’ naps. Similarly, Helmus and colleagues (1997) found that a late-morning nap of 120 minutes (TIB) improved afternoon alertness more than a 15-minute (TIB) nap in sleep deprived participants. Again, these naps were not maintenance naps as they were taken after a night of sleep deprivation. These studies suggest that the length of a nap can affect the recuperative benefits of the nap, with a long nap being more beneficial than a short nap.

When considering the length of a nap, their duration should also be consistent with the principles of sleep cycles to minimise the chance of waking directly from slow-wave sleep. Although naps are not miniatures of the normal nocturnal sleep period (Dinges, 1989; Weitzman et al., 1974), sleep cycles still occur. Sleep stages cycle throughout a sleep period in a certain sequence with a period length of approximately 90 minutes. The cycle starts with a descent through the relatively light stages of sleep (stages 1 and 2), down to the comparatively slower wave, deeper sleep (stages 3 and 4), and then ascends up to end with a REM period (Sleep Research Society, 1993). In their review of countermeasures to sleep inertia, Ferrara and De Gennaro (2000) suggested that naps be timed to last for either about 20 minutes (TIB), or else about 80 to 100 minutes (TIB), to minimise the chance of waking from the slow-wave sleep portion of the sleep cycle. In the case of the 20 minute nap, the napper is more likely to have only cycled into light stage 1-2 sleep, and therefore potentially avoids the likelihood of awakening
from a stage 3-4 sleep which undoubtedly would produce more sleep inertia. Ferrara and DeGennaro suggested that an 80-minute nap may be more recuperative as a full sleep cycle can be obtained, and may therefore have longer lasting benefits than a shorter nap.

Taken together, these results suggest that a short ‘maintenance’ nap, with a minimum of ten minutes and a maximum of one hour, can help to reduce fatigue and therefore increase performance over a period of sleep loss, while a longer nap may provide more benefits, although probably with diminishing returns. When discussing nap length, it is important to remember that the amount of sleep obtained in a nap will usually be less than the length of the nap opportunity (L. Signal, personal communication, 2002). This is because most sleep periods will have a period of wake time at the start (i.e. the sleep onset latency), and they may also have awakenings during the sleep period. The amount of wake time during a sleep period can be affected by several factors, including the ingestion of stimulant drugs which can increase the amount of wake time, and the presence of a sleep debt which will decrease the amount of wake time.

8.2.3 How long do nap benefits last?

While it has been shown that naps can increase performance and alertness levels compared to not napping, an important question remains about the length of time that the benefit will last.

Dinges (1989, 1992a) stated that ‘prophylactic’ or ‘maintenance’ naps can improve performance and physiological sleepiness for up to 12 hours after the nap is taken, even though subjective sleepiness or mood may not improve. However, Dinges (1995)
explained that the length of time that a nap will be of benefit will depend on the length of the nap and the level of sleep debt accumulated prior to the nap. A short nap, or a nap that occurs after a prolonged period of sleep loss will not be as effective or as long lasting as a longer or earlier (‘prophylactic’) nap.

For example, Dinges and colleagues (1987) demonstrated that a long two-hour (TIB) ‘prophylactic’ or ‘maintenance’ nap taken after only six hours awake improved performance but not until 12 hours after the nap, while a nap taken after 18 hours awake improved performance within one hour after the nap. Performance testing was conducted every 2.4 hours during the experiment. Both groups’ improvements lasted for more than 24 hours. A long two-hour nap taken after 30 hours awake also improved performance although not to the same extent and for only 8 hours. The early ‘maintenance’ naps provided the greatest improvement, and the longest lasting improvements.

Similar results were obtained in another study by Dinges and colleagues (1988). Performance improvements were found for a long (two-hour TIB) ‘prophylactic’ or ‘maintenance’ nap visible ten hours after the nap, with the improvements lasting for approximately 30 hours. Naps occurring later, after 30 hours awake, produced improvements that lasted for less than 12 hours, which was considerably less than the ‘maintenance’ naps. In comparison to the performance improvements, Dinges and colleagues (1988) noted that the subjective mood variables did not improve with the naps. This again suggests that the individuals were not aware of the performance improvements that occurred with the napping during the sustained wakefulness period.
(Dinges et al., 1988). This may make naps unattractive unless the benefits are stated explicitly.

Gillberg (1984) investigated the effect of a short one-hour (TIB) nap, during a 24-hour period awake, on early morning performance, measured at 0700 hours. The results indicated that an early morning nap (0430 to 0530 hours) improved the morning performance (measured 1.5 hours after the nap), while the evening nap (2100 to 2200 hours) also improved the morning performance, although this was measured ten hours after the nap. This trend for improved performance was confirmed by improved alertness scores using sleep latency tests measures ten hours after the nap. These naps occurred after a modest amount of missed sleep (less than 24 hours of continuous wakefulness).

**8.2.4 Naps and the next main sleep period**

Some researchers suggest that napping during the day should be avoided because it could have a negative effect on the next night time sleep period. Åkerstedt and Gillberg (1986), and Åkerstedt, Torsvall, and Gillberg (1989) assert that napping in conjunction with night shift could have negative effects on the next main sleep period, such as increasing sleep latency and reducing the amount of slow-wave sleep. A study by Åkerstedt, Arnetz, and Anderzen (1990) recorded the sleep/wake patterns of doctors over a night shift period, using ambulatory EEG and EOG monitoring and a self-report events diary. They found an increased sleep latency on the recovery sleep and suggested this was due to the doctors’ previous nap during their night shift. On the other hand, several researchers disagree with this position. Several studies, both field studies (Aber and Webb, 1986; Buysse et al., 1992; Hayter, 1985) and experimental
studies (Aschoff, 1994; Rosekind, Gander et al., 1994; Rosekind, Graeber et al., 1994) have concluded that napping does not have adverse effects on the subsequent night time sleep period. For instance, the cockpit nap study by Rosekind and colleagues (Rosekind, Gander et al., 1994; Rosekind, Graeber et al., 1994) did not find any change on the pilots subsequent sleep period as a result of their nap. A review conducted by Dinges (1989) stated that although afternoon naps containing slow-wave sleep may reduce the subsequent amount of slow-wave sleep seen in the next sleep period, there does not appear to be any evidence showing napping to be associated with more nocturnal sleep difficulties, such as trouble initiating or maintaining sleep. Napping does not appear to have any major adverse effects on the next main sleep period.

### 8.2.5 Summary

According to the research, the minimum amount of sleep required per 24 hours is at least seven but preferably eight hours of consolidated sleep, which requires a time in bed period of greater than eight hours, and which should occur across the night or predawn early morning hours. This allows the body and brain to obtain the minimum amount of sleep that it requires to function optimally, while placing the sleep at that time helps to anchor or stabilize the endogenous circadian rhythm system. A short nap, with a minimum length of ten minutes of sleep, can also be taken across the daytime hours to help improve alertness and performance for some time after the nap is taken. The length of the nap and the amount of sleep debt accumulated prior to the nap will determine the extent of the improvements and the length of time that the improvements from the nap will be seen. While a short nap during a sleep loss period can be restorative, either a longer nap, or a short ‘maintenance’ nap (of 30 to 40 minutes in bed) taken before the sleep loss period, may provide greater benefits and for a longer
period of time, than the nap taken after some sleep loss has occurred. In keeping with Balkin and colleagues (2000) study, sleep loss is said to have occurred when less than seven hours of sleep has been obtained in the previous 24-hour period, or after 17 hours awake following a minimum of seven hours sleep. A short ‘maintenance’ nap of 30 to 40 minutes of time in bed is recommended, and may provide between 20 to 30 minutes of sleep.

8.3 The Circadian Rhythm in Ability to Sleep – When to Take a Nap

As discussed previously, numerous studies have shown that the rhythm of sleepiness or alertness in humans follows a biphasic pattern. The major sleepiness period occurs in the early morning hours (0100 to 0400 hours) and a secondary bout of sleepiness normally occurs in the mid-afternoon (e.g. Lavie, 1986; Mitler et al., 1988; Strogatz et al., 1987). A review of circadian rhythms by Åkerstedt and Gillberg (1981a) stated “there are certain portions of the nychthemeron [day/night cycle] which are suited for sleep while others are not” (p. 493). Sleep that occurs out of phase with the circadian rhythm (e.g. sleeping from 1000 to 1200 hours) tends to be shorter and more fragmented than sleep that occurs in phase (Åkerstedt, Hume, Minors, and Waterhouse, 1997; Zulley, Wever, and Aschoff, 1981). This has important implications for the positioning of naps. Naps taken at certain points of the circadian rhythm may be more beneficial than those taken at other points.

8.3.1 Ability to sleep

Numerous studies have been conducted to determine whether the timing of a sleep period across the 24-hour period has an affect on its characteristics, such as the ease of falling asleep and staying asleep.
Webb and Agnew (1975) used various ultra short sleep schedules to test the effects of sleeping at various points across the sleep/wake circadian rhythm. They used sleep/wake cycles of 9, 12, 18, 30, and 36 hours with a 1:2 sleep/wake ratio. They determined that the timing of sleep periods across the 24-hour period affected the quality of the sleep that could be obtained, particularly the sleep onset latencies. Participants found it easier to fall asleep when the sleep period coincided with the endogenous circadian rhythm sleepy times, such as the normal nocturnal sleep period time. Using a 20-minute ultra short sleep/wake schedule (5 minutes to sleep/15 minutes awake), Lavie and Scherson (1981) found that participants’ ability to sleep across the day varied; sleep was easier to obtain in the mid-afternoon (1500 to 1600 hours) than at the other times across the day. Similarly, Lack and Lushington (1996) studied participants’ ability to sleep across the 24-hour period and found a biphasic sleep propensity pattern. Participants’ ability to fall asleep was greatest in the early morning hours (0330 hours), with a smaller secondary period in the mid-afternoon (1330 hours). Lavie and Weler (1989) used an ultra short sleep/wake paradigm to examine the effects of long two-hour (TIB) naps placed at either the afternoon sleepy period (1500 hours) or later at 1900 hours during the so-called sleep ‘forbidden’ zone, a time at which our circadian rhythm physiology says it is usually difficult to sleep (Lavie, 1986). The naps placed during the sleep conducive times of the circadian rhythm, for example mid-afternoon, were more efficient than naps placed outside of these times, for example later in the evening.

In so-called time free environments (e.g. living in a cave or in an artificially lighted laboratory isolated away from any time cues like sunlight or clocks), people are
permitted to sleep whenever and for however long they desire. Such free-running studies have shown that sleep periods were longer when they occurred across the low part of the circadian body temperature rhythm, and were shorter if they started as temperature was rising (Czeisler et al., 1980). In the real world, body temperature reaches its daily low point in the early hours of the morning (pre-dawn period around 0400 hours), so longer sleep periods occur at night (midnight to 0800 hours), and shorter sleep periods occur when beginning later in the morning. Campbell and Zulley (1985a) found similar results, but they also found a secondary sleep period occurring during the rising limb of the circadian body temperature rhythm. In the real world, this would correspond to the afternoon around 1400 to 1600 hours. It was concluded that the timing of the circadian rhythm was a major determinant of the duration of sleep.

Åkerstedt and Gillberg (1981b) tested participants’ ability to sleep at various times across the 24-hour period. Although they were looking at a full sleep period rather than a nap, their results indicated that the time of day when sleep occurred affected the characteristics of the sleep, such as sleep length and the amount of various sleep stages. Sleep length was longest when it occurred in the evening hours (1900 hours) and could extend into the early morning hours, and shortest when it started in the early morning (0700 to 1100 hours) or noon hours. This is because sleep at these latter times would be encroaching on the time when the circadian clock is moving the brain and body into wake mode, and the biological drive for waking up is strongest. This is the “wake maintenance” zone of Strogatz and colleagues (1987).

Åkerstedt, Hume, Minors, and Waterhouse (1993) investigated the effects of an irregular sleep/wake schedule on sleep characteristics. They studied long sleep periods
of six hours (TIB) as well as shorter one-hour (TIB) nap periods over several points across the 24-hour period. Results indicated that sleep characteristics, such as sleep length, were affected by the time when the sleep period occurred. Åkerstedt and colleagues (1993) suggested that nap sleep would be more sensitive to the effects of circadian rhythm timing than longer sleep periods as naps are only allotted a short period of time. This means that naps are very sensitive to any factor that will disrupt the sleep such as increasing the sleep onset latency or fragmenting the sleep period, as the circadian rhythm timing can do.

Moses, Hord, Lubin, Johnson, and Naitoh (1975) discussed the quality and characteristics of short one-hour (TIB) naps placed over a 40-hour period. They found that while the naps overall had a recuperative value, the characteristics of the sleep within each nap depended on the time when it occurred. The sleep efficiency was the highest when the nap occurred in the early morning hours (0300 to 0600 hours), during the circadian sleepy time. Richardson and colleagues (1982) used an MSLT protocol to study the pattern of sleep tendency across the 24-hour period. They found that the time of the scheduled nap had a significant effect on the participants’ ability to fall asleep. They again found a biphasic pattern of sleep tendency, with sleep being easy to obtain in the early morning (0730 hours) and during the afternoon (1530 hours). Participants found it more difficult to sleep later in the mid-morning (0930 hours) and late evening hours (2130 hours). These times may be somewhat later than the previous studies reported because these results were from young university students, who tend to have phase delayed circadian rhythms (meaning the peaks of alertness and sleepiness occur later) compared to non-university adults (Lack, 1986), and also the naps only occurred at two-hourly intervals (as standard for the MSLT protocol).
These results indicate that the ability to fall asleep and to maintain sleep is affected by the timing of the sleep period. The most efficient sleep periods occur in the early morning hours (midnight to 0500 hours) and in the afternoon (1300 to 1600 hours). A nap placed during these times, such as in the afternoon, would therefore be more efficient than a nap placed outside of these times, such as in the evening hours.

8.3.2 The outcomes of differently timed naps

A limited amount of research has been conducted to discover whether the timing of naps within the circadian rhythm has a direct effect on their recuperative outcomes. While there is some conflict between studies, the majority of studies suggest that the timing of a nap is important for determining its recuperative benefits for performance. However, these results need to be treated with an element of caution because with severe sleep deprivation the homeostatic drive for sleep can become so strong that people can get the same amount of sleep in a nap placed at any time in the circadian rhythm (Dinges et al., 1987).

Dinges and colleagues (1988) compared long two-hour (TIB) naps taken during either the circadian rhythm trough (around 0300 hours) or at the peak of the circadian rhythm (around 1500 hours) over a 54-hour period of sleep deprivation with intermittent performance tasks. They found both types of naps were beneficial for the participants’ performance, with no difference between the naps placed at the circadian peak or trough times. Similarly, Dinges and colleagues (1987) did not discover any difference between long two-hour (TIB) naps placed at the circadian peak or trough times during a 56-hour period of otherwise sustained wakefulness on performance or alertness.
measures. These two studies did not find any significant difference between naps placed at the two extremes of the circadian rhythm, namely the peak and the trough points, for subsequent performance. This may be due to the severe sleep deprivation accumulated across the study increasing the homeostatic drive for sleep to such a strong level that the participants would have been able to sleep in a nap at any time in the circadian rhythm, and thus benefit from any sleep (Dinges et al., 1987, 1988). These studies did not investigate naps offered at other times of the circadian rhythm.

Gillberg (1984), however, studied the difference between a one-hour (TIB) nap placed either at 2100 hours or 0430 hours, during a night otherwise awake. He found that the early morning nap was more effective than the late evening nap for subsequent performance. This may have been due to the morning nap occurring over the sleep-preferred phase of the circadian rhythm, which would therefore have allowed a greater amount of sleep to occur than the evening nap (Gillberg, 1984). No afternoon nap was tested.

Naitoh (1981) found that a long nap placed in the afternoon between 1200 and 1400 hours was beneficial for recuperation after a prolonged period awake (45 to 53 hours) whereas a long nap between 0400 and 0600 hours was not. These naps were recovery naps, however, occurring after total sleep deprivation, and not the ‘maintenance’ type naps taken prior to sleep loss. Hayashi, Ito, and Hori (1999) found that a short 20-minute (TIB) nap (after a normal night of sleep) placed at noon was not as beneficial as a short 20-minute (TIB) nap placed later in the mid-afternoon for improving performance. This subtle difference between the timing of the nap within the afternoon
occurred despite the fact that the two naps were similar in the amount and quality of sleep obtained.

### 8.3.3 Summary

The results from the above studies indicate that the recuperative benefits (i.e. restoration of alertness) gained from a nap may depend on the timing of the nap within the circadian rhythm system. Studies suggest naps that occur during the afternoon (between 1300 and 1600 hours) are more effective and may provide greater improvements for performance than naps that are taken at other times across the day. Although the above results indicate that the most effective time for sleep occurs across the early morning hours (midnight to 0600 hours), the previous section and the following section both recommend that this period of time be used for a longer main sleep period (more than 6.5 hours) rather than a nap, whenever possible. It is also recommended that naps are to be taken to supplement these longer sleep periods, and they should be taken ‘prophylactically’, such as before commencing a night shift or long work shift. It is also recognised that if a shift worker has not been able to obtain sufficient prior sleep to support their duration of wakefulness, a nap taken at any time when their schedule allows, would be better than no nap at all.

### 8.4 Sleep Inertia and Groggy Performance Effects After a Nap: The Time Between the Nap and the Next Performance Period

Sleep inertia, a term first used by Lubin and colleagues (Lubin, Hord, Tracy, and Johnson, 1976) has been defined by Naitoh and Angus (1989) as the "phenomenon of inferior task performance and/or disorientation occurring immediately after awakening from sleep" (p. 226). This period of sleep inertia is characterised by feelings of
grogginess and lethargy, and a resistance to full alertness. It is usually accompanied by remnants of a sleep stage 1 EEG pattern (Naitoh and Angus, 1989). This means that even though individuals appear to be behaviourally awake, they are still cognitively asleep, as they do not yet demonstrate a fully wakeful EEG pattern (Naitoh, Kelly, and Babkoff, 1993).

