Children's Sleep in the Family Environment: A Pilot Study Using Actigraphy with 6 – 8-Year-Old New Zealand Children

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Public Health

at Massey University, Wellington,
New Zealand.

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2010

Abstract

Historically, children were considered to rarely experience sleep problems and daytime sleepiness in middle childhood (5 – 12-years of age), however more recent findings indicate this may have changed. Psychosocial and environmental factors, such as technology use and bedtime routines, have been associated with reduced sleep quantity and/or quality. Links have also emerged between shorter sleep duration in children, and an increased risk of obesity in childhood and adulthood. Although a number of studies have investigated children's sleep internationally, data are limited on both average sleep duration and the stability of sleep patterns of New Zealand children. This study aimed to collect normative data on the sleep of 6 – 8-year-olds, living in New Zealand, across both school and non-school nights, identify modifiable factors that impact on children's sleep within the family environment, explore the relationship between children's sleep and BMI, and pilot methods for potential future research. Actigraphy and diaries were used for seven consecutive days and nights, as well as a questionnaire incorporating the Children's Sleep Habits Questionnaire (CSHQ), with 52 families living in the Wellington region. Stable objectively measured sleep patterns were identified, consistent with findings of Nixon et al. (2008). School night sleep duration was found to be, on average, longer than non-school night sleep, and parents tended to over-estimate their children's sleep duration. Mean school night sleep duration was 9.9 hours (*SD* = 0.5) and non-school night sleep duration was 9.5 hours (*SD* = 0.7). No differences were identified between boys' and girls' sleep, and the 14% of children categorised as being overweight did not exhibit significantly different sleep patterns from the rest of the sample. Modifiable factors of technology and caffeine use were associated with differences in children's sleep, as were non-modifiable familial factors of shiftworking adults living in the home, childcare duration and finishing times, and younger children in the household. Recommendations for future research include increasing the size and diversity of the sample, extending actigraphic recording to at least 10 consecutive days and nights to incorporate two weekends, using PSG with a sub-sample of children, and implementing a longitudinal study.

Acknowledgements

I would like to thank all of the children and parents who put in so much time and effort to participate in the study, without whom this would not have got off the ground. I would also like to acknowledge the numerous (busy) school principals who willingly allowed flyers to be distributed.

I feel very privileged to have been supervised by Professor Philippa Gander and Dr Leigh Signal. Their wealth of knowledge, support, and patience has enabled this process to be a positive learning journey, and is much appreciated.

Thank you also to Dr Dawn Elder for her paediatric expertise. Her availability of clinical follow-up for families was invaluable.

The entire team at the Sleep/Wake Research Centre has provided a supportive learning environment, for which I am grateful. In particular, I would like to thank Rosie Gibson for leading the way with her infant sleep study (and sharing so much knowledge on the process); Jo Fink for proofreading, formatting, and (many hours of) listening; Bronwyn Sweeney for formatting and providing many pearls of wisdom; Ally Clark for double entering all my data; and Margo van den Berg for her valuable statistical expertise.

Thank you to Brigit Laidler and Caro Robinson for providing excellent proofreading and feedback. I would also like to acknowledge the generous support of numerous friends who provided food, coffee, and childcare when it was most needed. Also a big thank you to Pat Muller, Marie Brown, and Alistair Brown who came to the rescue with their grandparenting expertise.

This project was able to be carried out due to funding by the Massey University Research Fund. I would also like to acknowledge the financial assistance I received from the Massey Masterate Scholarship.

Last, but certainly not least, I would like to thank my wonderful family. Thank you to Emily and Alex who put up with many hours of mother-absenteeism and helped to count down the sleeps to the end of “my project”. And, of course, thank you to Colin who supported and encouraged me throughout the ups and downs of this journey, and believed I could do it without faltering.

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1. Introduction

1.1 Overview

Middle childhood (5 – 12-years of age) is a time when children's routines become predominantly based around school. Social and recreational activities often increase and children begin to gain independence from their parents in various aspects of daily activity. Sleep during this stage of life is important for both mental and physical development and well-being (Mindell & Owens, 2003).

When all is well, middle childhood is deemed to be a time of good quality sleep and for daytime sleepiness to be rare prior to significant pubertal changes of adolescence. It is estimated, however, that approximately one quarter of children in this age group will experience a problem with their sleep at some time (Owens, 2005).

A number of psychosocial and environmental factors such as school schedules, technology use and family routines can impact children's sleep (Gruber, Sadeh, & Raviv, 2000) resulting in potential decreased sleep duration and/or reduced sleep quality. Importantly, links have emerged between shorter sleep duration in childhood and an increased risk of obesity in childhood and adulthood (Marshall, Glozier, & Grunstein, 2008a).