Sleep inertia occurs after waking from long sleep periods as well as from shorter naps. Studies indicate that the length of time people are affected by sleep inertia can vary from a couple of minutes to as long as 20 to 30 minutes, or even up to several hours, according to several factors, including the duration of prior wakefulness, the length of the nap, the time when the nap is taken, and also the type of task being performed (Ferrara and De Gennaro, 2000; Jewett et al., 1999; Krueger, 1989; Muzet, Nicolas, Tassi, Dewasmes, and Bonneau, 1995; Naitoh, 1981). In fact, sleep inertia is more pronounced when waking from slow-wave sleep (sleep stages 3 and 4), when waking from sleep occurring after accumulating a large sleep debt (the so-called recovery sleep), and when waking during the circadian trough time of the sleepiness rhythm (0100 to 0400 hours) (Ferrara and De Gennaro, 2000). Although these factors are highly related, and typically have the slow-wave sleep component in common, they will be discussed in turn.

8.4.1 Slow-wave sleep within naps

Dinges, Orne, and Orne (1985b) studied the effect of slow-wave sleep on sleep inertia by investigating the performance decrements (as an indicator of sleep inertia) after a long two-hour nap (TIB). The results demonstrated a relationship between the amount and depth of slow-wave sleep in the nap and the level of cognitive performance
decrement after the nap. Cognitive performance was reduced proportionally to the amount of slow-wave sleep during the long 2-hour nap. Naitoh, Kelly, and Babkoff (1993) investigated the effect of sleep stage on sleep inertia using short 20-minute (TIB) nap opportunities during a 64-hour period of continuous work. They found that when participants woke from slow-wave sleep the sleep inertia was worse than when they woke from other sleep stages (light stages 1 and 2, and REM sleep). Waking from slow-wave sleep became more common with increasing sleep deprivation.

A study by Ferrara, De Gennaro, and Bertini (2000) demonstrated that the performance decrements associated with sleep inertia were worse after a night of sleep which contained more slow-wave sleep than normal (i.e. a recovery sleep), compared to a normal night of sleep consisting of less slow-wave sleep.

These results demonstrate that waking from a period of slow-wave sleep increases the likelihood and the amount of sleep inertia after the nap. Naps should be planned in order to avoid naps that make slow-wave sleep more likely, in hopes of minimising the likelihood of waking from slow-wave sleep and thus minimising sleep inertia after the nap. While waking from slow-wave sleep has important implications for the resulting sleep inertia, the benefits of slow-wave sleep within a nap for recuperation is discussed in chapter 8.2 and later within this section (8.4).

### 8.4.2 Sleep loss prior to napping

Salame and colleagues (1995) investigated the impact of sleep inertia on cognitive functioning after naps taken over a simulated night shift in participants who were experiencing limited sleep loss (as they had a full night of sleep prior to the study).
One group of participants napped from midnight to 0100 hours, and the other from 0300 to 0400 hours. Under these conditions a mild decrease in performance speed but not accuracy was found immediately after both naps compared to a control group of participants who worked through the night without an intervening nap. This study found that with no prior sleep deprivation and only limited sleep loss during the one night awake, sleep inertia was not a major problem after a one-hour (TIB) overnight nap either at midnight or at 0300 hours (Salame et al., 1995). This study did not examine what would happen when a nap was taken during a night shift when a sleep debt had been accumulated, such as resulting from the accumulation of sleep loss, for instance from working a series of night shifts.

To examine the influence of sleepiness on sleep inertia, Balkin and Badia (1988) tested subjective sleepiness ratings and performance levels following night time awakenings from sleep. Participants were woken at hourly intervals (from 2400 to 0700 hours) over four nights, at which time they completed a 20-minute testing session (including a subjective sleepiness measure and an addition test). After this they were allowed to return to sleep (with their sleep onset latencies being measured) allowing a maximum of 40 minutes to sleep until the next testing session. This protocol allowed a maximum of five hours sleep per night for the four nights, therefore allowing a sleep debt to accumulate. The increasing sleep loss over the nights, shown by a decrease in sleep latencies across the study, exacerbated the sleep inertia seen on awakening for both speed and accuracy of calculations (Balkin and Badia, 1988).

Dinges, Orne, and Orne (1985a) investigated the effect of sleep loss on nap sleep and the performance upon waking from the nap. They found that long two-hour (TIB) naps
occurring late in a sleep deprivation period, (and therefore with increasing sleep loss), contained greater amounts of slow-wave sleep, which resulted in a more severe post sleep performance decrement or more sleep inertia. According to Dinges and colleagues (1985a), the effects from sleep deprivation may interact with the circadian rhythm effect in a nonlinear manner, complicating the effects of sleep loss on sleep inertia. From their results they concluded that naps should occur before 36 hours of sleep deprivation in order to minimise the sleep inertia effects seen on cognitive performance after waking from the nap. The naps occurring after 36 hours of sleep deprivation produced high levels of sleep inertia, demonstrated by severe cognitive performance decrements upon awakening from the nap.

These results demonstrate that prior sleep loss resulting from inadequate nocturnal sleep increases the sleep inertia that will occur after a nap. Naps should therefore be planned so that they occur before any substantial sleep loss has occurred (i.e. the ‘maintenance’ naps) to ward off or protect against the incidence of sleep inertia after the nap.

### 8.4.3 Circadian rhythm timing of nap taking

While it has been shown previously that sleep is easy to obtain in the early morning hours (midnight to 0500 hours), it was recommended that this period of time be used for an extended main sleep period rather than a nap. This is because the sleep inertia following a nap occurring in the early morning hours (past midnight) can be considerable.
Two studies previously discussed by Dinges and colleagues (1985a, 1985b) showed that napping in the circadian rhythm trough time (roughly 0100 to 0400 hours) resulted in a greater amount of sleep inertia. Both studies indicated that afternoon naps (or naps taken during the afternoon circadian lull approximately 1400 to 1600 hours) were better than circadian trough naps (approximately 0200 to 0400 hours), as these naps produced greater sleep inertia, indicated by greater impairment, or worse performance decrements. Naitoh and colleagues’ (1993) study, also discussed previously, demonstrated that their participants found it extremely difficult to wake up from naps placed during the circadian rhythm trough time (0100 to 0400 hours), especially after some sleep deprivation had been accumulated. This difficulty waking can be attributed to increased sleep inertia.

Matsumoto (1981) studied two-hour (TIB) long naps, beginning at 2200, 0200, 0400, or 0600 hours, in order to establish the best time for an overnight nap during a night shift. A full night of sleep preceded the study. The two-hour nap opportunities beginning at 0400 and at 0600 hours contained larger amounts of slow-wave sleep compared to the other earlier naps. They also found that the participants’ mood upon waking was at its worst after the 0200 to 0400 hour, and the 0400 to 0600 hour naps. Although performance was not measured in this study, these results of increased slow-wave sleep and deteriorated mood suggest that sleep inertia would be a concern with naps occurring around 0200 to 0600 hours in the early morning. Lavie and Weler (1989) examined the effects of long two-hour (TIB) naps placed at 1500 hours or later at 1900 hours. Their post-nap sleepiness levels and mood data results indicated that the 1500 hour nap had less sleep inertia than after the nap started in the early evening. They also
found that greater amounts of slow-wave sleep were associated with more sleep inertia. Performance measures were not collected.

Naitoh (1981) used a sleep deprivation period of 45 to 53 hours to study the effect of differently timed ‘naps’ on subsequent performance. These naps were the only sleep allowed during the experiment. He found that after 45 hours awake a long two-hour (TIB) nap at 0400 hours produced so much sleep inertia immediately after the nap that participants were no better off than participants who had remained awake the whole time, although benefits which Naitoh attributed to the nap were seen after a further six hours awake. A long two-hour (TIB) nap at midday (1200 hours) taken after 53 hours awake, however, improved participants’ performance almost to baseline levels once the initial sleep inertia had dissipated, which occurred after approximately one hour of being awake after the nap (therefore at 1500 hours). These results indicate that the time when a nap is taken can affect the duration of sleep inertia.

These results suggest that in general, napping during the early morning hours produces a greater incidence and duration of sleep inertia than napping at other times, such as during the afternoon. If one expects to perform shortly after awakening from a nap, then naps should be avoided during the circadian rhythm low time of the early morning hours (0100 to 0500 hours), as sleep inertia upon waking can be more pronounced and more difficult to overcome at that time.

8.4.4 Summary

The above three factors are highly interrelated and must all be considered when scheduling a nap in order to maximize nap benefits and to minimize the negative effects
of a nap (i.e. incidence and duration of sleep inertia upon awakening). Naps should be structured so that they minimise the amount of slow-wave sleep that will occur within the nap in order to make the occurrence of sleep inertia less likely.

In work situations a short ‘maintenance’ nap should not be delayed until a large sleep debt has accumulated. If the nap is delayed slow-wave sleep will likely predominate and produce more sleep inertia upon awakening. Naps should be placed in the late morning (after 0800 hours) or early afternoon (1300 to 1600 hours) rather than the evening (2000 hours) or early morning hours (0100 to 0400 hours) as slow-wave sleep is more likely at these later times (Dinges, 1989; Ferrara and De Gennaro, 2000). The afternoon timing of a nap is also consistent with the occurrence of the afternoon sleepy period, the time during the afternoon when the ability to sleep is naturally facilitated.

A short ‘maintenance’ nap of 30 to 40 minutes duration in bed, which may provide between 20 to 30 minutes of sleep, can help to reduce fatigue and improve alertness and performance for some time after the nap is taken. A nap of this length also reduces the likelihood of waking from slow-wave sleep, and thus limits the extent of sleep inertia that may occur after the nap (Ferrara and De Gennaro, 2000). After any nap, no matter how carefully placed and timed, workers should still allow a period of ‘recovery time’ after waking and before resuming work duties to permit any sleep inertia to dissipate. Workers should not return to work immediately after waking up as their performance, including reaction times and cognitive abilities, can be adversely affected by sleep inertia (Ferrara and De Gennaro, 2000). A report by Dawson and Fletcher (1997) recommended that emergency service workers such as
ambulance personnel should not engage in any critical decision making or performance
tasks like driving for a minimum of 20 minutes following waking from a nap, to allow
their sleep inertia to dissipate.

8.5 Using Napping in the ‘Real World’ as a countermeasure to Shift Work Fatigue

The napping principles discussed above have been studied in several work settings
where shift work is often required to investigate the practicability of napping for the workers. Perhaps the two best examples come from the aviation industry, and the US
and Canadian railroad industries, where napping strategies have since been included as part of their overall fatigue management programs.

As part of the NASA Ames fatigue countermeasures program, several studies have been conducted to investigate the benefits of a planned nap for pilots during long-haul flights (e.g. Rosekind, Gander et al., 1994; Rosekind, Graeber et al., 1994; Rosekind et al., 1995; Wyatt and Bootzin, 1994). For instance, in one major study, individual pilots (in a 3-person piloting crew) were allocated a 40-minute (TIB) nap opportunity (which resulted in an average of 26 minutes of sleep time), while in the cockpit seat and in an enroute cruise mode of flight. The naps were followed by a 20-minute recovery period to allow any sleep inertia effects to dissipate before resuming flight duties. Pilots’ performance and physiological alertness were improved after the nap compared to that of pilots who were not allowed to nap during the flight. Increased performance levels were particularly noticed during the critical descent and landing sections of the flight (Rosekind, Gander et al., 1994; Rosekind, Graeber et al., 1994; Rosekind et al., 1995). Since these studies have found such positive results, aviation crew napping strategies
have been implemented by several airlines, including Air New Zealand (Powell, 2000) to help manage aviator fatigue build-up during long-haul flights.

Many field trials have been conducted within the Canadian railway industry to determine the usefulness of napping during work hours for managing fatigue in their workers. Due to the positive findings of the trials, napping strategies have been implemented in most class 1 railroad companies in the US and Canada (since March 2000) as part of their employee fatigue management programs (Sherry, 2000). These railroads include Conrail, Burlington Northern Santa Fe, Union Pacific Railroad, Amtrak, Canadian National Railroad, and CSX Transportation. The fatigue management strategies implemented by these companies include several components, such as work scheduling changes, and education about sleep and fatigue, as well as the introduction of the permission for workers, even rail engineers who operate the trains, to nap for a short period of time when fatigued during their duty shifts. While specific details of each program vary substantially and are not openly available, the basis is that workers are permitted a short nap if fatigued and the opportunity permits. For example, napping is allowed when the train has stopped in a siding on the Burlington Northern Santa Fe railroads, or the train is delayed for a period of time on the Canadian National Railroad. Appropriate safety measures must be taken before the nap, such as only one operator is permitted to nap at a time, and they must make sure that the other workers are aware that a nap is to be taken. Sherry (2000) stated that since the introduction of napping, there had not been any reports of safety or operational problems or difficulties resulting from the naps. Allowing naps during a work period to help combat operator fatigue was considered an important component of the fatigue management programs in the US and Canadian railroad industry.
8.6 Summary

Napping can be a very effective coping strategy for shift workers. The four principles to consider when planning a nap in order to optimise the recuperative benefits of the nap are the type of nap, the timing of the nap, the duration of the nap, and the period of sleep inertia that occurs after a nap. ‘Maintenance’ naps, which supplement an adequate main sleep period and which occur before fatigue has developed, are more effective for enhancing alertness and maintaining performance than naps that are taken once fatigue and sleepiness have developed (i.e. the ‘recovery’ nap). Naps that occur in the mid-afternoon (1300 to 1600 hours) are more efficient in terms of sleep quality and are therefore more beneficial for shift workers than naps that occur at other times of the day. Naps should be avoided in the early morning pre-dawn hours (0100 to 0500 hours), as sleep inertia on waking from these naps can be extreme. Short ‘maintenance’ naps of 20 to 40 minutes duration (time in bed), can reduce fatigue and improve alertness, for a number of hours after the nap. If a sleep debt is accumulated from inadequate nocturnal or day time sleep, then longer naps are required for them to be as effective as a ‘maintenance’ nap. All naps, especially if long or taken in the early morning hours, are followed by a period of sleep inertia, which impairs alertness and performance. All naps must allow time after waking before commencing any work activities or driving to allow sleep inertia to dissipate. The length of time needed will depend on the amount of sleep debt accumulated prior to the nap and on the length of the nap taken. Some practical guidelines for napping by shift workers are provided in chapter 10.
9. BRIGHT LIGHT, MELATONIN, STIMULANTS, AND SEDATIVE-HYPNOTICS FOR SHIFT WORKERS

There are a number of strategies besides napping that have been investigated as possible means to help workers cope with the demands of shift work. These include the use of bright light therapy and melatonin administration to phase shift the circadian rhythm system, stimulant drugs to maintain alertness at work, and sedative-hypnotic medications to help workers sleep especially during the day. These strategies are addressed in this chapter.

9.1 Bright Light and Melatonin

9.1.1 Bright light

Bright light (>2500 lux) can be used to alter the timing of the endogenous circadian rhythm system, a process known as re-entrainment (see chapter 1). Bright light can either advance or delay the timing of the circadian rhythm system depending on the time of its occurrence. Put simply, exposure to bright light in the evening (i.e. after sunset) will induce a phase delay and exposure to bright light in the morning (i.e. before sunrise) will induce a phase advance of the circadian rhythm system. A phase delay occurs when the internal timing of the circadian rhythm system shifts to a later timing than would be usual for a normally entrained individual. The result is an internal body timing that is late compared to the external clock time. A phase advance occurs when the timing of the circadian rhythm system moves in the opposite direction, resulting in the internal timing of the body being early for the external clock time.
Bright light exposure is thought to have a dual role in causing such phase shifts of the circadian rhythm system. First, it directly stimulates the suprachiasmatic nucleus (SCN) of the hypothalamus (which is the location of the endogenous circadian pacemaker or clock), resulting in a relationship known as the *bright light phase response curve*. A *phase response curve* is simply a plot of the phase-shifting effects of a substance, such as bright light, as a function of its time of administration (Lewy, Ahmed, and Sack, 1996).

The *bright light phase response curve* indicates that under normal entrainment conditions, a phase delay will occur with exposure to dusk light and a phase advance will occur with exposure to dawn light. The inflection point for a phase delay versus an advance appears to be the core body temperature minimum (which for a normally entrained individual occurs at approximately 0400 to 0500 hours), therefore the timing of the bright light exposure in relation to the core body temperature rhythm is critical. Bright light before this point (i.e. in the late evening to early morning hours before 0400 hours) will induce a phase delay, and bright light after the core body temperature minimum (i.e. in the morning hours after 0500 hours) will induce a phase advance (Czeisler et al., 1989; Minors, Waterhouse, and Wirtz-Justice, 1991; Dijk et al., 1995). As well as phase shifting the circadian rhythm system, bright light exposure may also reduce the amplitude of the circadian rhythm, making it more susceptible to the phase shifting effects of subsequent bright light (Swanson, 1999).

The second effect of exposure to bright light in the evening is that it suppresses the endogenous melatonin secretion from the Pineal gland within the brain, making its secretion occur later in the night/early morning hours. This results in a delaying effect
on the circadian rhythm system, delaying the early morning sleep conducive period (i.e. the time of maximum sleepiness) so that it occurs later in the morning (the maximum sleepy period for a normally entrained individual occurs around 0100 to 0400 hours). A delayed circadian rhythm will mean the individual will feel sleepy somewhat later in the morning than usual, and will be able to sleep for a bit longer than usual into the later morning hours (Czeisler et al., 1990; Eastman, 1992; Martin and Eastman, 1998; Swanson, 1999). The function and use of melatonin is addressed in more detail in the following section (9.1.2).

The ability to change the phase of the circadian rhythm system has appeal for shift work situations, as shift workers are often required to work and sleep at times that are not conducive for their normally entrained circadian rhythm system. Eastman and colleagues (1995) reported on the effect of bright light treatment for phase shifting circadian rhythms in shift work situations. According to their review, while carefully controlled laboratory studies have demonstrated that bright light therapy can help phase change the circadian rhythms of participants in simulated shift work situations, field studies investigating ‘real’ shift workers (who must deal with the real conflicting natural time cues or zeitgebers of the 24-hour cycle) have shown that this is a much more difficult task (Eastman, 1990; Mitchell, Hoese, Liu, Fogg, and Eastman, 1997).

The studies reviewed by Eastman and colleagues (1995) and Eastman and Martin (1999) indicate that in controlled laboratory studies, the circadian rhythm system of participants can be advanced (i.e. moved earlier) when the light/dark cycle is phase advanced, and delayed (i.e. moved later) when the light/dark cycle is phase delayed. In these simulation studies, the bright light schedules were able to phase change the
circadian rhythm system by about two hours per day. The participants exposed to the phase delay conditions experienced faster phase changes, and they reported it to be a more pleasant experience than the participants who were exposed to the phase advance conditions. Changing the phase of the circadian rhythm system resulted in better daytime sleep and better nighttime alertness for the participants.

Such simulation studies, however, have very tightly controlled ‘light’ and ‘dark’ periods. Subsequent studies (reviewed by Eastman et al., 1995; and Eastman and Martin, 1999) have relaxed the control over having complete darkness by allowing participants to be exposed to natural light in the morning, as happens in the ‘real world’ on the way home from a night shift. These studies demonstrated that the exposure to morning light prevented the circadian rhythms from phase delaying (and in some cases produced a minor phase advance tendency), therefore interfering with the circadian adaptation to night work. These later studies demonstrate the importance of bright light exposure being combined with appropriate darkness to produce the most effective adaptation for shift work. This means avoiding sunlight on the way home from night shift in the morning, and sleeping during the day in complete darkness. Avoiding the bright light in the morning seems critical as light at this time impinges on the phase advance portion of the bright light phase response curve, and can stop any phase delaying effects from the bright light therapy (Eastman, Stewart, Mahoney, Liu, and Fogg, 1994). This research would suggest the need for dark sunglasses to be worn on the way home from night shift, although this may not be appropriate if driving.

Apart from the use of bright lights, the timing of sleep periods is also important to consider for circadian rhythm adaptation in shift work, mainly because sleep normally
occurs in the darkness (Eastman and Martin, 1999). Laboratory studies reviewed by Eastman and colleagues (1995) have demonstrated that bright light, together with consistent changes in the sleep/wake cycle, produced phase shifting effects (phase delays and advances) which were larger than the changes possible for either bright light or sleep/wake cycle changes alone (i.e. the range of entrainment was about four hours for bright light, two hours for sleep/wake cycle changes, and six hours for both combined). The best adaptation therefore occurs when the timing of bright lights and sleep periods in the dark are compatible (Eastman and Martin, 1999).

Recent research has demonstrated two findings which may increase the appeal of bright light as a potential therapy for shift work situations (reviewed by Eastman et al., 1995; Dijk et al., 1995; and Eastman and Martin, 1999). First, studies indicate that the exposure time needed to induce phase changes may not be as long as was originally thought. Research has shown that three hours of bright light treatment can result in the same phase shifting effects as six hours (both 5000 lux). Second, studies indicate that medium intensity light (1200 lux) can produce the same circadian re-entrainment as the high intensity light levels first studied (6000 lux), suggesting the light intensity levels required to induce phase shifts may be lower than first thought. Both of these recent findings, the shorter duration and lower intensity of light required, increase the appeal of using bright light as a means for circadian re-entrainment and improving adaptation of workers to night work.

Despite these positive findings, however, there are other reasons to suggest caution regarding the use of artificial bright light therapy for shift workers. Of concern is that there are many questions about the use of bright light that still need to be answered.
This includes basic questions such as what is the optimal intensity and timing of bright light treatment, and what is the importance of light attenuation at other times? Another important question concerns the health consequences of constantly changing the phase of the circadian rhythm system, and whether this is better or worse than working and sleeping at the wrong circadian phase (Eastman et al., 1995). Also of concern is the fact that using artificial bright light to alter the timing of the circadian rhythm system is a complex issue. Expert advice and consultation is needed to plan the correct schedule of bright light, darkness, and sleep periods for each specific shift work roster. It is important to note that incorrectly timed artificial bright light can result in the circadian rhythm system moving in the wrong direction, resulting in the worker being sleepier and less able to cope with night work. The schedules required can be rather complex and they must be followed on work and non-work days, therefore making them unpopular with most shift workers (Cole et al., 1990; Swanson, 1999). These are crucial questions and concerns that must be addressed before artificial bright light therapy should be introduced in shift working organizations to manipulate the phase of the circadian rhythm system for night shift workers.

9.1.2 Melatonin

Melatonin is a neurohormone secreted from the Pineal gland within the brain during night time darkness. As noted in the preceding section, bright light at night will suppress its secretion. Melatonin also has another role. Exogenous, synthetic melatonin has been used as a chronobiotic, that is, “a drug that shifts all circadian rhythms in the desired direction and acts as a zeitgeber to maintain stable phase once the latter is obtained” (p. 605, Arendt, Skene, Middleton, Lockley, and Deacon, 1997). In other words, the administration of exogenous melatonin has phase shifting abilities.
Melatonin can phase delay or advance the circadian rhythm system depending on the time of its administration and the dose. Its phase response curve is about 12 hours different than the bright light phase response curve (not surprisingly, as melatonin is only produced in darkness). Melatonin administered in the afternoon will therefore result in a phase advance, and melatonin taken in the morning will result in a phase delay (Arendt and Deacon, 1997). The maximum magnitude of such phase shifts in humans is thought to be about 30 to 60 minutes per day of treatment (Zhdanova, Lynch, and Wurtman, 1997).

Studies reviewed by Lewy and colleagues (1996) have shown that melatonin administration during the day for night workers can help them adapt to the inverted sleep/wake cycle. Without melatonin, most of the night workers studied did not adapt to the night work, even after a week of nights. The lack of adaptation may be because the lighting levels of most work places overnight is insufficient to suppress melatonin secretion and therefore to induce any phase shifting effects. Administering melatonin during the day may have helped the workers adapt by delaying their circadian rhythm system, which would then allow the morning light on the drive home from night shift to act on the delay portion of the phase response curve (rather than the normally positioned phase advance portion), thus delaying their rhythms further. It seems that exogenous melatonin administration can re-set the endogenous biological clock, with melatonin in the morning producing phase delays and melatonin in the afternoon producing phase advances of the circadian rhythm system (Lewy et al., 1996).

Apart from its chronobiotic properties, melatonin has also been investigated as a hypnotic. Melatonin has been shown to increase sleepiness and to improve subjective
and objective sleep quality and duration, under simulated time zone and shift work conditions (with or without conflicting bright lights) and in healthy adults under normal nocturnal sleeping conditions (Arendt and Deacon, 1997; Matsumoto, 1999; Zhdanova et al., 1997). These hypnotic effects are typically seen within 30 to 120 minutes of administration (Zhdanova et al., 1997), and are time-of-day dependent, such that hypnotic effects occur if melatonin is ingested while endogenous plasma levels are low (Stone, Turner, Mills, Nicholson, 2000). The hypnotic effects of melatonin are thought to be due to its hypothermic effect. That is, melatonin lowers core body temperature, and a lower core body temperature is conducive for sleep (Dawson and Encel, 1993; Dawson and van den Heuvel, 1998; Hughes and Badia, 1997; Satoh and Mishima, 2001; Van Reeth, 1998). Such findings have resulted in melatonin being considered as potentially beneficial for shift workers.

Some recent research, however, has begun to question the usefulness of melatonin administration for shift work situations. Sharkey, Fogg, and Eastman (2001) investigated the sleep-promoting properties of melatonin to determine whether or not melatonin could improve day time sleep and therefore improve alertness and performance during simulated night shift conditions. Participants ingested 1.8 mg of sustained-release melatonin half an hour before two consecutive day time sleep periods occurring after two nights of simulated night shift (8 hours). Melatonin improved the day time sleep for the first of the day time sleep periods, by improving the sleep maintenance in the last half of the sleep period. The melatonin had no effect on the second day time sleep period despite the dose and the salivary concentration of melatonin being the same. The reasons for this finding (possibly related to the pharmacokinetics of melatonin or to an interaction with sleep need) require
investigation. The melatonin had no effect on night shift sleepiness, measured by the MSLT, or performance, measured by computerised neurobehavioural testing. The participants still experienced increased sleepiness and impaired performance during the night shift, particularly towards the end of the night shift (at the time typical night shift workers are finishing work and driving home). The improved day time sleep on day one was not enough to compensate for working at the unfavourable circadian time of the night shift.

Further laboratory studies and the limited field studies available have also suggested caution, indicating that while subjective sleep quality and objective sleep onset latency can improve with melatonin, negative results have been found for several objective performance measures recorded after melatonin-aided sleep (Arendt et al., 1997; Folkard, Arendt, and Clark, 1993; Rogers, Phan, Kennaway, and Dawson, 1997). It is clear that further research is required to assess the effect of melatonin on subsequent performance (measured objectively) to clarify the extent of any sedation carry-over effects that may occur after melatonin-aided sleep.

Apart from the negative effect on some performance tasks of melatonin, there is also concern about the reports by some research participants of negative subjective feelings (i.e. ‘feeling worse’) after consuming melatonin (Zhdanova and colleagues, 1997). Side effects of melatonin can include drowsiness (often desirable), nausea, headache, giddiness, and light-headedness. It is not known whether these side effects are due to the timing of the administration, the dose of melatonin used, the type of melatonin preparation, or differences in individuals’ sensitivity to exogenous melatonin administration. Although the effects are thought to be dose related, there is little known
about the dose effects of melatonin, or which characteristic of the melatonin administration is the most important. Even the mode of melatonin operation in the body is unknown. The long-term health consequences of regularly consuming melatonin, including over several consecutive days as well as over several years, as would be required for shift workers, are unknown at this time. There is also no information available at present regarding the effect of melatonin when combined with other medications or medical conditions, including pregnancy. There is some evidence to suggest that melatonin can worsen the symptoms associated with the sleep disorder obstructive sleep apnea (Mendelson, 1997). Further research is clearly needed to address these important issues. Until these questions have been sufficiently answered, and while there is little to no regulation of melatonin manufacture in many countries including the US and Australia, the use of melatonin should not be recommended for shift workers at this time (Arendt and Deacon, 1997; Mendelson, 1997; Monk, 2000).

9.1.3 Bright light and melatonin together

While both bright light and melatonin have been discussed as having circadian rhythm phase shifting abilities, it is important to note that the light/dark cycle is considered a much stronger zeitgeber (or time cue) than melatonin. Bright light is thought to have a major effect on the timing of the circadian rhythm system, while melatonin is thought to have more of a ‘fine-tuning’ effect (Lewy et al., 1996). Because of this, exogenous melatonin administration will have very little benefit if there are competing influences from bright light sources. This difference in strength between bright light and melatonin can be seen in a study by Dawson, Encel, and Lushington (1995). These authors compared the effects of nocturnal bright light and day time melatonin administration to phase shift the circadian rhythms over three simulated night shifts.
The bright light produced a significant phase shift of the circadian rhythms, while the melatonin was unable to produce any phase shifts. The melatonin did however reduce the core body temperature of the participants, which allowed them to sleep better during the day (measured by wrist actigraphy), particularly when combined with the light treatment. The light treatment group was the only group to show improvements in cognitive psychomotor performance during the night shifts. This was thought due to the alerting effect of exposure to bright light, and the suppression of endogenous melatonin secretion across the night shifts. The bright light treatment was able to improve the circadian adaptation to the night shift, and improve performance at night, much better than the administration of melatonin (Dawson et al., 1995).

The time of maximal effect for bright light and melatonin administration is during the ‘twilight’ transitions, when each is not normally present (i.e. therefore bright light at night and melatonin during the day). The correct timing for each of these to induce a phase change is bright light in the morning (i.e. the pre-dawn hours, after about 0500 hours) and melatonin in the afternoon for a phase advance, and bright light in the evening/early morning hours (i.e. before about 0400 hours) and melatonin in the morning for a phase delay (Lewy et al., 1996). With this said however, the effect of continual adaptation and re-adaptation to night and day work on the human body is unknown at this time, therefore further research is needed before strategies that manipulate the phase of the circadian rhythm system on a regular basis should be recommended.

9.2 Stimulants

Stimulant drugs, such as the popular caffeine, are thought to be widely used within the
population to overcome fatigue and enhance alertness, although actual research addressing this issue is rare. Johnson, Roehrs, Roth, and Breslau (1999) conducted a representative community-based telephone survey (n=2 181 adults; aged 18 to 45 years) within the Detroit metropolitan statistical area in the US, to investigate the use of medications as aids to alertness within the population. Just over 5% of the respondents said that they had used medication to enhance their alertness in the last 12 months, mainly by using over-the-counter medications (73%). The majority of these users reported using the medication for just a short duration (< 1 week), and most only used it infrequently (74.8% used the medications less than 30 times in the last year). A minority of people reported using such medications regularly for longer periods (17% used it for over a month). There was a significantly greater use of alertness enhancing medication for shift workers (8.5%) compared to non-shift workers (4.9%) and unemployed (2.4%) individuals. This is not surprising given that shift workers report poorer sleep and greater fatigue than non-shift workers. A major limitation with this study is that caffeinated foods and beverages were not included in the study. Caffeinated foods and particularly drinks are known to be a common method of enhancing alertness in the population, and not including these in the study may have lead to an underestimation of the use of drugs actually taken to enhance alertness. The use of cafēine for shift workers is addressed below.

9.2.1 Caffeine

Caffeine is a widely available stimulating compound, actually a drug, readily available in coffee, tea, chocolate, or even in pill form at any pharmacy counter, which is often used to combat fatigue. Consumption of cafēine is often associated with other factors such as promoting social interaction, for example during a coffee break or rest break.
away from work duties, that may increase its refreshing effects and enhance its appeal. Studies have investigated the effect of caffeine on simulated shift work performance, and have compared its effect to another well-known alertness enhancing strategy, that of napping. The effect of a combination of naps and caffeine has also been studied in an effort to help determine the most effective use of these strategies as part of an overall fatigue management strategy in real work situations such as shift work.

Muehlbach and Walsh (1995) investigated the effect of caffeine on overnight performance and physiological sleepiness in a simulated shift work environment, and also on the sleep of participants the next day. Participants’ performance was measured using a computerised simulated assembly line performance task, while sleepiness was measured using the MSLT procedure and with questionnaires. Participants received two caffeinated drinks (each approximately equivalent to the caffeine in one cup of drip filtered coffee; total caffeine average 142 mg per night) in the late evening (2220 hours) and early morning (0120 hours) hours of the night shift for three nights, followed by two nights of placebo drinks. A similar procedure was conducted to test five placebo nights (consuming decaffeinated coffee). The results indicated that the caffeine administration was able to reduce the participants’ sleepiness, as indicated by increased sleep latencies on the MSLT. Participants also rated themselves more alert on the first caffeine night than the placebo nights. Performance was also enhanced with the caffeine, resulting in fewer errors committed. The circadian trough in alertness was still present in the caffeine nights, although it was not as severe as the placebo nights. There did not appear to be any residual effect of the caffeine on the subsequent day time sleep. As the caffeine was taken early in the night shift, it had been metabolised prior to the sleep period. The last two nights of the caffeine group indicated no residual
or rebound effects from the discontinuation of the caffeine (Muehlbach and Walsh, 1995). Caffeine at commonly ingested concentrations, early in the night shift, may therefore help to improve performance and alertness, with no effect on the subsequent day time sleep period.

Walsh, Muehlbach, Humm, Dickins, Sugerman, and Schweitzer (1990) investigated the effect of a single (large) dose of caffeine at 2220 hours (and consumed over the next 30 minutes) on night time sleepiness/alertness. The amount of caffeine consumed was equivalent to two to four cups of coffee. The results indicated that the caffeine was able to reduce sleepiness (indicated by longer sleep onset latencies on the MSLT) and improve alertness (indicated by improved abilities to stay awake in the Repeated Test of Sustained Wakefulness protocol) across the simulated night shift. The alerting effects of the caffeine lasted over 5.5 hours to about 7.5 hours. The subjective indications of sleepiness, however, did not reveal the usefulness of the caffeine; participants were not aware that their physiological sleepiness was reduced by the extent that it was. The beneficial effect of the caffeine was not necessarily realised by the participants.

While caffeine has been shown to benefit alertness by decreasing the sleep onset latencies recorded with the MSLT protocol, interesting results have been found by Kelly, Mitler, and Bonnet (1997). These authors used the MSLT and the Maintenance of Wakefulness Test (MWT) to test the effects of caffeine during a prolonged period of sleep deprivation (64 hours). Starting with the first evening of sleep deprivation participants received either placebo or caffeine capsules (300 mg) at 6-hourly intervals (totalling seven doses). Participants also undertook a MSLT and MWT at various
intervals during the laboratory session. The caffeine revealed differential effects for the MSLT and the MWT. The caffeine produced some improvement when measuring sleepiness with the MSLT for the first 24 hours only, while the caffeine produced larger and more beneficial effects when measuring alertness, or the ability to remain awake with the MWT, for the entire sleep deprivation period. The caffeine resulted in MWT latencies similar to the baseline latencies, while the MSLT revealed latencies similar to the placebo condition throughout the sleep deprivation period. The MWT appears much more sensitive to the alerting effects of caffeine than the MSLT. Further studies are needed using the MWT to clarify the benefits of caffeine for alertness and the ability to stay awake during sleep loss situations such as night shift, rather than relying on studies which measure sleepiness using the MSLT. Such a difference between the MSLT and the MWT, and what they actually measure, is discussed further in chapter 9.3 in relation to sedative-hypnotic medications.