When sleep problems occur, the impact can be far-reaching. Children's mood, behaviour and learning can suffer (Alfano, Zakem, Costa, Taylor, & Weems, 2009; Buckhalt, El-Sheikh, Keller, & Kelly, 2009; Gregory & O'Connor, 2002), and the risk of accidents (Li, Jin, Owens, & Hu, 2008) and obesity increase (Landhuis, Poulton, Welch, & Hancox, 2008). Parents may in turn experience mood and sleep difficulties, resulting in potential family discord (Bell & Belsky, 2008). Issues with learning and behaviour at school may also add strain on community resources. Sleep in middle childhood is therefore an important area of public health.

Although a number of international studies have investigated children's sleep, limited objective data exist on the sleep of New Zealand children. In order to better understand how long and how well our children are sleeping, this study has focused on the objective measurement of sleep as well as psychosocial factors within the family context that may have an impact. Methods have been piloted to identify study design requirements for future research.

Chapter One provides a broad overview of sleep. Basic sleep physiology, including sleep architecture and regulation, is outlined along with sleep changes across the lifespan. Options for measuring children's sleep are reviewed, as is current New Zealand and international literature on the sleep quantity and quality of school-aged children. A summary is provided of psychosocial and demographic factors that affect children's sleep, the prevalence and impact of common sleep problems and the relationship between children's sleep duration and obesity. In response to identified research gaps, thesis aims are outlined.

1.2 Normal Human Sleep

What is sleep and why do we do it? This has fascinated people throughout history and led to a variety of beliefs about what occurs during sleep. Broadly speaking, these theories, including ancient Chinese, Egyptian and Mesopotamian beliefs dating back to 3000BC (Williams, 2005), can be dichotomised according to whether they classify sleep as a passive or active process (Dement, 2005; Williams, 2005). Sleep science as it is known today is relatively young, with beginnings associated with the discovery of the discrete state of rapid eye movement (REM) sleep in the early 1950s by Nathaniel Kleitman and Eugene Aserinsky (Dement, 2005; Hobson, 2002; Williams, 2005). Since then technological advances and the dedicated work of many researchers have led to the growing body of knowledge we have today about the active process of sleep. A number of gaps still remain, however, including what exactly sleep is for (Williams, 2005). In order to examine children's sleep, it is beneficial to have an understanding of basic human sleep structure, or sleep architecture, and mechanisms that regulate sleep-wake cycles.

1.2.1 Sleep Architecture

Normal human sleep consists of two separate states – non-rapid eye movement (NREM) sleep and REM sleep. Across a normal period of sleep these alternate in a cyclical pattern (Carskadon & Dement, 2005; P. Gander, 2003).

NREM

During NREM (pronounced non-REM) sleep, relatively low levels of brain activity occur but physiological systems in the body continue to be actively regulated and body movements remain intact. NREM sleep is typically divided into four stages – 1, 2, 3 and 4 (see Figure 1.1). The stages are defined by distinct brain wave (electroencephalogram or EEG) patterns, eye movements (electrooculogram or EOG), and muscle tone (electromyogram or EMG). As outlined in section 1.4.1, these physiological variables can be simultaneously recorded by a technique known as polysomnography or PSG (Carskadon & Dement, 2005; P. Gander, 2003; Guilleminault & Kreutzer, 2003; Mindell & Owens, 2003; Rama, Cho, & Kushida, 2006).

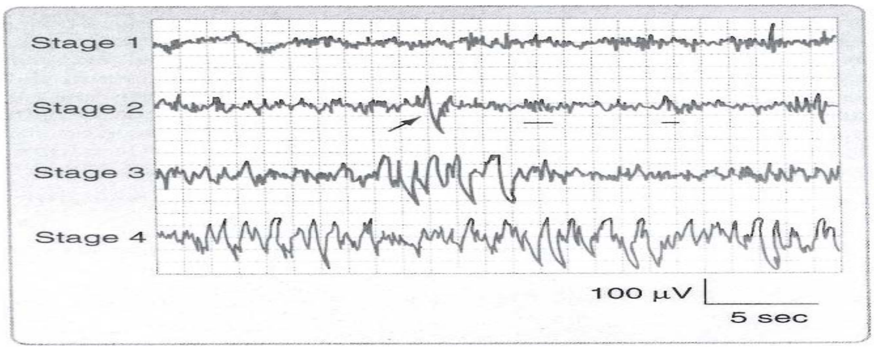

Figure 1.1. An example of NREM sleep recorded by PSG. The arrow indicates a K-complex and the underlining shows two sleep spindles. Adapted from Carskadon, M. A., & Dement, W. C. (2005). Normal Human Sleep: An Overview. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and Practice of Sleep Medicine* (4th ed.) (p. 13). Philadelphia: Elsevier Saunders.

Stage 1 sleep, as well as stage 2, is often referred to as 'light sleep'. In the normal sleep of young adults, initial stage 1 often lasts from 30 seconds to five minutes, and it is common to drift in and out of NREM stage 1 sleep a number of times before descending into stage 2. During the transition from wakefulness to stage 1 NREM sleep, EEG activity changes from low voltage mixed frequency and alpha waves (measured as 8 – 13Hz) to theta waves (3 – 7Hz). Slow rolling eye movements, recall of fragmented visual imagery (hypnogogic hallucinations) and short involuntary muscle contractions (hypnic jerks) often occur (Carskadon & Rechtschaffen, 2005; Gander, 2003; Mindell & Owens, 2003).

Stage 2 is usually deemed to be the beginning of 'true' sleep. Occasional bursts of rapid rhythmic EEG activity (sleep spindles) and high amplitude slow wave spikes (K-complexes) identify the beginning of stage 2 NREM sleep (see Figure 1.1). As this stage progresses, larger, slower waves (delta waves, < 2Hz) of EEG activity begin to occur (Carskadon & Rechtschaffen, 2005; Gander, 2003; Mindell & Owens, 2003).

Stage 3 and Stage 4 sleep is also referred to as slow-wave sleep (SWS) or 'deep' sleep. Stage 3 is entered when delta waves account for 20 - 50% of the sleep pattern, and stage 4 when they make up more than 50%. Breathing is most regular and slowest during SWS and this is the time when it is most difficult to awaken people (Gander, 2003; Mindell & Owens, 2003). Slow-wave activity reduces the longer people are asleep and increases in relation to the length and quality of prior wakefulness (Borbely & Achermann, 2005; Chokroverty, 2009; Horne, 1992). This is discussed further in section 1.2.3.

REM

REM sleep is different to NREM sleep or wakefulness, to the extent that there are three distinct states of existence (Gander, 2003). Although EEG during REM sleep looks similar to that of being awake, bursts of rapid eye movement occur and EMG activity is suppressed, as illustrated in Figure 1.2 (Carskadon & Rechtschaffen, 2005; Gander, 2003). REM sleep is sometimes referred to as 'paradoxical sleep', with the paradox being high levels of cortical brain activity (associated with dreaming) but virtual body paralysis (Carskadon & Rechtschaffen, 2005; Gander, 2003; Jouvet, 1999).

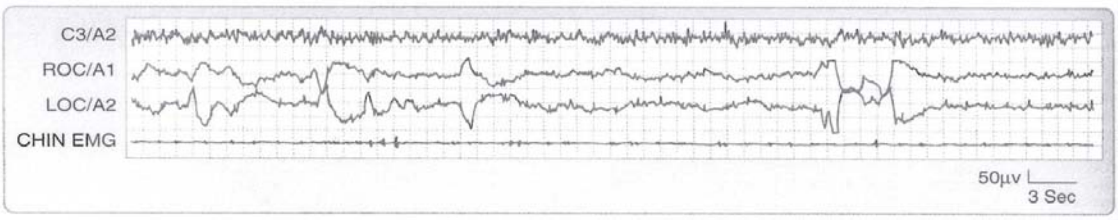

Figure 1.2. An example of REM sleep recorded by PSG. Eye movements appear as out-of-phase deflections in the left and right EOG channels. Adapted from Carskadon, M. A., & Rechtschaffen, A. (2005). Normal Human Sleep: An Overview. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and Practice of Sleep Medicine* (4th Ed.) (p. 1368). Philadelphia: Elsevier Saunders.

Sleep Cycles

Ideally, although not always, NREM and REM sleep alternate in a cyclical pattern with each cycle lasting approximately 90 – 110 minutes in normal adults and 90 minutes in school-aged children. Approximately 4 – 6 cycles occur during a regular sleep period in healthy young adults. The first two cycles are dominated by SWS, compared to REM sleep which increases from the first to last cycle (Chokroverty, 2009). Children spend a greater amount of time in SWS than adults (see Section 1.3). Figure 1.3 illustrates a typical pattern for a healthy 8 year old sleeping at night.