Several studies have compared the effect of caffeine to those of taking a nap. A study reported by Bonnet and Arand (1995a) compared consuming caffeine to taking naps and found that although a two- to three-hour (TIB) nap produced similar performance improvements to 150 to 300 mg of caffeine (about two to three cups of coffee), the improvements following the nap were more consistent and steady, and longer lasting than the rise and fall of the caffeine results. Similar results were obtained by Schweitzer, Muehlbach, and Walsh (1992) who found that a three-hour (TIB) evening nap improved the participants’ overnight work shift performance levels to a similar extent as two to three cups of coffee prior to a single overnight shift. The early morning performance decrement normally anticipated in the circadian rhythm trough (0100 to 0400 hours) was still present in both groups although the decrease was
attenuated compared to no intervention. Horne and Reyner (1996) found that a short 15-minute (TIB) afternoon nap had similar alerting effects on driver sleepiness to those benefits gained from 150 mg of caffeine (about two cups of coffee). It appears that caffeine and naps can both enhance alertness.

Several researchers have also studied the outcome of combining caffeine with a nap. Reyner and Horne (1997) found that caffeine ‘combined’ with a short nap of up to 15 minutes (TIB) (caffeine taken then the nap within a 30 minute period) was more beneficial than caffeine on its own. Bonnet and Arand (1994b) found that a ‘maintenance’ nap followed by caffeine across the overnight work period was more beneficial than the nap alone. Bonnet and Arand (1994a) concluded that a ‘maintenance’ nap followed by caffeine across the night was more helpful for overnight performance than a series of short naps taken across the work period were. The conclusion seems to be that a ‘maintenance’ nap combined with some caffeine consumed across the night may produce better performance overnight than either a nap or caffeine used on its own.

While coffee has been the most common, convenient source of caffeine for decades, a new source is becoming readily available. This is the ‘functional energy drinks’, available as cans of soft drink, but which contain high quantities of caffeine and other drugs such as taurine and glucuronolactone. Reyner and Horne (2002) investigated the alerting effects of a common functional energy drink by examining driver sleepiness (occurring in the afternoon after a night of sleep restricted to 5 hours). Consumption of the energy drink (250 ml of drink, containing 80 mg caffeine) resulted in participants feeling more awake and alert, and also better performance on the simulated driving task.
(fewer driving incidents, measured as lane drifting), particularly in the first 90 minutes of the two-hour drive. The authors noted that the results found in their study with only 80 mg of caffeine were similar to results found with 200 mg of caffeine when in coffee. It was suggested that the energy drink, with its extra ingredients, may be more effective than coffee. The regular, continued use of such a drink has not been investigated and should be before recommending the use of such drinks on any regular, long-term basis. It would appear that caffeine in the more common form of coffee may be a safer means of consuming caffeine for shift workers at this time.

9.2.2 Modafinil

While caffeine remains the most common stimulating compound consumed by shift workers, there is a new ‘anti-fatigue’ compound that may be of benefit for shift workers (Roth and Roehrs, 1996). Modafinil is a stimulant drug (an alpha 1 central adrenergic agonist), which is currently used for treating the excessive day time sleepiness associated with narcolepsy and to a lesser extent hypersomnia. Modafinil can decrease the sleepiness associated with these disorders, thus improving day time vigilance and the ability to stay awake and alert, and can decrease the sudden sleep attacks characteristic of narcolepsy. Modafinil can achieve this without interfering with the normal nocturnal sleep period or planned naps. That is, patients are still able to sleep when they choose to. Modafinil does not inhibit the ability to sleep, but rather enhances the ability to remain awake. Unlike the amphetamines usually prescribed for narcolepsy, and also caffeine, modafinil is thought to have minimal peripheral side effects, minimal toxicity, a low abuse potential, no tolerance effects, and no effect on sleep architecture. The long-term effects of this drug in humans are not known, although narcolepsy patients have reportedly been treated for three years without
showing any signs of drug dependence or tolerance (Åkerstedt and Ficca, 1997; Billiard et al., 1994; Lyons and French, 1991).

Because of its ‘anti-fatigue’ effects, together with the fact that it has shown minimal side effects or typical drug effects such as tolerance or withdrawal, it has been proposed as a safe drug which could help maintain alertness in situations resulting in sleep deprivation, such as the sustained operations of the military. There is also the suggestion that it may be helpful for the ‘sustained operation’ type situations required for shift workers on night shift.

One of the few studies to investigate the effect of modafinil on healthy volunteers was conducted by Lagarde, Batejat, Van Beers, Sarafian, and Pradella (1995). Eight healthy males participated in the study, which consisted of two 60-hour sleep deprivation laboratory sessions; one was a treatment session consisting of three doses of modafinil (200 mg) per 24 hours, and one placebo session with equivalent spacings of placebo drugs. During the laboratory sessions participants completed MSLTs to measure vigilance, and filled in questionnaires. Four of the participants had ambulatory EEG recordings during the laboratory sessions. The modafinil was able to significantly increase the vigilance of the participants (i.e. increased sleep latencies compared to placebo). The modafinil was also able to suppress all microsleeps for the first 48 hours compared to the placebo condition, in which microsleeps occurred with increasing frequency and duration from the outset of the sleep deprivation. When taking the modafinil, the participants reported feeling more alert than placebo and they found it easier to tolerate the sleep deprivation; they reported feeling better overall. This is the first study to demonstrate the microsleep suppressing effect of modafinil during sleep.
deprivation, indicating the quality of the waking effect of modafinil. Unlike the anti-sleep effect of other stimulants, participants taking modafinil were still able to fall sleep during the MSLT trials, even though it took them longer. The modafinil was very effective in improving vigilance, with very little side effects or carry-over effects in sleep deprived healthy individuals.

As previously discussed, caffeine has been shown to be an effective and common method used to improve alertness and performance during sleep loss situations. Wesensten and colleagues (2002) compared the alerting properties of caffeine (600 mg) to modafinil (200 mg and 400 mg) over a 54.5-hour sleep deprivation period in 50 healthy young adults. Cognitive performance tests (from the Walter Reed Performance Assessment Battery), mood, and objective alertness (using a modified MWT) were measured across the study. The results revealed similar objective cognitive performance improvements with 200 mg and 400 mg modafinil as with 600 mg of caffeine. The 400 mg modafinil also produced similar alerting effects on the MWT as the 600 mg of caffeine. Modafinil 200 mg and 400 mg was able to maintain performance over the circadian low point, as was the 600 mg caffeine. With no significant, consistent dose-response pattern found in the study, the dose-response pattern of modafinil remains unclear. There were very infrequent side effects reported for the modafinil, with the greater number of side effects being reported for the 600 mg caffeine condition (such as heart pounding and nausea). The authors concluded that as the two drugs had comparable effects on performance, the fact that caffeine is the more widely available and cheaper drug, it would probably continue to be the drug of choice for sustaining alertness and performance during sleep deprivation conditions.
Napping has also been shown to be an effective method of improving alertness during sleep deprivation situations (see chapter 8). Batejat and Lagarde (1999) compared the effect of modafinil to napping, as well as a combination of the two, to help determine the relative effectiveness of modafinil. Situations were simulated to mimic the sustained working hours required during military operations, using eight healthy male military participants. Participants experienced modafinil (200 mg) or placebo with and without a six-hour (TIB) nap during the 60-hour sleep deprivation procedure. Performance was measured using a standard test battery used by the armed forces for research purposes (the AGARD STRESS battery; the Advisory Group for Aerospace Research and Development – Standardized Tests for Research with Environmental Stressors). The test battery measured reaction time, mathematical processing, memory, spatial processing, unstable tracking, grammatical reasoning, and divided attention. Similar results were found for the nap as the modafinil. The nap improved performance, maintaining performance similar to the start of the sleep deprivation period, while modafinil also improved performance, particularly for tasks that are sensitive to sleep deprivation. The combined modafinil and nap improved performance, again particularly for the tasks most sensitive to sleep loss, although the improvements were similar to that for the nap alone (as the nap alone was quite effective at maintaining performance particularly in the second half of the study). The sleep condition was determined as the ‘countermeasure of choice’ by these authors, as it brought performance back to a similar level as the start of the experiment without the need to consume any drugs. It was thought that the modafinil maybe useful when the ability to sleep is not possible, or during longer periods of sleep deprivation when a short sleep may not be enough to maintain safe performance.
As modafinil is still a relatively new drug, further research is needed to examine its long-term effects and contraindications for use. The majority of experimental studies conducted have examined healthy fit individuals such as military personnel, while the majority of clinical trials have examined patients with medical conditions causing excessive daytime sleepiness such as narcolepsy. The long-term use of the drug by individuals with other pre-existing medical conditions or medication usage needs to be investigated, as does the impact of continual short-term usage of modafinil repeated at intervals over a long period of time, as would be required by rotating shift workers.

Further research is also needed to investigate at what doses and under what work conditions modafinil may produce side effects. Two recent studies by Caldwell (2001; Caldwell, Caldwell, Smythe, and Hall, 2000) have reported side effects from modafinil, including vertigo, nausea, and dizziness. It was not known, however, whether the side effects were due to the dose of modafinil used (which was 600 mg over a 40-hour period of sleep deprivation) or the type of work situation being investigated (which involved pilots being tested in a flight simulator, which therefore involved moderate amounts of motion). These findings demand further research. While modafinil is currently approved to treat patients with narcolepsy, its use as a stimulant for shift workers is not feasible at this time.

While modafinil is not recommended as a stimulant for shift workers, it would appear from the research that caffeine, in the form of coffee, may be useful for shift workers on the night shift, provided it is taken early in the night shift so that it will be out of the system by the morning sleep period. The combination of caffeine with a nap may be even more beneficial for alertness than caffeine (i.e. a coffee) on its own. The practical
aspects of caffeine use to enhance alertness for shift workers are addressed in chapter 10.3.4.

9.3 Sedative Hypnotics

It is often thought that shift work is associated with an increased use of hypnotic medication, including alcohol, as a means to help the shift worker sleep. Several survey studies have been conducted to investigate this issue. For instance, Gordon, Cleary, Parker, and Czeisler (1986) analysed data from the 1980 ‘National Center for Health Statistics National Survey of Personal Health Practices and Consequences’ to identify the impact of shift work (night work and variable shift work together) on health practices in the US. Twenty-six percent of the employed men and 18% of the employed women were shift workers. These shift working men were more likely to be heavy drinkers, while the shift working women were more likely to use sleeping tablets and tranquillizers on a regular basis and to be heavier drinkers, than normal day and fixed afternoon workers.

Johnson, Roehrs, Roth, and Breslau (1998) conducted a representative community-based telephone survey of 2181 adults (aged 18 to 45 years) within the Detroit metropolitan statistical area in the US to investigate the use of ‘sleep aids’ (including medication and alcohol) within the population. The results revealed alcohol and medication use as a sleep aid to be fairly common in the sample. Approximately 13% had used alcohol and 18% had used medication (10% used over-the-counter medication only and 5% used prescription medication only) as a sleep aid over the previous 12 months. Shift work was found to be a factor related to sleep aid use. A higher proportion of shift workers (16.9%) used alcohol as a sleep aid than day workers
(12.2%) and those not working (12%). Shift workers also reported a higher use of medication as sleep aids than day workers (18.3% of shift workers vs. 16.1% of day workers).

Niedhammer, Lert, and Marne (1995) investigated the use of minor tranquillizers and hypnotics among female nurses working in hospitals in France. Six percent of the sample was classified as a ‘user of hypnotics and/or tranquillizers’, by reporting ‘sometimes’ or ‘usual’ usage of hypnotics or mild tranquillizers. These nurses were significantly more likely to be shift working nurses, in particular permanent night shift workers. These nurses (‘user of hypnotics and/or tranquillizers’) also reported more sleep disorders, poorer health, and greater fatigue than non-users. As the time schedule was also related to the reporting of sleep disorders, it was thought that the shift work resulted in the sleep disorder, which was then followed by the medication use. Barak and colleagues (1996) surveyed 131 female rotating shift working nurses in Israel. Hypnotic medication was used more than once a week by 4.6% of the nurses. Alcohol consumption of three or more drinks daily was reported by 6.1% of the nurses. It was thought that this rate of alcohol use may be lower than may be reported in other studies due to the low rates of alcohol consumption in general in Israel.

It seems that shift work may be associated with an increased use of hypnotic medication (including the erroneous use of alcohol, which is discussed in section 10.2.3) as a method to facilitate sleep, especially for women. As all the data collected were self-report, it is possible that the figures reported underestimate the actual numbers of shift workers using psychotropic drugs as an aid to sleep.
Whether or not the use of these drugs is associated with better sleep and therefore better work performance for shift workers is another question. According to Puca and colleagues (1996) hypnotic therapy can improve the sleep difficulties associated with shift work. The sleep quality and quality of life of 15 shift working air force radar controllers who had complained of sleep problems and other difficulties with shift work, was assessed before and after 21 days of hypnotic therapy. Triazolam was used in the study as it is a short-acting benzodiazepine with a rapid-onset and a short half-life of 1.5 to 5.5 hours. The results indicated an increase in sleep quality and quality of life with the drug use (e.g. participation in more recreation activities, and less anxiety and emotional disturbances reported). There was no sedation carry-over demonstrated in this study. Using a short acting benzodiazepine such as triazolam limits the chance of any sedation carry-over effects on the next wake period, such as the night shift after a day time sleep.

Porcu, Bellatreccia, Ferrara, and Casagrande (1997b) investigated the effect of 20 mg temazepam on day time sleep and subsequent nocturnal sleepiness/alertness and performance of participants on a simulated night shift (n=8 males). The MSLT was used to examine sleepiness (sleep tendency) while the Maintenance of Wakefulness Test (MWT) was used to evaluate alertness (the ability to stay awake) during the simulated night shift. Performance was assessed using two pencil-and-paper tests. The temazepam increased the total sleep time compared to placebo, without any changes to sleep architecture. The longer sleep associated with the temazepam increased the sleep latencies on the MWT, indicating a better ability to remain awake than with placebo, although no difference was found for the sleepiness measured with the MSLT. It seems that the participants were able to remain awake better with the temazepam-aided sleep
without having any effect on their ability to fall asleep. These two tests appear to be measuring quite different physiological processes; alertness or “\textit{wakeability}”, and sleepiness or “\textit{sleepability}”. The performance data was maintained over the night shift period, with no difference between the temazepam and placebo conditions, indicating no sedation carry-over effect for the drug treatment, but also no beneficial effects of the extra sleep obtained with the temazepam.

Porcu, Bellatreccia, Ferrara, and Casagrande (1997a) investigated the usefulness of temazepam for enhancing a day time ‘maintenance’ nap taken before a night shift. Ten males participated in the study. Temazepam (20 mg) or placebo was given to participants before a day time nap of approximately 6 hours (TIB), occurring between 1430 to 2200 hours. They were then kept awake the following night for a simulated night shift, which included subjective (questionnaires) and objective measures of sleepiness (the MSLT). The temazepam increased the day time sleep length compared to the placebo, however, there was no effect of this increased sleep on the subjective or objective sleepiness the following night shift. There was no sedation carry-over effect of the drug on nocturnal sleep tendency, although there was some carry-over to one of the several pencil-and-paper tests performed during the night. The majority of the performance tests were unaffected by the drug condition. The temazepam was effective in increasing the amount of day time sleep obtained without having any residual effect on the night shift performance, however, the sleepiness experienced during the night shift was not improved compared to a nap taken without any drug treatment (i.e. the placebo condition). While there was no effect on sleepiness during the night, there may have been an improvement in alertness or the ability to remain awake during the night as shown by the previously discussed study by these authors.
(Porcu et al., 1997b). As the MWT was not conducted in this study, further research needs to be conducted to investigate the effect of medication-enhanced prophylactic sleeps and the subsequent alertness demonstrated on the night shift.

While sedative-hypnotic medication has been shown to improve the sleep period, mainly by increasing total sleep time and reducing the number of awakenings without causing any major changes to sleep architecture, the impact of this extra sleep on night shift performance is more debatable. Studies provide mixed results when it comes to the effect of this extra sleep on sleepiness, alertness, and especially on performance (Walsh, Muehlbach, and Schweitzer, 1995). The studies already discussed support findings from earlier studies (Walsh, Schweitzer, Anch, Muehlbach, Jenkins, and Dickins, 1991; Walsh, Sugerman, Muehlbach, and Schweitzer, 1988; Wesnes and Warburton, 1986), which have indicated little beneficial effects of medication-enhanced day time sleep on night shift performance. A recent study by Casagrande, Ferrara, Curcio, and Porcu (1999) has shown some improvement with medication-enhanced day time prophylactic sleep on overnight performance for a vigilance task known to be very sensitive to sleep deprivation and circadian variation (a three-letter cancellation task). Further research is needed using sensitive measures such as this, as performance on such tasks may reveal subtle improvements in night shift performance with medication-enhanced sleep, and would therefore help determine whether or not the use of such medications would be of help to the performance of night shift workers.

While medication-enhanced day time sleep has been shown to improve “sleepiness/alertness”, the finding of differential effects for ‘sleepiness’ and ‘alertness’ requires further research attention, especially given that the majority of studies to date
have measured ‘sleepiness’ (with the MSLT), even though ‘alertness’ (measured with the MWT) may provide the more appropriate measure when dealing with workers in real night shift situations. In real night work situations, shift workers can use their motivation to stay awake and an upright posture to help them remain awake, as with the MWT (Bonnet and Arand, 2001).

Studies have indicated mixed results for the use of sedative-hypnotics in shift work situations. While day time sleep duration may be improved with the use of medications, this translates into only a marginal improvement in alertness (i.e. the ability to remain awake), and little if any improvement for night shift performance. As highlighted throughout the thesis, however, one of the biggest complaints of shift workers is difficulty sleeping during the day when on night shifts. Using sleeping tablets to assist their day time sleep is often seen as an ‘easy fix’ for the problem. The practical aspects of sedative-hypnotic use for shift workers are discussed in chapter 10.3.4, as are alternative non-pharmacological strategies that should be considered first.