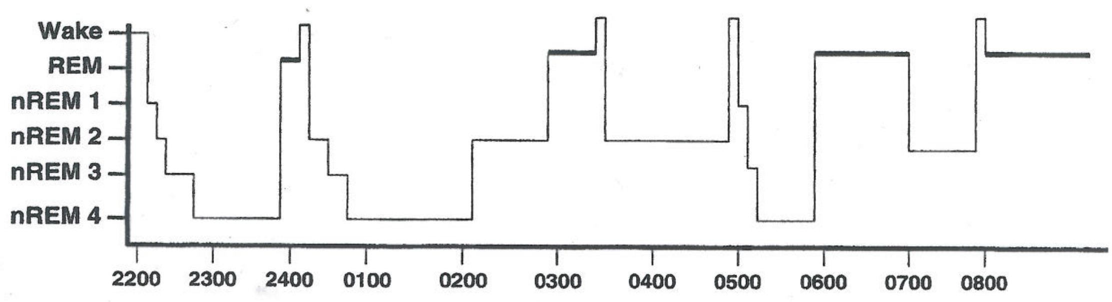

Figure 1.3. Hypnogram showing the sleep architecture of an 8 year old child. Adapted from Capp, P. K., Pearl, P. L., & Lewin, D. (2005). Pediatric Sleep Disorders. *Primary Care: Clinics in Office Practice, 32,* 549 – 562.

1.2.2 Sleep Onset and Offset

There is no exact moment when sleep commences (sleep onset). Instead, gradual behavioural and physiological transitions occur including changes in EEG, and cognitive and mental processing. Sleepiness starts before stage 1 NREM is reached and is characterised by drooping, heavy eyelids and the potential clouding of senses. Slow eye movements (SEMs) occur at sleep onset and continue in stage 1 NREM sleep (Chokroverty, 2009).

Sleep offset, or the moment of awakening, is also a gradual process. During this period sleep inertia occurs. This is sometimes described as 'sleep drunkenness' and is experienced as a graduated return to a state of wakefulness or alertness (Chokroverty, 2009).

1.2.3 Sleep/Wake Regulation

At least two processes play a part in the physiological regulation of sleep and wake timing – circadian rhythms and the sleep homeostat (Gander, 2003). A complex interaction between the two influences sleep initiation, consolidation and architecture (Beine, 2007).

Circadian Rhythms

These have been defined as "the self-sustained oscillations of living systems that display near-24-hour periodicity when the system is kept away from all external time cues" (Van Gelder, 2004, p. 166). Basically they are cycles, approximately 24 hours in length, of behaviour and physiology that are generated by endogenous biological clocks (Mistlberger & Rusak, 2005).

In humans, a central clock located in the suprachiasmatic nucleus (SCN) of the hypothalamus regulates many of the body's functions including the timing of hormone production and sleep-wake rhythms (Reid, Zee, & Buxton, 2010). The circadian system assists sleep-wake timing by sending signals that are interpreted as 'sleep gates' when high-circadian sleep pressure exists (Tzischinsky, Shlitner, & Lavie, 1993, as cited in Jenni & LeBourgeois, 2006) and 'wake maintenance zones' when circadian sleep pressure is low (Strogatz, 1986, as cited in Jenni & LeBourgeois, 2006). In the early evening, the wake-promoting signal of the circadian system is at maximum levels and in the early morning it is at its lowest (Dijk & Czeisler, 1995, as cited in Jenni & LeBourgeois, 2006).

Circadian rhythms continue (or 'free-run') with near 24-hour periods in environments without time cues, but are normally synchronised to the 24 hour day by a variety of environmental stimuli called zeitgebers. The process known as entrainment involves daily phase shifts induced by stimuli to correct the difference between the intrinsic pacemaker period and the environmental cycle period (Mistlberger & Rusak, 2005). Simply put, this enables the body to synchronise to the 24-hour environmental day even though the biological clock's cycle is typically longer.

Light is the dominant zeitgeber for humans (and most other species) but non-photic zeitgebers, such as social or work/school-imposed schedules and physical activity, also play a role in entraining rhythms (Mistlberger & Rusak, 2005). A series of studies in adults found that the combination of bright light and social cues resulted in more robust regularly timed circadian rhythms compared with bright light or social cues on their own (Wever, 1989, as cited in McGraw, Hoffmann, Harker, & Herman, 1999). Exercise has been found to elicit phase shifts in people, with exercise at night potentially delaying the SCN pacemaker and exercise in the afternoon and evening advancing it (Buxton, Lee, L'Hermite-Baleriaux, Turek, & van Cauter, 2003).

Sleep Homeostat

The sleep homeostat is the process by which a person's need for sleep (sleep propensity) increases in relation to the amount of time they have been awake (Sorenson, Carskadon, & Ursin, 2007). The nature of this drive for sleep is unknown, but the process has been conceptualised as a homeostatic pressure that increases across waking and dissipates with sleep (Fuller, Gooley, & Saper, 2006).

A measure of the sleep homeostat is the strength of slow-waves (NREM stages 3 and 4) relative to other frequencies in brain activity. The longer a person stays awake, the faster they enter SWS and the greater the duration of SWS when they next fall asleep (Gander, 2003). Another marker for sleep homeostasis is the time it takes to fall asleep (sleep latency), with faster sleep onsets associated with sleep deprivation (Jenni & LeBourgeois, 2006).

Two-Process Model

One model widely adopted as a conceptual framework of sleep regulation is the two-process model (Borbely, 2009). Jenni and LeBourgeois (2006) concluded that the two-process model of sleep regulation was useful for understanding sleep-wake behaviour and problems in children as well as adults.

The two-process model considers the alternating pattern of wakefulness and sleep to be the result of the interaction between two processes, S and C (see Figure 1.4) (Beersma & Gordijn, 2007). Process S represents the homeostatic process of sleep need which increases during waking and decreases during sleep (Beersma & Gordijn, 2007; Borbely & Achermann, 2005). In contrast, process C is entirely controlled by the circadian pacemaker and sets limits on process S, according to the time of day. As soon as S is at its lower limit during sleep, awakening occurs. When S reaches its upper limit during wake, sleep begins (Beersma & Gordijn, 2007).

A number of adaptations have been made to the two-process model. A sleep inertia process (W) was added to create the three-process model (Folkard, Akerstedt, &

MacDonald, 1999, as cited in Borbely & Achermann, 2005), and Zavada et al. (2009, as cited in Borbely, 2009) developed a process Z to account for changes in different regions of the brain in sleep homeostasis.

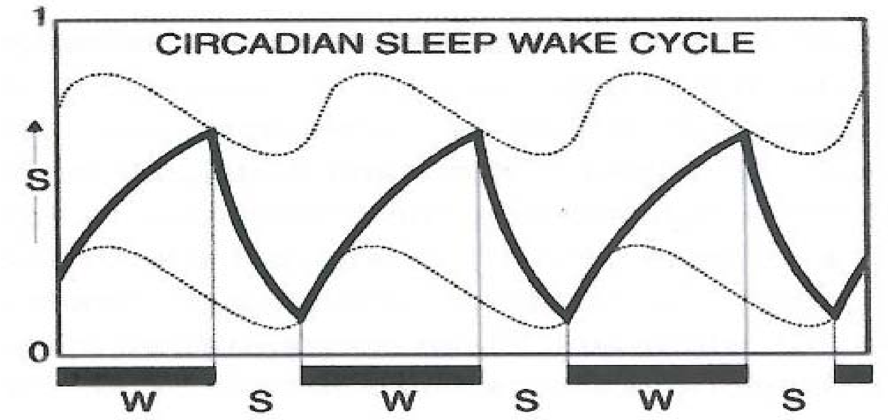

Figure 1.4. The two-process model of sleep regulation. Process S represents sleep need that increases during waking (W) and decreases during sleep. The dotted lines represent process C which is controlled by the circadian pacemaker. Adapted from Beersma, D. G. M., & Gordijn, C. M. (2007). Circadian control of the sleep-wake cycle. *Physiology & Behavior, 90,* 190-195. Doi:10.1016/j.physbeh.2006.09.010.

1.2.4 Function of Sleep

Sleep has a multiplicity of functions, which are not yet well understood. A number of theories exist regarding sleep's functionality, some of which are outlined below.

Restorative Theory

This theory proposes that NREM sleep functions in the restoration of body tissue, and REM sleep in the restoration of brain tissue (Frank, 2006; Sheldon, 2005b). Findings that support this include the increased secretion of anabolic hormones, such as growth hormone and testosterone, and decreased levels of catabolic hormones, such as cortisol, during sleep. Additionally, the feeling of being refreshed after sleep, and increased SWS after sleep deprivation, support the role of NREM sleep as being restorative (Dement, 2009). It may be, however, that sleep influences the physiological processes involved in tissue restoration as opposed to having a direct effect (Sheldon, 2005b).

REM sleep is thought to assist the restoration of central nervous system (CNS) function. It may have evolved to incorporate knowledge and learned behaviours acquired during wakefulness and to reprogramme innate behaviours (Jouvet, 1975, as cited in Sheldon, 2005b). During REM sleep, the synthesis of CNS proteins is increased (Giuditta et al., 1984, as cited in Sheldon, 2005b) and significantly higher proportions of this sleep state are found in foetuses and newborns, gradually decreasing across the early years of life (Sheldon, 2005b).

Energy Conservation Theory

Animals with a higher metabolic rate have a longer total sleep time, suggesting that energy is conserved during sleep (Zepelin & Rechtschaffen, 1974, as cited in Chokroverty, 2009). The energy conservation theory observes that during sleep, energy reduction is greater than during quiet wakefulness and that sleep provides enforced rest periods (Sheldon, 2005b). However, in humans the reduction in metabolism that occurs during sleep is only slight (approximately 8 – 10%) compared with relaxed wakefulness (Chokroverty, 2009; Sheldon, 2005b). This equates to around only 120 calories being conserved during 8 hours of sleep compared to the expectation that significantly more calories would be conserved if energy conservation was sleep’s main function (Chokroverty, 2009).