9.4 Summary

Several drug strategies have been reviewed as possible means to help workers cope with the demands of shift work. Apart from the bright light therapy, all of the strategies involve the ingestion of drugs. As noted throughout the chapter, all strategies that involve drug use should be viewed with considerable caution as all drugs have the potential for adverse side effects including the possibility of unforeseen long-term consequences. The use of drug centred therapies should not occur at the expense of other non-pharmacological strategies such as behavioural strategies and proper shift work scheduling. Any drug therapy for shift workers should be carefully monitored by
a health professional and should be considered a short-term solution only. The practical aspects of using bright lights on night shift, and the practical recommendations regarding the use of melatonin, caffeine, and sedative-hypnotics for shift workers are addressed in chapter 10.
PART 3:

THE OHS APPROACH TO MANAGING SHIFT WORK
10. THE SHIFT WORK HAZARD CONTROL STRATEGIES

10.1 The Occupational Health and Safety Approach

Shift work involving work outside of normal day time hours poses a serious hazard to workers, with probably the most hazardous schedules being those that involve night work. It is argued that a new approach is needed to manage shift work. Changes are needed in shift work practices and workplaces to improve the safety, performance, health, and quality of life for shift workers. The new approach is to introduce an Occupational Health and Safety (OHS) framework to shift work. Applying the OHS laws to shift work settings would ensure that all workers are provided with a safe and healthy workplace and system of work, and are protected at work from hazards as far as practicable. While shift work may be recognised as a hazard to a greater or lesser extent in different jurisdictions, there has been little recognition of the hazardousness of shift work within Australia.

The OHS framework requires the identification of hazards, an assessment of the risk associated with the hazard, and the implementation of control measures to eliminate or reduce the risks (NOHSC, 1997). Introducing an OHS framework to shift work would place a duty of care responsibility on both employers and employees to assess and then control the hazards associated with shift work. The four main, clearly identifiable, ‘foreseeable’ hazards associated with shift work, which have been addressed, are: difficulty sleeping during the day and therefore greater levels of fatigue and sleepiness both on and off the job; an increased risk for accidents and errors at work and after work, including traffic crashes; an increased likelihood of health and well-being problems; and increased social and domestic difficulties. Control strategies are needed.
to eliminate or reduce the risks associated with these hazards, and any other potential hazards arising from shift work. The duty of care responsibility applies to all foreseeable hazards associated with the work, even if no specific OHS ‘regulations’ or ‘codes of practice’ exist for those hazards, as is the case with shift work. There is a need within Australia for guidance material, such as a code of practice, to ensure that appropriate steps are taken to reduce the risks associated with shift work.

There are practical strategies available that can be used to reduce the risks associated with shift work, and these will be discussed in this chapter. These can be considered the risk “control” measures within the OHS framework. The strategies have been divided into those strategies that are aimed primarily at employers (called ‘extrinsic’ strategies) and those aimed at the employees (called ‘intrinsic’ strategies). The intrinsic measures are those factors largely under the control of the shift worker, while the extrinsic measures are those factors largely outside the direct control of the shift worker but which they can influence (for example through the consultation process with their employers). While this distinction is important, the thesis will also stress the mutual responsibility from both parties that is essential to effectively reduce the risks associated with shift work. Mutual responsibility is required in two ways; firstly, both types of strategies must be adopted within a workplace (i.e. both extrinsic and intrinsic strategies), and secondly, within each type of strategy, both workers and management must be involved to ensure the success of the strategies (i.e. the distinction between ‘worker strategies’ and ‘manager strategies’ is not completely separate). The mutual responsibility required by both employers and employees is often overlooked in the existing shift work literature, despite it being a crucial component in reducing the risks associated with shift work. Introducing an OHS framework, with its emphasis on a
‘duty of care’ for both employers and employees, will help emphasize this aspect.
Consultation between employers and employees is also required by the NOHSC and their standards and codes of practice for Australian workplaces. The NOHSC state that consultation should be a continual process and may deal with issues such as:

- identifying hazards;
- the approach to be used in assessing the risks;
- deciding and implementing risk control measures;
- training programs;
- reviewing the effectiveness of controls (NOHSC, 1997, Consultation, training, information section, para. 3).

Identifying the hazards and controlling the risks must incorporate consultation between employers and employees. Employees should also be consulted before any changes are made in the workplace that may impact on their health and safety. Introducing the OHS framework will therefore encourage co-operation and consultation between employers and employees, and this will be essential to ensure that each strategy is tailored to each group of workers in each workplace.

Under the OHS framework, the options for managing workplace risks are arranged into three categories within a ‘hierarchy of control’. The hierarchy of control measures indicate the preferred priority of the types of control measures available. The first level of control is to eliminate the hazard altogether. The second level of control, when a hazard cannot be eliminated, is to minimise the risk of harm associated with the hazard. Options at this level include substitution, modification (e.g. to equipment or process), isolation, and engineering controls (e.g. screens and guards). The third level of control
options include administrative controls (e.g. warning signs or work schedules) and personal protective equipment (including training on its correct usage). Level one options should be tried before level two options, while level three options should not be used alone in the long term, and are ideally only backup measures.

In keeping with the concept of the OHS hierarchy of hazard control measures, the strategies available to improve the safety and health of shift workers can be prioritised from those that provide the largest benefits, to those strategies that, while still important, do not provide such a large return. The measures can be prioritised by the efficacy with which they control the hazard posed by shift work. This is an important element because as there are numerous strategies available, it is important that employers and employees know which strategies need to be addressed first and more comprehensively, and which strategies may be delayed and attended to further down the track when time or finances permit. It is important to identify the key strategies that will provide the greatest benefits for employees and employers and therefore deserve the greatest investment in terms of time and money. This distinction is provided for within the OHS legislation as the choice of control measures can be determined by whether or not they are ‘reasonably practicable’; that is, the benefits outweigh the costs. Such a cost/benefit analysis will allow employers to fulfil their duty of care efficiently. It is essential to note, however, that the greatest benefits of all for shift workers may result from combining as many of the strategies as possible (Monk, 1988).

This thesis presents a new approach for dealing with shift work coping strategies. As such, it also provides a new template on which to design shift work workplace education packages, for both workers and management. The area of shift work
education is an important area and one that is currently very limited within the shift work literature. Introducing an OHS framework will highlight the necessity of shift worker education and ensure that these employees are provided with relevant information, instruction, training, and supervision so they can work in a safe manner, in accordance with the employers’ duty of care. The thesis will therefore have valuable practical implications for shift work organizations. The recommendations provided in the present thesis also provide the framework for the development of national standards and codes of practice for dealing with the hazards of shift work at a national level.

The remainder of this chapter is devoted to detailing the practical aspects of managing shift work within an OHS hierarchy of shift work hazard control measures framework. The intrinsic hazard control measures are addressed in section 10.2, which is followed by the extrinsic hazard control measures in section 10.3.

10.2 The Occupational Health and Safety Hierarchy of Intrinsic Shift Work

Hazard Control Measures

The ‘intrinsic’ hazard control strategies are those factors largely under the control of the shift worker, and are therefore aimed mainly at the employees. This section begins with a summary table of the intrinsic control measures, in descending order of priority (table 1). The practical aspects of each control strategy are then discussed in detail (the relevant section numbers are provided in the summary table).
Table 1

The *Intrinsic Control Measures* in *Descending* Order of Priority

<table>
<thead>
<tr>
<th>Control Measure</th>
<th>Brief Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obtaining adequate main sleep</td>
<td>This is of the most profound importance. The sleep strategies used, including the recommended timing for the main sleep period, will depend on the type of shift roster being worked (as discussed in 10.2.1).</td>
</tr>
<tr>
<td>Napping</td>
<td>Naps can be used to supplement the main sleep and improve safety (as discussed in 10.2.2).</td>
</tr>
<tr>
<td>The sleep environment</td>
<td>A good sleep environment can improve the main sleep obtained (as discussed in 10.2.3).</td>
</tr>
<tr>
<td>Food timing and content</td>
<td>Appropriate meal planning may limit GI upsets and improve general health (as discussed in 10.2.4).</td>
</tr>
<tr>
<td>Domestic and social strategies</td>
<td>An understanding and tolerant domestic situation, and supportive friends and colleagues can improve the health and safety of shift workers. Good communication strategies are essential (as discussed in 10.2.5).</td>
</tr>
<tr>
<td>Health status</td>
<td>There are several medical conditions which when present should either exclude or advise against the individual being involved with shift work (as discussed in 10.2.6).</td>
</tr>
<tr>
<td>Fitness and exercise</td>
<td>Physical fitness may have a role in combating some of the adverse effects of shift work (as discussed in 10.2.7).</td>
</tr>
</tbody>
</table>
10.2.1 Main sleep timing

The timing of the sleep period during the day for night shift workers is very important to consider. This sleep is influenced by the two characteristics of the circadian rhythm system discussed in chapter 1. First is the timing of the circadian rhythm system with respect to sleep and wake conducive periods. Apart from the main sleep conducive portion (usually occurring at night), there is a smaller ‘secondary’ sleep conducive period, commonly referred to as the ‘post-lunch dip’ of alertness, occurring during the mid-afternoon. This afternoon sleepy period is usually more prominent in sleep-deprived individuals and in sleep-conducive conditions. Second is the natural tendency of the circadian rhythm system to phase delay, particularly in the absence of external zeitgebers. The timing of zeitgebers such as sunlight and the main sleep period can be manipulated to either maintain or delay the phase of the circadian rhythm system, the latter resulting in the sleep conducive periods moving later in time each day. The timing of the sleep period for shift workers will also depend on the type of shift work schedule that is being worked (i.e. a fast, slow, or permanent night shift roster) (see chapter 6.2). Knowledge of these two circadian rhythm principles, and the type of roster being worked, can be used to determine the best time for shift workers to sleep.

Fast Shift Rotations

One useful approach for shift workers with a fast shift rotation (such as working one or two days on a particular shift before changing) is to basically maintain a day time setting of the biological clock over the entire work period. To do this, workers should keep as many time cues in synchrony with the day time as possible, and should not permit their body clock to adjust to a night time work schedule. Workers with this schedule should:
(1) Go to bed as soon as they get home from night shift, following the sleep hygiene principles (see chapter 10.2.3). If they are working only the one night shift, this morning sleep should be for about two to three hours, and should be followed by a good long sleep that night. If they are working another night shift, this first morning sleep should be much longer, while the second morning sleep will be shorter (as for the one night shift).

(2) Have a nap at home before the night shift. The early afternoon may be an ideal time for this. Napping strategies are discussed further in chapter 10.2.2.

(3) Take a short nap (e.g. 30 to 40 minutes TIB) during the early part of the night shift if possible. Naps during the night will be followed by a period of sleep inertia (especially if sleeping around 0400 hours, or for longer than 40 minutes), which will temporarily impair work performance and safety, therefore time must be allowed to wake up from the nap before returning to work duties. Sleep inertia was discussed in detail in chapter 8.2.2.

(4) Spend some time outside in the daylight before and after the night shift. Sunglasses should not be worn on the drive home from night shift, unless driving into the sun, when sunglasses may be required for safe driving. Using sunlight as a zeitgeber is discussed further in chapter 10.3.4.

(5) Avoid a heavy, large meal during the night shift. Meal times should be kept as consistent as possible. This will help the circadian rhythm system with its timing, and it can help cut down on the GI complaints that are common among shift workers.

Maintaining a day orientation during the night shift will mean that sleepiness will occur over the night shift for these workers. There are strategies for dealing with this, such as
having regular rest breaks, varying work tasks, and having a brightly lit work environment, and these are discussed in chapter 10.3.2.

_Slow Shift Rotations_

For shift workers on a slow rotating roster (such as working approximately five or more days on the one shift before changing to another shift type), the best approach for the period of night shift is to rapidly adjust the body clock to a setting for being awake at night time. Although complete adjustment to night time living is rare, the following strategies can help. While working the night shift these workers should:

1. Go to bed as soon as they get home from night shift, following the sleep hygiene principles (see chapter 10.2.3). This is better than attempting to sleep later in the day as the earlier bed time allows the body clock to run late (phase delay), and by fewer hours, which it prefers. The easier it is for the body clock to adjust, the more sleep will be obtained.

2. Avoid placing the main sleep in the evening (1700 to 2100 hours) because (a) body temperature is nearing its peak which makes sleep difficult to obtain, (b) this would place the sleep period at the wrong time for the body clock to adjust to (i.e. this would change the clock to an earlier setting which is much harder to do), and (c) as sleep itself is a time cue it would confuse the body about when sleep time is.

3. The afternoon can be used for a nap to top up the amount of sleep obtained before the next night shift. If insufficient sleep was obtained in the morning sleep, then a nap should be taken in the afternoon to make up at least seven to eight hours of sleep.
(4) Avoid napping during the night shift, unless very sleepy. A nap if taken should be short (e.g. 30 to 40 minutes TIB), and remember to allow for sleep inertia afterwards.

(5) If possible, early morning daylight (e.g. at sunrise) should be minimised on the drive home from night shift, as this is a strong biological time cue. Sunglasses should be worn on the drive home from night shift. The use of sunlight as a zeitgeber is discussed further in chapter 10.3.4.

(6) Try to maintain three regular, predictable healthy meals, varying only the timing of the ‘lunch meal’ if possible. The meal in the middle of the night shift should not be a heavy or large one.

It should be remembered that the circadian rhythm system is slow to adjust to being awake at night. So although these strategies will help the body clock adjust, the process is very slow, and the adjustment process is rarely complete. Therefore, the daytime sleep is likely to be generally shorter, lighter, and more fragmented than night sleep. This means that after a few night shifts, workers will accumulate a significant amount of sleep loss (sleep debt), which will make them very tired, particularly in the early morning hours (0100 to 0500 hours) and during the drive home near daybreak!

After the last night shift, workers on a slow rotation will have some time off before rotating to either day or evening shifts. On these days off workers should adjust their body clock to being awake in the day time. On their days off after their night shifts these workers should:

(1) After the last night shift, workers should only sleep for two to three hours the next morning. They should then get a good long sleep that night and the next few nights
as needed. Workers must be aware that during this initial recovery time they are likely to have a large sleep debt which may make many activities such as driving unsafe.

(2) Workers should surround themselves with ‘day time’ time cues on their days off, for instance exercising outdoors in the sunlight. As day time cues are frequent and strong, the shift back to a day time clock setting is easy and rapid.

(3) Workers may find it is easier to change from a night shift to an afternoon shift if there is minimal time off between shift changes, as they can keep their sleep period during the morning. With sufficient time off after night shift, and a subsequent change back to day time living, workers will find it easy to change to a day shift.

Permanent Night Shift
For those shift workers who are permanent night workers, or are returning to night shift after their time off, they should follow the strategies for ‘Slow Shift Rotations’ when working, while the ideal strategy for their days off is to remain nocturnal! As remaining nocturnal is not usually socially desirable, some compromise is possible. On their days off these shift workers should:

(1) Try to get up late in the morning (e.g. after midday) and go to bed late (e.g. after midnight).

(2) Avoid morning sunlight by staying inside or wearing dark sunglasses when outside.

(3) Try to stay with their night shift meal schedule as much as possible.

An important key for all shift workers to remember, whether on rotating or permanent shifts, is that the body clock decides where day and night is from the presence or absence of daylight, and from the schedule information that it receives. Shift workers
can help their body adjust to shift work by consistently following the appropriate suggestions for their schedule type, particularly for the sleep times and the exposure or not to sunlight.

### 10.2.2 Napping

Napping is an important strategy for shift workers (see chapter 3 and chapter 8; and also Hartley et al., 2001), although as Dinges (1995b) states, *“Napping is not a solution to every fatigue problem engendered by work schedules and operations. It is a limited fatigue countermeasure that can be of considerable benefit if used properly, and if its limitations are recognized”* (p. 51). The research and principles determining the effective use of naps as a fatigue management strategy have been reviewed in chapter 8. What follows is a brief summary of the main principles of napping which incorporates some practical recommendations that shift workers can use to help them make napping an effective coping strategy.

It is important that naps are not thought of as a suitable alternative to obtaining longer duration good quality main sleep periods. Rather, naps should be considered as a supplement or augmentation to those longer main sleep periods. Unimpaired performance requires that people obtain a minimum of seven but preferably eight hours of sleep, requiring longer than eight hours in bed, per 24-hour day (see chapters 1, 3, and 8). As shift workers are not always able to obtain enough sleep in one sleep period, a strategy of using ‘maintenance’ naps can be of benefit for maintaining alertness, particularly when shift work schedules include working night shifts or extended hours (see chapters 8 and 10.2.1). When a work period is scheduled such that sleep loss is to be expected, such as with night work, then napping can be very beneficial.
The best time for a nap is before the period of sleep loss, that is, before a night shift. Naps that are ‘prophylactic’ (i.e. the ‘maintenance’ nap), taken before sleep loss has accumulated, enhance alertness and performance over the wake period much more than naps that occur during the period of sleep loss (i.e. the ‘recovery’ nap). Naps are best when taken after a normal night of sleep and before fatigue develops. Shift workers should aim to take a ‘maintenance’ nap before working a night shift. ‘Maintenance’ naps can enhance alertness levels and therefore improve the performance of workers during a period of sleep loss such as a night shift, even though they may not always be aware of these benefits. If an insufficient main sleep period has been obtained, a ‘recovery’ type nap would be preferred compared to no nap in order to increase the amount of sleep to a minimum of seven to eight hours per 24-hour day. A nap to recover sleep after a sleep period that is incomplete is often a necessary countermeasure for shift workers, particularly when working a series of consecutive night shifts. These naps will likely produce greater sleep inertia on waking.

The ability to fall asleep and to maintain sleep is affected by the timing of the sleep period within the circadian cycle. It therefore follows that the recuperative benefits (e.g. restoration of alertness) gained from a nap may depend on the timing of the nap within the circadian rhythm system. Naps that occur during the afternoon (between 1300 and 1600 hours) are more efficient and may provide greater improvements for performance than naps that are taken at other times across the day time. A ‘maintenance’ nap should therefore be planned for the afternoon before commencing a night shift. ‘Maintenance’ naps during the afternoon (1300 to 1600 hours) are preferred over those scheduled as overnight or particularly early morning naps (0100 to 0500
hours) as the latter can have a prolonged period of sleep inertia after waking from the nap (as discussed in chapter 8). Sleep inertia can reduce alertness and cognitive abilities. Greater amounts of sleep inertia means that more time is required after waking from the nap for sleep inertia to dissipate and therefore before it is safe to return to work duties. ‘Maintenance’ naps may be taken during a night shift provided they are planned to occur early in the night shift, before the circadian low in alertness (i.e. therefore before 0100 hours), to limit the amount of sleep inertia experienced on waking from the nap. A ‘maintenance’ nap taken early in the work period can improve performance and lessen the fatigue and sleepiness experienced later in the shift.