Learning Theory

This theory views sleep as playing a crucial role in the process of memory and learning (Frank, 2006; Sheldon, 2005b). A meta-analysis of animal studies conducted by Smith (1996, as cited in Stickgold, Hobson, Fosse, & Fosse, 2001) concluded that REM sleep is critical in the consolidation of procedural learning but not in declarative memory. Declarative memory relates to the learning of facts and events whereas procedural memory corresponds to learning how to do something, such as riding a bike (Wagner, 2007).

Smith (1996, as cited in Stickgold, et al., 2001) proposed that after procedural training, which was done with rats, ‘REM windows’ occur when increased amounts of REM assist memory retention. Supporting this, studies with humans have shown that

REM deprivation after training impairs procedural learning (Smith, 1987, & Smith, 1996, as cited in Stickgold, et al., 2001).

A number of studies have shown declarative memory tasks not to be dependent on sleep (Castaldo, Krynicki, & Goldstein, 1974, as cited in Stickgold, et al., 2001). Others suggest SWS early in the night may assist declarative memory consolidation (Plihal & Born, 1997, as cited in Stickgold, et al., 2001) which is particularly relevant for children who have high amounts of SWS compared with adults. Backhaus et al. (2008) found that in a group of 9 – 12-year-olds (*N* = 27) declarative memory retention was significantly increased only after a sleep interval, either immediately after learning or after daytime wakefulness. They therefore concluded that in children sleep does play an active role in declarative memory consolidation. It has also been proposed that the length of the NREM-REM sleep cycle may play an important part in declarative memory (Sheldon, 2005b). Overall, disturbed sleep is not conducive to learning or concentration, but the proof that sleep is essential for memory consolidation is still to be found (Siegel, 2005).

Unlearning Theory

The juxtaposing theory to learning and memory consolidation is that of unlearning. This is based on the premise that the brain needs to eliminate unnecessary or undesirable information in order to prevent being overloaded (Plaford, 2009). Sleep, particularly REM sleep, may reduce or prevent unwanted information acquired during waking to remain. This enables the reprogramming and consolidation of more important material by using a 'reverse learning' mechanism (Crick & Mitchison, 1983, as cited in Sheldon, 2005b).

Emotional Regulation

REM sleep may play a role in emotional processing and the regulation of mood and emotion (Cai, 1991). Perlis and Nielsen (1993, as cited in Harvey, Mullin, & Hinshaw, 2006) summarised three findings that support this theory. Abnormal REM sleep can be seen in a variety of people diagnosed with psychiatric disorders such as schizophrenia and major depression. Secondly, mood and stress prior to sleep seem to influence dream content, emotion within dreams, latency to REM, and REM density (De Koninck & Brunette, 1991, as cited in Harvey, et al., 2006). Thirdly, daytime mood has been shown to be influenced by REM sleep and dreaming. Evidence of this has been derived from studies involving REM deprivation which have produced irritability, anxiety, and reduced adaptability the following day (Perlis & Nielsen, 1993, as cited in Harvey, et al., 2006).

Neuroscience literature has also shown the presence of amygdala activity during REM sleep (Maquet et al., 1996, as cited in Harvey, et al., 2006). These structures have been associated with the acquisition of emotional memories, which enhances the possibility that REM sleep's role is that of emotional regulation (Harvey, et al., 2006).

NREM sleep may also play a part in the regulation of emotions. One of the strongest adverse effects of sleep deprivation has been found to be increased negative mood (Dinges et al., 1997, as cited in Harvey, et al., 2006). Emotional behaviours such as concentration and psychotic tendency can be disrupted by sleep deprivation (Wilkinson, 1965, as cited in Cai, 1991). Shorter NREM sleep durations have been found in people diagnosed with depression and schizophrenia (Spiegel, 1986, as cited in Cai, 1991) and conversely, Wehr et al., (1979, as cited in Cai, 1991) found that increased NREM sleep in people diagnosed with depression resulted in improved mood.

Function of Dreaming

Besides theories relating to REM function such as the facilitation of memory storage, learning, and unlearning, it has been proposed that a major function of REM sleep, and dreaming associated with it, is the development and maintenance of personal identity. In dreams people appear to be present in the first person and there is always (except in people who are congenitally blind) a succession of events occurring in a typographical setting. This, combined with the fact that dreams are often difficult to remember, led to the conclusion that *being* in the dream world, as opposed to remembering what happened while there was most important (Staunton, 2001).