The recommended duration of a nap is a somewhat more complicated issue. A dose-response curve has been shown for the length of naps, suggesting that the longer the nap the greater the benefit. While this is true, the relationship is not linear, with the greatest recuperation being derived from the early part of a nap, as sleep is most efficient early in a sleep period (Dinges, 1995b). While longer naps may provide more benefits, although probably with diminishing returns, they are more likely to contain deep, slow-wave sleep, especially if a sleep debt has accumulated, and are therefore more likely to produce greater amounts of sleep inertia than shorter naps (Naitoh, 1981).

A long nap may therefore be taken when sufficient time is available before starting work duties to allow the sleep inertia to dissipate. Such long naps are recommended to be about 90 to 110 minutes in length (i.e. TIB). These lengthy naps are more likely to be the ‘recovery’ type of nap, when insufficient main sleep has been obtained. When there is limited time available after the nap before leaving for work or resuming duties
at work, a short nap should be taken in order to minimise the sleep inertia. Such short
naps are recommended to be about 30 to 40 minutes in length (i.e. TIB), which have
been shown to allow between 20 to 30 minutes of sleep to occur (e.g. Rosekind, Gander
et al., 1994; Rosekind, Graeber et al., 1994; Rosekind et al., 1995; L. Signal, personal
communication, 2002; Wyatt and Bootzin, 1994). Naps as short as 20 to 30 minutes
(TIB) have been shown to provide improvements across the work period compared to
no nap (see chapter 8).

The length of time that a nap will be of benefit will depend on the duration of the nap
and the level of sleep debt that had been accumulated prior to the nap (Dinges, 1995b).
A short ‘maintenance’ nap of 30 to 40 minutes (TIB) can improve performance and
physiological sleepiness for up to 12 hours after the nap is taken, even though
subjective sleepiness or mood may not improve (Dinges, 1989, 1992a). If a significant
amount of sleep loss has occurred, then a longer nap is usually required to provide a
similar amount of benefit, although longer naps have the disadvantage of producing
greater amounts of sleep inertia.

A carefully planned nap can improve alertness for a number of hours after the nap
while minimising the amount of sleep inertia that will occur immediately on waking
from the nap. After any nap though, no matter how carefully placed and timed,
workers should still allow a period of ‘recovery time’ after waking and before resuming
work duties to permit any sleep inertia to dissipate. A minimum of 10 minutes is
recommended, while 20 minutes would be preferred.
10.2.3 Sleep environment – the “sleep hygiene” rules

There are several strategies, based on the principles of good *sleep hygiene*, that shift workers can use to improve their day time sleep (Hauri, 1993; Hauri and Linde, 1990; Hopson, 1986; Lamberg, 1984; Monk, 2000; Monk and Folkard, 1992; Morin Culbert, and Schwartz, 1994; and Sloan et al., 1993). Firstly, it is important to prepare for bed and to follow the same pre-sleep rituals that normally occur before night sleep. This can include brushing one’s teeth, having a shower, and putting on the usual nightclothes. Doing this prepares the brain and body for sleep. This is especially important for day sleep as the physiological and environmental conditions for day sleep are not as conducive as they are for sleep at night.

It is also important to ensure that the bedroom environment is conducive for sleep. Again, the same principles as for night sleep apply. The bedroom should be both dark and quiet. Heavy, thick curtains or even black plastic or foil can be used over windows to reduce the amount of light in the bedroom, and eyeshades can also be worn to help cut out light. As many known sources of noise should be reduced as possible. This means turning the phone down and disconnecting the doorbell if possible. It also means asking friends and family not to call during the sleep times. Other people in the house, including partners and children, should also be aware of the shift workers’ sleep times so they can be as quiet as possible. *White noise* such as a fan can be used to mask external noises such as traffic noise, and earplugs can also be worn to help cut out noise.
Other factors that should be considered are caffeine (found in coffee, tea, chocolate, and cola drinks) and alcohol consumption. Caffeine is a stimulant, alerting the brain and body, which stays in the bloodstream for more than five hours after being consumed. This means that coffee, tea, cola drinks, and chocolate should be avoided in the five hours before a sleep period. If a tea or coffee is normally consumed towards the end of a night shift, this can be replaced with a decaffeinated variety or one of the many caffeine-free herbal teas that are available, although there is some recent evidence to suggest that even decaffeinated tea and coffee may still produce some alerting effects (Quinlan, Lane, Moore, Aspen, Rycroft, and O’Brien, 2000). The effective use of caffeine by shift workers to maintain alertness while at work is discussed in chapter 10.3.4. Alcohol should also be avoided before going to sleep. While alcohol does have an initial sedating effect, it is very disruptive for sleep that occurs later. Alcohol causes many arousals and awakenings in the latter part of the sleep period, making the sleep very fragmented. Alcohol also suppresses REM sleep, resulting in a REM rebound effect and therefore disturbed sleep, when alcohol is not consumed.

10.2.4 Meal timing and content

It is important that meal times for shift workers are kept as regular and as consistent as possible (see chapter 4.2). Shift workers should try to maintain a consistent time for ‘breakfast’ and ‘dinner’ meals, and vary the time of the ‘lunch’ meal as needed when working night shift. On the night shift, it may be preferable to eat one small meal rather than frequent snacks during the night, although this may depend on personal preference. Keeping the time and the number of meals as consistent as possible will help reduce the gastrointestinal upsets that are common among shift workers (Duchon and Keran, 1990). Meal times should never be rushed. There should be time to sit
down and relax, and to eat slowly. Shift workers should avoid eating while working, as meals times should provide a break away from work duties.

Foods to Avoid on the Night Shift

Foods high in fat and sugar should be avoided on the night shift. Sugary foods give a short-lived burst of energy (about 20 minutes), which is followed by a rebound slump in energy. They can also lead to weight gain and dental problems (e.g. increased cavities). Fatty foods are hard for the body to digest over the night and can lead to stomach upsets. They can also lead to weight gain and can increase the risk of heart disease.

Examples of high fat, high sugar foods to avoid on the night shift include fatty meats (e.g. salami, bacon, sausages, corned beef, hot dogs), fried foods (e.g. potato chips, hot chips, fried rice), full-fat dairy foods (e.g. full fat cheese or creamy sauces), pastries (e.g. meat pies, or sweet pies and pastries), and large amounts of butter or margarine (Circadian Technologies, Inc.).

Some types of foods can lead to stomach upsets on the night shift and should therefore be avoided. These include spicy foods and seasonings (including black pepper, chilli peppers, cayenne pepper, onions, garlic, chilli, Tabasco sauce, BBQ sauce, strong mustards), and tomato juice or sauce (Circadian Technologies, Inc.).

Foods to Eat on the Night Shift

Meals and snacks on the night shift should be well-balanced and nutritious, and should contain complex carbohydrates, proteins, and be low in fat. High protein foods may
help to increase alertness, while high calorific foods such as fat may promote sleepiness (Penn and Bootzin, 1990), which is not desirable on the night shift. Shift workers should aim to bring suitable food from home to help avoid the temptation to snack on unhealthy junk food, which is commonly found in workplace vending machines. It is also important for workers to drink plenty of fluids, which means six to eight glasses of water every day. While some of this water may be replaced with diluted fruit juice or weak decaffeinated tea such as herbal tea, it is important to make sure that some plain water is consumed.

Examples of foods which are high in complex carbohydrates and protein and low in fat, which are therefore suitable for eating on night shift, include pasta (including noodles), rice, potato (e.g. micro-waved), whole grain breads (including rolls), crackers, whole grain cereals, fruit and vegetables (raw or cooked, with no fat or spice), lean meats (e.g. skinless chicken, fish including canned tuna), tofu, legumes and beans (including soybeans and baked beans), and low fat dairy foods (Circadian Technologies, Inc.).

Some suggestions for night shift meals and snacks include re-heated homemade casseroles, dinners, or soup (including lean meat or chicken with vegetables and pasta), toast (including toasted English muffins or crumpets) with low fat spreads, sandwiches, fruit (either fresh, dried, or preserved in natural juice), rice-crackers or other low fat savoury biscuits with low fat vegetable dips or cheese, and low fat yoghurt (Circadian Technologies, Inc.).
**10.2.5 Domestic and social strategies**

Social support from family and friends, as well as from work colleagues, can help a shift worker cope with the demands of working unusual hours (see chapter 4.6). As non-shift workers are generally unaware of what shift work is really like, it is important that shift workers talk to their family and friends about their situation and help them understand what it is like, and how they can help. It is important for the family of shift workers to know that night shift workers must sleep during the day, and that obtaining enough sleep is vital for their ability to function efficiently for the next shift. It is also important that shift workers spend time with family and friends, however, not at the expense of losing sleep.

The most important concept that shift workers need to remember to help them manage their social and domestic life is that of communication and planning. Shift workers must discuss their shift work experience with their family so that family members understand how important the day time sleep is for a night shift worker, and when these sleep times will occur. It is important that these sleep times are protected and are not cut short because the family does not understand its importance. Putting up the shift work roster on the fridge, with the sleep times indicated, can be a great way to communicate with the family when work and sleep times will be. This shift work roster can also be used to plan family activities around the work and sleep times. Any appointments or activities need to be scheduled so that they do not interrupt the sleep period. Planning ahead is important for shift workers, and also their family. Family members can use the shift work roster to plan their activities so they can arrange quiet activities or to go out of the house during the sleep times of the shift worker. The
house needs to be quiet when a shift worker is sleeping. Friends could also benefit from knowing the shift work roster so they will not phone or visit during the sleep times, and they can also organise activities around the shift worker’s roster. Organising social activities with other shift working families is helpful, as they understand the conditions and limitations of shift work and can therefore be a great source of support (Circadian Technologies, Inc.).

Following from the advice above is that it is important that shift workers do not forget their families. Just as the main sleep time should be planned in advance and protected from interruptions, so should the time shift workers spend with their family. It is vital to plan time, such as making a ‘date’, to spend time with them. This time should come before attending to domestic chores or other activities. Be aware that shift work can affect the family in a number of ways. Partners and children of shift workers can often feel lonely and neglected particularly when the shift worker is working nights. Shift workers must be aware of their family’s feelings and concerns, and should discuss any issues that arise early on before they become major issues (Circadian Technologies, Inc.).

After planning sleep times and family times, it is important that shift workers take time to look after themselves. For instance, it is important that time is made for regular exercise, remembering that exercise should not occur in the couple of hours before a sleep period (see chapter 10.2.7). Exercising with a friend or family member is a great way to combine socialising and exercising for shift workers (Circadian Technologies, Inc.).
10.2.6 Health status - risk factors and contraindications for shift work

Smolensky and Reinberg (1990) report that most occupational health professionals are aware of the fact that not all individuals are biologically capable of, or tolerant to, shift work. Some can adhere to rotating shift schedules, which include periodic night time duty throughout their working life, for 35 years or more, without health problems or medical complaints of any kind. On the other hand, some healthy young workers can exhibit medical intolerance to the rigors of shift work from early in their shift work experience. There are several medical conditions, which if present should advise against but not necessarily exclude the individual from being involved with shift work. There are also several medical conditions, which when present should potentially exclude the individual from shift work. These two situations are addressed below.

Risk Factors

According to the shift work literature, there are several medical conditions that if present should be used as grounds for counselling prospective employees about the potential risk that shift work may pose for their health, and for establishing adequate medical surveillance for those who decide to undertake such a work schedule. According to Scott and Ladou (1990) these risk factors include the presence of mild medical conditions such as: mild insomnia, mild asthma, chronic obstructive bronchitis, non-insulin-dependent diabetes mellitus, visual impairment, the presence of various mild cardiac risk factors, a history of depression, the use of medications known to have circadian variation in effectiveness, the use of central nervous system drugs, a history of seizures, mild digestive disorders, frequent indigestion, mild irritable bowel syndrome, and as discussed in chapter 4.5, women with menstrual disorders or who are
pregnant. People with these conditions may not be suitable for shift work (Costa, 2001a). People with noisy or otherwise disturbing housing conditions, people with long commute times to and from work, those over 40 years, or women with small children, may also not be suitable for shift work. It has also been suggested that extreme morning types and people with rigid living patterns would not adapt well to shift work, although the evidence for this is mixed (Thierry and Meijman, 1994).

**Contraindications**

Further to the risk factors above, Scott and Ladou (1990) as do others, recommend that some medical conditions should be used to screen out, or potentially *preclude* an individual from shift work. These contraindications for shift work include more serious medical conditions such as: moderate to severe sleep disorders (e.g. insomnia, sleep apnea, narcolepsy), gastrointestinal disease/disorders (e.g. chronic gastritis, peptic ulcer, chronic active hepatitis, cirrhosis, chronic pancreatitis, severe irritable bowel syndrome), ischemic heart disease, cardiovascular disease, hypertension, insulin-dependent diabetes, severe thyroid and suprarenal pathologies, nervous disorders (e.g. medication dependent epilepsy, chronic anxiety or depression, brain injury with sequelae), chronic renal impairment, malignant tumors, and possibly pregnancy (Costa, 2001a; Koller, 1996; Monk, 1997; Scott and Ladou, 1990; Thierry and Meijman, 1994). Many of the above conditions require food or medication intake at consistent times, and this is not always possible when working shift work (e.g. Costa, 1997). There is a serious risk that shift work could aggravate the above medical conditions, potentially having serious consequences. People with any of these conditions may not be suitable for shift work positions, and should be counselled accordingly.
The impact of shift work on an individual, however, results from a complex interaction between many factors, including family and social, personal lifestyle, and medical factors. The outcome is multi-faceted and cannot be predicted with any certainty before commencing shift work. The conditions listed above, however, highlight individuals that may be at a greater risk from shift work than others. Such individuals should be carefully counselled if they are considering a career that involves shift work. These individuals need to be made fully aware of the potential risk that shift work may have for their health and well-being. As the precise outcome cannot be predicted with certainty, however, the final decision regarding a shift work position should rest with the individual concerned. These individuals would require careful medical monitoring while engaged in shift work in order to identify any medical problems early in their development.

10.2.7 Fitness and exercise

As discussed previously (see chapter 7.4), maintaining physical fitness may be an important strategy for shift workers. Harma (1996) suggests that shift workers should perform regular, moderate physical exercise rather than intensive training to maintain their fitness. The timing of these exercise periods is important to consider for two reasons. Firstly, light to moderate physical exercise, such as 20 minutes of aerobic exercise, can help the body wake up and feel ready for work. Secondly, studies have indicated that the timing of exercise may act as a zeitgeber to affect the phase of the circadian rhythm system (Piercy and Lack, 1988). This knowledge leads on to two different exercise strategies. One strategy is to change the timing of exercise so that it always occurs before the start of a work shift, as this may help the body wake up and adjust to the changing work times of shift work, while the other strategy is to maintain
exercise at a regular time of day to help maintain the synchronisation and phase of the circadian rhythm system while working shift work (Harma, 1996).

The important distinction between these two recommendations is the effect that the timing of the exercise may have on the timing of the endogenous circadian rhythm system (i.e. maintaining or changing the phase of the endogenous body clock and therefore the timing of the circadian rhythm system). Which of these outcomes a shift worker may prefer may depend on the type of shift work roster being worked. For those shift workers with a rapid or fast rotating roster, the recommendation given previously (chapter 10.2.1) was to maintain a day time orientation for the body clock. Consistent with this advice would be the suggestion to keep the time of exercise periods at a regular time of the day (as much as possible). For those shift workers with a slow rotating roster, the recommendation given previously (chapter 10.2.1) was to rapidly change the timing of the body clock to a night time setting for the period of night shifts and back to a day time setting for the period of day shifts. Consistent with this advice would be the suggestion to alter the time of exercise periods so that they occurred before the work period. While this is the theoretical suggestion given the available research, the degree to which these two strategies may be of actual help to shift workers is unknown and is in need of research.

An important aspect of exercise timing that must always be considered is that any exercise should occur at least three hours before the main sleep period. This is because exercise increases body temperature and alertness, which makes sleep more difficult. It is also important that exercise is not too strenuous before work in order to avoid feeling too tired or exhausted for work. The impact of the timing of exercise for shift workers
deserves further research attention, especially given that research has shown physical fitness to improve shift work tolerance. Until further research has been conducted to clearly establish the best time for shift workers to exercise, including the impact that different exercise strategies may have for different shift work schedules, individual preference for exercise times (e.g. morning or evening) may be sufficient.

10.3 The Occupational Health and Safety Hierarchy of *Extrinsic* Shift Work Hazard Control Measures

The ‘extrinsic’ hazard control strategies are those factors largely outside the direct control of the shift worker but which they can influence. These strategies are therefore aimed primarily at employers. This section begins with a summary table of the extrinsic control measures, in descending order of priority (table 2). The practical aspects of each control strategy are then discussed in detail (the relevant section numbers are provided in the summary table).
Table 2

The *Extrinsic Control Measures* in *Descending* Order of Priority

<table>
<thead>
<tr>
<th>Control Measure</th>
<th>Brief Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduling of shift work</td>
<td>While there is no one best shift design for all situations some design principles, incorporating knowledge of the influences of circadian rhythm physiology, can be used to improve the shift system (as discussed in 10.3.1).</td>
</tr>
<tr>
<td>Work conditions</td>
<td>Good working conditions can improve the health and safety of shift workers (as discussed in 10.3.2).</td>
</tr>
<tr>
<td>Health</td>
<td>The monitoring of worker health status and health interventions need to be considered, as shift workers have a higher prevalence of some health problems (as discussed in 10.3.3).</td>
</tr>
<tr>
<td>Bright light, caffeine, and sedative-hypnotic medication</td>
<td>Specific interventions such as bright light during the night shift, caffeine, and sedative-hypnotic medication, may have a role in facilitating shift work tolerance (as discussed in 10.3.4).</td>
</tr>
</tbody>
</table>

**10.3.1 Shift work scheduling recommendations**

Good schedules are advantageous for both the worker and the company and both safety and productivity can improve with a good shift work schedule (Tepas, Paley, and Popkin, 1997). As Snyder (1995) reiterates, there is no 'one best' shift work schedule that can work in every shift work situation. There will always be trade offs between
certain aspects in any schedule. This is because of the many different factors involved, including many interactions between them. Each workplace must therefore carefully consider each principle in relation to its particular work demands and worker population, and decide on the most safe and satisfactory schedule for them.

Developing the best shift system for employees is complex and requires both consultation with employees and evaluation of the new system. Unintentional consequences can always follow the choice of any new shift work system so any change requires careful monitoring and modification when needed. Indeed, Sakai, Watanabe, and Kogi (1993) have shown that by using a strategy of planned discussion and consultation, joint decision making taking into account workers’ needs and preferences, and an evaluation processes to identify any changes that may need to be made, a shift work roster can be changed successfully with a high level of motivation and satisfaction. The recommendations that should be considered when designing a shift work schedule are as follows (based on Iskra-Golec, 2001; Knauth, 1993, 1996, 1997, 2001; Monk, 1997; Rosa and Colligan, 1997; Swanson, 1999; Tepas et al., 1997; Wedderburn, 1991). The numbers given in brackets indicate the chapter reference where the research justifications are provided.

Recommendations for Good Shift Work Schedules

(1) The balance of evidence suggests rapidly rotating shifts are preferred to slowly rotating or permanent night shift, although opinions are not unanimous on this point (6.2).

(2) Avoid many consecutive night shifts (maximum of 3) (6.2).

(3) Forward (clockwise) rotating rosters are preferred to backward (counter-clockwise) rotations (6.3).
(4) Avoid quick shift change-overs. The minimum rest break between shifts (i.e. from the end of one shift to the start of the next shift) should be at least 11 consecutive hours (6.5).

(5) After the last night shift two days off as minimum is recommended (6.5).

(6) Avoid long work periods followed by long break periods. The recommended maximum number of consecutive working days is five to seven. This should be followed by at least two consecutive days off (6.5).

(7) Avoid single work days between days off (6.5).

(8) Plan free weekends (Saturday and Sunday). One to two full weekends free per month is desirable to enhance social contact (6.5).

(9) Avoid consecutive long work shifts (i.e. >8hrs) (including overtime). There should be no more than three 12-hour shifts, or two if night shifts, per week. Two or more days off should follow (6.5).

(10) Tailor shift length to the type of work being done (i.e. heavy physical work is fatiguing and cannot be sustained for long shifts) (6.2).

(11) Tailor work tasks to the appropriate shift time when possible (i.e. monotonous work and work requiring concentration is harder during the night shift) (6.2).

(12) Consider distributing tasks during the shift according to fatigue levels and the time (e.g. avoid heavy or critical tasks at the end of night shift as fatigue is too great and the risk of errors and accidents is too great) (6.2).

(13) Morning shifts should not start too early (i.e. not before 0600 hours) (6.1).

(14) Evening shifts should finish as early as possible (6.1).

(15) Night shifts should finish as early in the morning as possible (6.1).

(16) Consider flexible start-finish times, and allow flexibility to change shifts if required (6.1).
(17) Travelling time should be considered as a factor when setting schedules (e.g. when determining start and finish times) (6.1).

(18) Regular and predictable schedules are important. This allows workers to plan their sleep time and other commitments. Avoid last minute roster changes (e.g. provide >24hrs notice of changes) (6.7).

(19) Provide regular rest breaks during shifts (6.6).

(20) Consider worker preference (5), which may include factors such as child care arrangements (5.4).

Additional Things Employers can do to Help Shift Workers

(1) The work environment should be carefully considered. Adequate lighting, good ventilation, a comfortable temperature, reduced noise levels, and access to hot meals or a microwave are important for night workers (10.3.2, 10.3.4).

(2) Provide easy access to ‘healthy food choices’ in the workplace, such as in vending machines and canteens (10.2.4).

(3) Provide easy, regular access to health care and counselling facilities (4, 10.2.6, 10.3.3).

(4) Employee education about shift work is critical. Shift workers’ families should be involved (11).

(5) Encourage discussion among shift workers to share their experiences and methods of coping with shift work. This can help reduce their feelings of isolation, and let them know that they are not alone (4.6, 10.2.5).

(6) Work meetings and social programs should be organised for shift workers at appropriate times for their work roster (10.2.5).
Shift Work Scheduling for the Older Shift Worker

As older workers generally cope better with morning shifts than night shifts, rescheduling may be done to give older shift workers more morning shifts (Harma and Ilmarinen, 1999). Their preferences for earlier starting times should be taken into account where possible when scheduling the starting times for day shifts. Rapidly rotating rosters are preferred to slow ones for older workers to reduce the amount of consecutive night work. Some have recommended that older shift workers (aged 45 to 50 years) be transferred to day work or morning shifts only (Harma and Ilmarinen, 1999), although it is generally better to give them a choice. Shifts should be scheduled with adequate time off between shifts to allow recovery and sleep before the next shift. Adequate rest breaks during a shift should also be given to counter fatigue, particularly for the older worker (see chapter 7.1).

10.3.2 Work conditions to improve performance on night shift

Regular rest breaks should be taken during all work periods (see chapter 6.6). A rest break of five to ten minutes every hour may be sufficient, although data on the optimum length of rest breaks is scarce. Shift workers should try to have a rest break at least every two hours. Social interaction during a rest break will help to increase arousal and combat fatigue. Movement, some physical activity, or light exercise including stretches can increase arousal via physiological mechanisms, and can therefore help combat fatigue and sleepiness, temporarily improving alertness and performance on the night shift (Penn and Bootzin, 1990; Rosa, 2001). A proper meal break should also be taken during the night shift. While food itself may increase arousal (e.g. protein), the meal break itself provides some variation from work, which
will increase arousal. Chapter 10.2.4 provides recommendations for which foods to eat and those to avoid on the night shift.

Some variation in the work being done across the night shift can help reduce fatigue and improve performance. Interesting tasks can help to increase arousal and therefore performance (Penn and Bootzin, 1990). Penn and Bootzin (1990) suggest that self-pacing of tasks over the night shift may reduce performance decrement, as can performance feedback from co-workers or supervisors. Tasks should be scheduled so that monotonous and boring tasks, and dangerous and critical tasks are done early in the shift whenever possible. Such tasks should not be left until the end of the night shift when workers are more likely to be fatigued and drowsy.

Moderate levels of meaningful noise, such as traffic sounds or particularly music, can temporarily, and to a small degree, enhance performance when sleep deprived. Lively and varied background music, such as classical music, may be of some benefit for alertness and performance on the night shift, although this is certainly not a cure for fatigue. The temperature of the workplace should be comfortable, and it should be well ventilated. Bright lighting may also help to increase arousal, and this aspect is discussed further in chapter 10.3.4.

10.3.3 Health – interventions and monitoring

Improving both the work environment and the worker are very important strategies for improving shift worker health and tolerance, and both should be encouraged in shift work settings (see chapter 4.6). Improving one without the other will not be as successful as improving both aspects. To improve both areas requires mutual
responsibility between employers and employees. Employers must provide their workers with an appropriate work schedule and work environment (both of which must be determined in consultation with the workers), and they must provide education programs to improve the workers’ coping strategies for working shift work. Employees must follow the recommendations provided to them for dealing with shift work effectively, such as maintaining their physical fitness, eating correctly, improving their social support networks, and ensuring that they obtain sufficient, good quality sleep every 24 hours so that they can perform at their best when at work. Although many strategies have been suggested, very few apart from the physiological need for sleep have been appropriately evaluated. As there is still much to uncover about the relationship between shift work and poor health, research must concentrate on developing comprehensive theories for shift work and health, as this will not only lead to a better understanding of the relationship, but also help with the development of practical intervention strategies for reducing the impact of shift work on workers’ health.

Despite the limited understanding of how shift work impacts on health, there is little doubt that it does. This fact should not be forgotten. As Koller (1996) states “... though simple casual relationships cannot easily be proven, there is general agreement that shift and night workers are a population at risk ... , and that this is reason enough to plan efficient health measures for persons working shifts.” (pp. 31-32). Koller (1996) and others (e.g. Scott, 2000) therefore recommend that medical examinations and counselling be provided for workers before and during their shift work employment. Shift workers should receive regular health check ups and health advice, including screening for signs of gastrointestinal and cardiovascular disorders, and
education on how to deal with shift work (including sleeping, eating, and social strategies). This will allow shift work related health problems to be detected early and will provide information, encouragement, and motivation to adopt appropriate coping strategies. The emphasis of these checks should be on preventative measures, rather than waiting for treatment to be needed. It has been recommended that these checks continue for five years after shift work is ceased.

10.3.4 Bright light, melatonin, caffeine, and sedative-hypnotic strategies

Bright Light

Bright light is a powerful zeitgeber; its presence or absence can affect the timing of the circadian rhythm system. There are strategies recommending appropriate exposure to or avoidance of bright light for shift workers, in the form of daylight, which depend on the type of shift work roster being worked.

The recommendation for fast shift rotation workers in chapter 10.2.1 was to maintain a day time setting of the biological clock for the entire work period, including the one or two night shifts. Shift workers with a fast shift rotation should therefore maximise their exposure to the most important normally timed zeitgeber, the light/dark cycle. They should spend time outside in the daylight both before and after a night shift, particularly in the morning hours. This will help to maintain the normal day time entrainment of the circadian rhythm system.

The recommendation for slow shift rotation workers in chapter 10.2.1 was to rapidly adjust the timing of the body clock for being awake at night for the period of night shift. This is best achieved by delaying the circadian rhythm system. A phase delay of
the circadian rhythm system will result in the early morning sleep conducive period moving later in time, which will allow the shift worker to sleep better during the day time and to feel more alert on the night shift. An important strategy to help the circadian rhythm system delay is to avoid or minimise exposure to sunlight early in the morning, particularly around sunrise, as early morning sunlight is a powerful time cue that will maintain the normal day time phase of the circadian rhythm system and prevent it from delaying. Sunglasses should therefore be worn on the drive home from night shift, with darker glasses being better provided the worker is not driving. Minimising exposure to morning sunlight should be combined with sleeping in a dark bedroom during the day in order to maximise the phase delaying effects. Recommendations have been provided in chapter 10.2.3 for darkening a bedroom. The correct timing of exposure to sunlight can also be used to phase adjust the circadian rhythm system back to a day time setting after the period of night shift. To maximise a change back to a day time setting, shift workers must expose themselves to daylight, particularly morning sunlight, as much as possible.

The use of artificial bright light as a means for circadian re-entrainment and thus improving adaptation of workers to night work was discussed in chapter 9.1. As chapter 9.1.1 concluded however, there are still too many unanswered questions regarding the use of bright light therapy for circadian re-entrainment for night shift workers to recommend use of bright light therapy in shift work organizations at this time.

Despite this recommendation, bright lighting in the workplace can help to increase alertness, improve performance, and reduce tension over the night shift, even without
having any circadian phase changing effects (Costa, Gaffuri, Ghirlanda, Minors, and Waterhouse, 1995; Daurat et al., 1993; Iwata, Ichii, and Egashira, 1997). The increased alertness levels may result from the suppression of melatonin secretion (as the presence of melatonin increases sleepiness) or from activation of the Reticular Formation in the brain, which increases arousal (Penn and Bootzin, 1990). Given that bright lighting can improve alertness, it is essential that workers be provided with a well-lit work environment, particularly for night shift workers, to help increase their alertness and thus performance and safety while at work (Monk, 2000).

**Melatonin**

As discussed in chapter 9.1, melatonin is a naturally occurring hormone, which has recently become available as an exogenous chemical preparation, which has been shown to act as a chronobiotic (i.e. can alter the phase of the circadian rhythm system) and also to have a hypnotic effect. The research regarding the use of melatonin in shift work situations was also discussed, and as chapter 9.1.2 concluded, the use of melatonin preparations for shift workers is not recommended at this time.

**Caffeine and Napping**

As discussed in chapter 9.2, caffeine used correctly, such as in small doses and in combination with a nap, can be an effective strategy for shift workers to improve alertness during a night shift. It is worth noting, however, that both strategies, consuming caffeine (e.g. coffee) and napping, have advantages and disadvantages. For Bonnet and Arand (2000) naps are seen as time consuming, and they involve a period of sleep inertia after the nap, however, their benefits are long lasting. Caffeine on the other hand is quick and easy to consume, but it involves all the standard drug effects
such as dependency, tolerance, withdrawal, and even side effects. It is also relevant to note that in real work situations a caffeinated beverage can be consumed during working time whereas a nap can usually be obtained only during non-working time.

Overall, caffeine may help shift workers to maintain alertness over the night shift, although as pointed out by Walsh, Muehlbach, and Schweitzer (1995), there are few if any studies investigating the use of caffeine in real shift work situations. Bonnet and Arand (2000) point out that the effects of napping or consuming caffeine in real world settings may vary compared to the findings from laboratory studies as real workers often have a sleep debt or have a tolerance to caffeine, which are factors normally controlled in research studies. While caffeine can increase alertness, it remains active for about five hours, so it should be avoided in the last few hours of the night shift so that it will not interfere with sleep at home after the night shift. Caffeine taken early in the night shift does not appear to interfere with subsequent day time sleep following the night shift. Coffee and other sources of caffeine should therefore be consumed early in the night shift (i.e. prior to the last five hours) so that its active ingredients will be metabolised and will not interfere with sleeping the next morning. An exception to this is if a worker is feeling very fatigued yet has to drive home after the shift. Some caffeine in this instance may help the worker arrive home safely, even if it means they may not be able to sleep as soon as they arrive home (Horne and Reyner, 1999). Caffeine should not be consumed when feeling alert and at times of the day when not really needed. This is necessary to avoid building up a tolerance to its effects, thus maximising its effects when it is consumed.
The results from comparative studies of caffeine and napping reveal that an early ‘maintenance’ nap may provide similar if not greater relief from fatigue during a work period than caffeine. Napping can do this without producing any of the problems associated with stimulant drug use (i.e. adaptation, dependency, and side effects), although as discussed in chapter 10.2.2, naps during the night will be followed by a period of sleep inertia, which will temporarily impair alertness and performance. If an early ‘maintenance’ nap can be taken before the night shift or early in the night shift (i.e. in the first few hours) then caffeine may not be necessary.

Perhaps the best strategy for shift workers is to have a ‘maintenance’ nap and a small dose of caffeine if required. This strategy allows for lower doses of caffeine to be consumed while having the same overall effects on alertness. This is important given that tolerance can develop quickly to caffeine (i.e. within three days), although the effect may be small in humans (i.e. some enhancement in alertness can still occur). This may be an effective strategy for shift workers, particularly if working more than one night shift and a sleep debt has therefore accumulated. In this situation a nap on its own may not provide enough sleep to overcome the sleep debt, while caffeine on its own would be required in a large dose in order to overcome the sleepiness. Combining the two offers the advantages of both while limiting the disadvantages, particularly in reducing the amount of caffeine required. These strategies, including a combination of the two, should be considered by all night shift workers before driving home after their shift. A short nap of 30 to 40 minutes (TIB) or a coffee towards the end of a night shift when a worker is feeling fatigued yet has to drive home is an important strategy that can help night shift workers arrive home safely after their shift (Horne and Reyner, 1999).
At present the use of caffeine alone tends to be the most common fatigue countermeasure for shift workers. Education and workplace policy are required to encourage shift workers to combine lower doses of caffeine with appropriately planned naps as part of their coping strategies.

_Sedative-hypnotics_

The use of sedative-hypnotic medication by shift workers is somewhat controversial. Many shift workers use these medications, including by self-medicating, because they want a simple method to improve their day time sleep while working the night shift. While these medications can improve the duration of day time sleep, the composition of this extra sleep is mainly light sleep (stages 1 and 2). This medication-enhanced sleep has not been shown to have any significant effect on work performance on the night shift, thus the value of these medications for shift workers is in question. This is especially so given that all drugs have the potential for side effects and the potential for abuse (including dependence, tolerance, and withdrawal) (Walsh, 1990). Given these findings, the use of sedative-hypnotic drugs are probably best left to those who are experiencing the greatest difficulty with sleeping on shift work, once other factors such as environmental causes or poor sleep hygiene, have been eliminated. These drugs should only be used for short periods of time, such as the first couple of night shifts when it is generally most difficult to sleep, and usage should be carefully monitored by a health professional, as all drug taking has associated risks. The regular use of these medications by shift workers in general should be avoided.
10.4 Summary

There are many recommendations and strategies that, when followed, can improve the ability of workers to tolerate shift work, thus improving their performance and increasing their safety, both on and off the job. To use the strategies effectively requires effort and motivation from both the employer and employee. Employers need to set schedules that conform to as many of the recommendations above as practical, and they need to provide suitable working conditions for night shift workers. They also need to provide education for their employees about the many strategies that they can follow to help themselves cope with shift work. The issue of education and training for shift workers is addressed in the following chapter. Employees need to do the right thing by themselves and their employer by following the recommendations and strategies that are given to them. This means maintaining their physical fitness and eating correctly, reporting minor health complaints to medical personnel before they become serious problems, maintaining social support networks with family, friends, and colleagues, and making sure that they obtain sufficient, good quality sleep every 24 hours, including taking naps when necessary. These strategies will ensure that they will arrive at work ready to perform as efficiently and safely as possible.