Foulkes (1982, as cited in Staunton, 2001) found that dream content becomes more complex as children increase in age. Staunton (2001) suggests that this is related to the level of development children have achieved during waking, when attempting to understand their environment and to separate themselves from it. For infants, creating a dream environment that they are in, at regular intervals throughout sleep, may enable them to remember who they are and develop a sense of personal identity. Additionally, as most dreams are forgotten, they are not burdened by having to store a large amount of information about actual dream experiences (Staunton, 2001). Notably, this is only one of a number of theories relating to dream function, and therefore requires further investigation.

As described, beneficial links have been identified between sleep and brain functioning, body maintenance, mood and emotional regulation, and the development of self-identity. It is therefore reasonable to assume that getting enough good quality sleep is important for children, particularly as they are in a stage of life involving a great deal of knowledge and skill acquisition as well as physical and emotional growth and development.

1.3 Sleep Across the Lifespan

Sleep changes as we age, which is a normal part of the human life cycle. Differences in sleep architecture of childhood, early adulthood and old-age are represented in Figure 1.5.

Newborn babies sleep a total of approximately 16 – 18 hours per day, which is made up of multiple bouts of sleep across day and night (Colten & Altevogt, 2006; Gander, 2003). Unlike any other stage of life, newborns have three types of sleep – active sleep (similar to REM), quiet sleep (similar to NREM), and indeterminate sleep (Davis et al., 2004, as cited in Colten & Altevogt, 2006). Sleep is entered through the active state, which accounts for approximately 50% of sleep (Mindell & Owens, 2003).

From 2 – 12 months of age sleep duration gradually decreases, with 6-month-olds sleeping approximately 14 – 15 hours in total including two naps accounting for 2 – 4 hours of sleep (Lee-Chiong, 2008). Sleep cycles are approximately 50 – 60 minutes long (Gander, 2003; Mindell & Owens, 2003), quiet sleep becomes the dominant sleep stage by 3-months of age (Lee-Chiong, 2008) and REM sleep accounts for approximately 30% of sleep in 1-year-olds (Sorenson, et al., 2007). Toddlers (aged 1 – 3 years) sleep a total of approximately 12 hours per day and naps usually decrease to once a day, resulting in a biphasic sleep pattern at around 18 months to 2-years-old (Lee-Chiong, 2008).

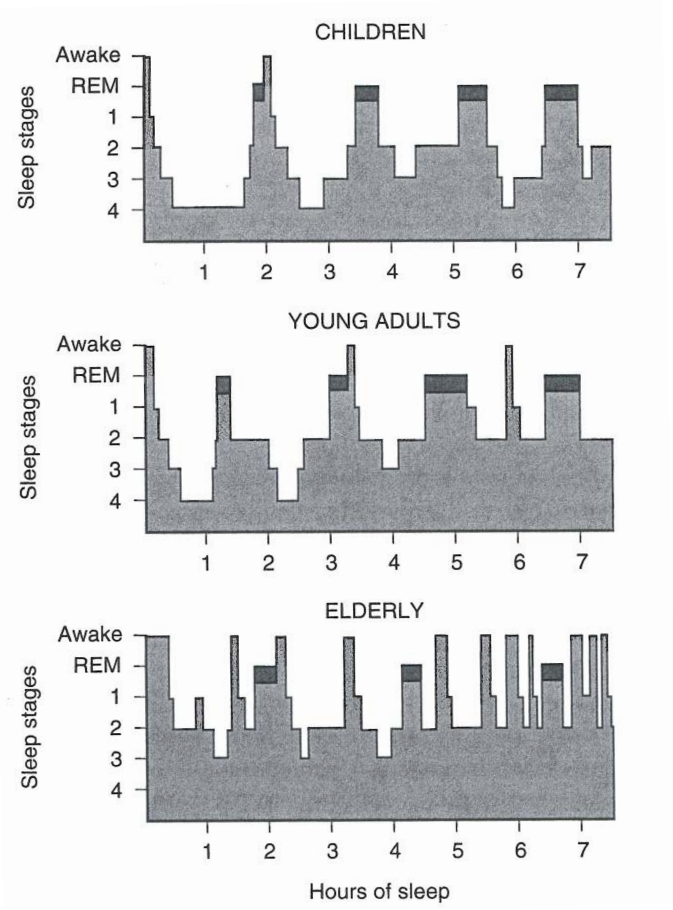

Figure 1.5. Night sleep hypnograms from a child, young adult and older adult. Adapted from Kales, A., & Kales, J. D. (1974) (p.489) as cited in Chokroverty, S. (2009). An Overview of Normal Sleep. In Chokroverty, S. (Ed.), *Sleep Disorders Medicine* (3rd Ed.) (p. 15). Philadelphia: Elsevier Saunders.