Introducing the OHS framework to shift work situations would ensure that both employers and employees apply as many of the strategies, or ‘risk control measures’ as possible, as both have a duty of care to reduce the risks associated with the hazards of shift work. While the above control measures have been prioritised according to the efficacy with which they control the hazard posed by shift work, in keeping with the OHS hierarchy of hazard control measures, combining as many of the strategies as possible would be the most beneficial, and will ensure that shift work becomes safer
and more tolerable. Placing shift work within an OHS framework will ensure that shift work is viewed as an important OHS issue and is therefore managed accordingly.
11. THE ROLE OF EDUCATION IN MANAGING SHIFT WORK

Effective workplace health and safety management requires training. Education programs for shift workers and their employers are critical. Many workers underestimate the impact that shift work can have on their lives, including on their psychological and physical health, and on their family and social life. Part of the education process must include providing accurate information about these factors, including the risks associated with sleepiness/fatigue for working and driving. Many shift workers suffer more than they need to because they have not been told how to cope effectively with shift work. Most shift workers, for example, are unaware that their body contains an endogenous clock, nor do they understand even the basics of their body’s circadian physiology, and that following certain principles based on this knowledge can help their body cope more effectively with shift work. Shift workers cannot develop effective coping strategies on their own; their employer must provide them with the appropriate information. Employers must do more than just provide education to their workers however. Shift workers can suffer greatly from bad work schedules and poor working conditions, especially on the night shift. It is therefore important that employers are educated as well, and that they use this information to implement better schedules and to improve work environments. Neither employee or employer education on its own is as effective as the combination of both.

There are of course certain incentives for employers to engage in such mutual education on the fundamentals of shift work. These include the well-established fact that worker performance follows rhythms throughout the day. In particular, worker performance fluctuates in terms of overall productivity, and in the numbers of errors of
both omission and commission and thus in terms of quality of production. These fluctuations are apparent across all work shifts, however the downturns seem even more likely and acute during the circadian lulls of the mid-afternoon, and especially in the middle of the night shift. Employers and employees both need to be cognizant and attentive to these performance facts. Of equal importance, employers must be aware that various shift work schedules not only impact on worker performance, but the shift schedules themselves impact on employee morale, job satisfaction, absenteeism, worker compensation claims, and on worker retention as well.

11.1 Designing Shift Work Education

Although there are a wide range of behavioural techniques available for dealing with the work and sleep factors commonly found in shift work conditions (e.g. Penn and Bootzin, 1990; see chapter 10), these techniques have rarely if ever been evaluated for use under specific shift work conditions (Tepas, 1993). There does not appear to be any structured, organised program or manual that has been evaluated in real shift work conditions, or been shown to be effective as a program for real shift workers. Tepas (1993) therefore provides seven general principles that can be used to guide the development of shift work educational programs within a workplace. These principles should guide the selection of material and the preparation of a shift work educational program. This program must educate both the workers and management.

The seven principles for developing a shift work educational program are:

(1) Provide Relevant information, including circadian, sleep, social, health and aging aspects

(2) Provide Practical information, considering the social and domestic situations of
the workers

(3) Focus on a Limited Number of points (7 +/- 2)

(4) Remember that It Takes Time and can not be rushed

(5) There is No Substitute for better scheduling practices

(6) Education should Supplement improved work schedule practices (particularly as the validity of shift work educational programs are unknown at present)

(7) An Evaluation of the program is needed (therefore a ‘needs assessment’ must be conducted before the program commences).

(Interested readers should consult the original source for further details; Tepas, 1993).

Additional, more specific advice relating to worker education and training within an OHS framework can be obtained from both UK regulations (which deals with shift work specifically) and from the Australian NOHSC (which does not address shift work).

According to the UK Management of Health and Safety at Work Regulations 1992, employers have a duty to provide health related information to their shift workers. The information should include:

- the potential health and social effects of shift work;
- arrangements for providing health assessments;
- how to seek advice for any relevant health complaints pertinent to work;
- coping skills;
- how to protect sleep;
- lifestyle advice with regard to smoking, diet, alcohol and exercise;
- advice regarding caffeine in drinks and

Guidelines have also been given by the NOHSC (1997) to help employers develop effective OHS training programs within their workplaces, although this does not cover shift work specifically. The NOHSC specifies that:

A training plan should include:

- health and safety induction programs for new employees;
- special training needs of employees changing jobs or responsibilities or returning to work after an extended absence;
- refresher training;
- training of managers and supervisors;
- training of health and safety representatives, and committee members where applicable.

The content of training programs should cover:

- health and safety policies and procedures;
- health and safety legislation, regulations, codes of practice;
- the consultative process and issue resolution procedures;
- the process of hazard identification, risk assessment and control;
- fitting, using and maintaining personal protective equipment;
- fire prevention and emergency response procedures;
- any new working procedures;
- health and safety procedures for any new equipment.
These guidelines are to help employers address their duty of care responsibility under the OHS Act to ensure a safe and healthy workplace and system of work for their employees. The NOHSC (1997) also requires that training for workers be “appropriate” for the particular employees concerned. Employees’ prior knowledge and experience, as well as communication ability (including literacy levels and competence with the English language), must be taken into account when developing a training program. Training programs must therefore be tailored to the group of individuals concerned.

When dealing with the issue of shift work and education, an important aspect is the distinction between information and education. Information is “the communication of news, knowledge, and facts”, while education, on the other hand, is “instruction or training whereby information is developed, learned, and used” (p. 200, Tepas, 1993, emphasis added). Tepas (1993) reminds us that the volumes of research information available dealing with the many aspects of shift work, while being essential for informing researchers of the issues and areas in need of improvement, does not equate to education. This information is there to inform us that education is required! An educational program rather than simple information dissemination is required in order to change shift workers’ behaviours. In line with this distinction, Monk (2000) states that a one off training seminar, where information is given, is unlikely to lead to long-term improvements and changes by the shift worker. Education must be continuous and carefully implemented by the employer.
These principles and guidelines need to be considered when designing a shift work education package for a workplace. The specific material to be covered, and the manner in which it is to be presented, needs to be tailored to the particular group of workers concerned. As will be pointed out below, it is important that education is provided to both employees and employers. Educating the workers will have minimal impact if they are forced to work an inappropriate shift work schedule.

11.2 Evaluating Shift Work Education

While shift work education is a very important issue, there have been surprisingly few studies conducted to evaluate the impact of education for real shift workers. Very little research is available to help determine which aspect of shift work education or which of the coping strategies (apart from the sleep requirement) are the most useful for shift workers. The research that is available in this area is discussed below, and while limited, it highlights some very important considerations in this area.

Holbrook, White, and Hutt (1994) examined the outcome of an educational training session about general sleep hygiene principles on the subsequent sleep satisfaction of shift workers. Shift working law-enforcement officers (n=38) were provided with information regarding general sleep hygiene principles, such as the effects of nicotine, caffeine, and hypnotics on sleep, in a one-hour lecture format. The results revealed that while the shift workers’ knowledge and awareness of the sleep hygiene principles improved after the lecture, their sleep satisfaction at a one-month follow up had not improved. The participants remarked at the follow up that they had difficulty implementing the new sleep hygiene principles mainly because their shift work
schedules did not allow them to (e.g. unpredictable shifts made practicing sleep hygiene “impossible”), and because many felt that they had little control over their sleep. Despite having the knowledge about correct sleep hygiene practices, these participants found it difficult to put them into practice. The authors concluded that to help shift workers put the knowledge of sleep hygiene into practice, firstly, a comprehensive behavioural program should be included as part of the education process, and secondly, management must provide appropriate shift work schedules so that the shift workers have the opportunity to use the sleep hygiene principles (Holbrook et al., 1994).

In a somewhat related study, Henderson and Burt (1998) investigated whether shift workers who followed shift work preparation and coping strategies had more positive attitudes and better health (both physical and mental health) than shift workers not following the strategies. Although the participants were not provided with any information about the coping strategies in this study, and thus no education occurred, some interesting results were found. One hundred and twenty two nurses (mean age 35 years), working various rosters, participated in the study. Participants completed questionnaires asking how frequently they engaged in a number of shift work preparation and coping strategies (including sleeping, eating, and socializing strategies), and about physical health symptoms, psychological well-being, sleep problems, shift work satisfaction, and social life satisfaction.

The results indicated that the best predictor of shift work coping was the social preparation strategy scores. Those shift workers who followed more positive socializing strategies tended to rate themselves more highly on psychological well-being, shift work satisfaction, and enjoyment of social life, as well as indicating fewer
sleep problems. On inspection of the individual components of the social strategies composite score, it was determined that the most important aspect was participating in sports and hobbies or ‘other interests’, which was associated with better psychological well-being and sleep, and higher satisfaction with shift work and social life. Keeping in touch with co-workers and taking regular breaks from work (e.g. long weekends and short holidays) was associated with fewer sleep problems (Henderson and Burt, 1998). The results also showed that diet related strategies and sleep strategies on days off were only used infrequently, and were not significant predictors of shift work coping or satisfaction in this study. This may be due to a lack of knowledge about these strategies, or an unwillingness to try them. As strategies for eating and sleeping appropriately for shift work (e.g. their timing) requires more specific knowledge, it may be that these shift workers were unaware of the strategies. It may also be that as following diet and sleep related strategies requires more motivation and effort than the other strategies such as playing sports or seeing friends, these shift workers may have chosen not to use them. This research suggests that some strategies may be more acceptable to shift workers than other strategies, and this should be taken into account when designing shift work education programs.

Wedderburn and Scholarios (1993) have also found that shift workers may not always agree with or use the suggestions and recommendations which aim to improve their coping abilities. Wedderburn and Scholarios (1993) distributed questionnaires to shift workers from two factories, to determine whether or not they used certain strategies that have been recommended as ‘good shift work practice’. The recommendations were taken from the Bulletin of European Shiftwork Topic 3: “Guidelines for shiftworkers” (Wedderburn, 1991, in Wedderburn and Scholarios, 1993). One hundred
and twenty responses were collected from both males and females. The results suggested that while some of the recommendations were agreed with and used by the shift workers, such as avoiding the use of sleeping pills and using a loud alarm clock to wake from sleep on time, several of the recommendations were not normally followed. These included going against the recommendations and drinking alcohol before bed (mostly by males), and also drinking tea and coffee late in the night shift, including in the two hours before their sleep time (Wedderburn and Scholarios, 1993). Greenwood, Rich, and James (1995) also found rotating shift workers to disregard some of the sleep hygiene recommendations, such as those concerning caffeine and nicotine intake, while acting in accord with other recommendations, in this case regarding alcohol consumption and the timing of exercise. Popkin and Coplen (1995) showed that while railway workers had a positive response to shift work education, there was no change in their behaviour.

The findings from these studies suggest that both social pressures (e.g. drinking coffee with co-workers late in the shift) and the immediate rewards of behaviours (e.g. drinking alcohol before bed) may be important influences that can affect a shift worker’s willingness to follow ‘good shift work practice’ guidelines. It is therefore important that all of the shift workers in a workplace take part in the education program, and that the workers be provided with appropriate information so they understand the reasons behind certain suggestions, rather than just being given a list of rules. Knowing the rationale behind each suggestion, such as why avoiding alcohol and caffeine before bed is important, can help them understand each recommendation, and therefore increase the importance, acceptance, and motivation for the recommendations. Being informed can also help shift workers to logically defend their
choices to others if required (e.g. declining the offer of a cup of coffee at the end of a night shift). Shift workers may also need to be taught specific behavioural strategies to help them put their knowledge into practice.

Research has also suggested that education about coping with shift work should occur early, before day one on the job. Minors, Healy, and Waterhouse (1994) demonstrated negative outcomes on the health, sleep, eating habits, and social life for a group of student nurses who were experiencing their first eight weeks of night shift. Many were worried beforehand about how the night work was going to affect them, and because their experience with the shift work was only for a relatively short time, they did not have sufficient time to develop any coping strategies. Overall, the eight-week experience was a rather negative one. Rather than let employees worry about and suffer from night shift work, it is important to educate them beforehand. This would ease their transition into night shift work, limiting their negative expectations and experience of night shift. The authors suggested that such forewarning might help reduce the negative spiral that can develop when initial fears are reinforced with a negative experience, which can result in subsequent negative perceptions and outcomes with further shift work exposure (Minors et al., 1994). To try to limit this downward spiral, which can reduce physical and mental health, it is important that employees are provided with education and training about effective coping strategies before they start night work.

11.3 Summary

While educating shift work employees and employers about effective methods to increase shift workers’ job satisfaction and safety is vital, the process may not be as
straight forward as first thought. First, while there is an abundance of scientific information available, there are few, if any, evaluated education packages available for use in shift work settings. Second, many of the recommendations that need to be incorporated into such programs are not always accepted or used by shift workers. Why this is so, and how this situation can be improved needs to be addressed.

Research is desperately needed to establish and evaluate training packages that would be suitable to implement in various shift work settings. While it is doubtful that a single package would suffice for all, there should at least be a framework that companies could consult to select and refine materials from that would suit their particular needs. These packages must contain information for both the employers and the employees. Improving shift workers’ job satisfaction and safety requires effort and commitment from both the employers and employees; neither employers nor employees can succeed in improving the situation on their own. For instance, a shift worker, while having knowledge of the sleep hygiene principles, will not be able to use them if the work schedule does not allow them to. Introducing the OHS framework to the area of shift work emphasises such a mutual responsibility between employers and employees. The OHS framework requires that both employers and employees take responsibility to control or minimize workplace hazards where practicable, thus providing a safe and healthy workplace for everyone in the workplace. The provision of education and training to employees is a major requirement of the employers’ duty of care responsibility under the OHS Act. Employees also have a duty of care responsibility to follow the instructions they are given in their workplace.
Education and training about the risks associated with shift work, and the strategies that can be used to control these risks, is a major component of the OHS framework. Appropriate education and training is an essential element required to improve the safety, performance, health, and quality of life for shift workers, which would subsequently benefit the community as a whole.
12. SUMMARY AND CONCLUSIONS

Shift work is an essential feature of modern society. At present, 14% of Australian workers are shift workers. Shift work, especially at night, has been associated in the literature with four main problems: difficulty with day sleeping and therefore greater levels of fatigue and sleepiness both on and off the job; an increased risk for accidents and errors at work and after work; an increased likelihood of health and well-being problems; and increased social and domestic difficulties.

Research has also suggested that the ability of workers to tolerate shift work could be affected by factors such as shift work scheduling, individual differences in physiology and psychological make-up, the ability to obtain adequate sleep including through the efficient use of napping, and the use of specific strategies such as bright light exposure and pharmacological aids (including melatonin, stimulant drugs, and sedative-hypnotic drugs).

Many researchers and academics have suggested that knowledge of such information could be used to improve the practice of shift work, and therefore improve the safety, performance, and quality of life of shift workers. The problem is that while the research community is aware of this information, it is not easily accessible and therefore not well known within the actual shift working community. Furthermore, even if this information were known to the shift working community, there is currently no legal obligation for shift work employers to heed any of the warnings or to take any steps toward minimising the problems. For a change in shift work practices and workplaces to occur, some method is needed to deliver the information in an
appropriate format, together with some form of encouragement or motivation to use the information, to the shift working community. Such a process would be necessary to improve the practice of shift work in reality.

Perhaps the best way to achieve this is to consider shift work from an Occupational Health and Safety perspective. Occupational Health and Safety (OHS) laws exist to ensure that all workers are provided with a safe and healthy workplace and system of work, and are protected at work from hazards. Once shift work is recognised as an OHS issue, a duty of care responsibility would exist in the workplace so that the hazards associated with shift work could no longer be ignored, and the necessary changes should be implemented to improve the situation for shift workers.

The thesis makes a significant, original contribution by considering shift work as an OHS hazard. Introducing an OHS perspective has provided the framework needed to organise the research material into a format that is meaningful and useful for shift working organisations. The thesis has identified the main health and safety hazards associated with shift work, which is the first step in the OHS risk management process, as described in chapter 1.5. Research has also been provided to help explain and thus understand the nature of the hazards and why they exist. Once the hazards have been identified control measures are required that can reduce the risks associated with the hazards. The thesis makes a significant contribution in this area of risk control by identifying numerous control strategies, providing both the research to explain why the strategies are important and how they work, and providing practical advice on how to implement the control strategies for shift workers. Further to this, the shift work hazard control strategies have been prioritised, in keeping with the OHS ‘hierarchy of hazard
control measures’ framework, which is important for the implementation of ‘reasonably practicable’ improvement programs within shift working organisations.

The hierarchy of hazard control measures provided in chapter 10 makes an important contribution to the management of shift work overall in Australia as it has the potential to form the basis of a code of practice for shift work, which is currently lacking within Australia. A code of practice provides the practical information required by employers to fulfil their duty of care responsibility to provide a safe system of work and safe workplace; this practical information has been provided and prioritised in the thesis. Once a satisfactory code of practice had been implemented within Australia, legally enforceable regulations could then be established, which would specify the essential duties required by law to control the risk associated with specific shift work workplace hazards. Such regulations would likely evolve from a systematic evaluation of the code of practice, as this would help identify which control measures provide the greatest benefits, and therefore which aspects of shift work would benefit from having regulations in place to ensure that appropriate control measures were implemented in all shift work organisations. Regulations would need to be implemented, as a code of practice on its own is not a legally enforceable document, and as such does not allow for effective enforcement or prosecution in cases of non-compliance. A situation where OHS regulations existed, accompanied by a code of practice to provide the practical assistance necessary to fulfill the regulations, would provide the greatest protection for shift workers, with consequent benefits for the community as a whole.

The OHS framework also emphasises a duty of care responsibility for both employers and employees to manage workplace hazards. As the thesis has demonstrated, this is
precisely what is required for the effective management of shift work. While chapter 10 clearly differentiates between those strategies aimed primarily at the employers (the ‘extrinsic’ strategies) and those aimed at the employees (the ‘intrinsic’ strategies), it was emphasised that control strategies must be implemented by both the employers and employees if shift work is going to be managed appropriately, providing the greatest benefits for the shift workers and the community. Placing the OHS duty of care responsibility on shift work employers and employees would ensure that the appropriate changes are made by both parties to improve the safety and manageability of shift work.

The thesis has established that shift work is an important OHS hazard, and as such requires careful consideration and informed commitment to ensure that it is managed appropriately. Improving the safety and performance of shift workers requires both employers and employees to take responsibility and to follow as many of the recommendations provided as possible. This is precisely what the OHS framework encourages in the workplace. With careful planning and consideration, and the right framework, shift work does not have to be as difficult or as dangerous as it has been in the past.
13. REFERENCES


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