By the time children start school at age 5-years-old, the majority have stopped napping (monophasic sleep pattern) and have approximately 10 – 11 hours sleep per night (Beine, 2007; Weissbluth, 1995). There is some variability in napping patterns, however. The National Sleep Foundation's (2004) *Sleep in America* poll indicated that 2% of 6-year-olds napped daily, compared with Kieckhefer, Ward, Tsai, and Lentz (2008) who found that 32% of 9 – 11-year-olds (N = 54) napped. Cultural variation also occurs in napping, with afternoon naps and later nocturnal sleep times being common in circum-Mediterranean communities. Worthman and Brown (Worthman & Brown, 2007) reported that Egyptian children aged 2 – 10 years regularly napped, with a mean diurnal sleep onset of 15:11 (SD = 1.3 hours), mean nocturnal sleep onset of 23:20 (SD = 1.4 hours), and mean total sleep per day of 11.0 hours (SD = 3.6).

At 5-years of age sleep cycles have normally increased to approximately 90 minutes long (Sheldon, 2005d). REM sleep has usually decreased to approximately 20 – 25% of total sleep time which, as illustrated in Figure 1.6, is the same as adults (Kahn, Dan, Groswasser, Franco, & Sottiaux, 1996; Wolfson, 1996). Unlike adults, however, the percentage of time spent in SWS is greatest in children before they reach puberty (Gander, 2003). Boys have been found to have a greater proportion of SWS than girls (Carskadon et al., 1987, as cited in Kahn, et al., 1996).

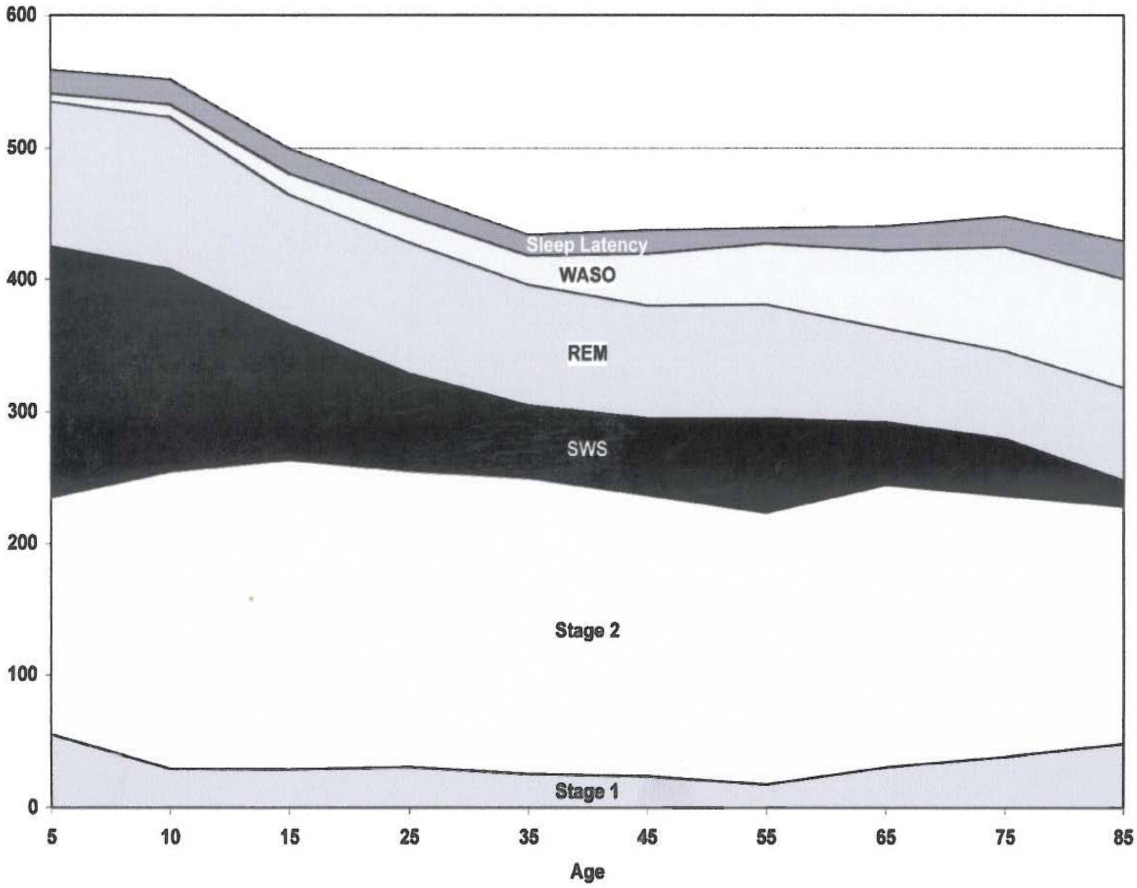

Figure 1.6. Trends across age for stage 1 and 2 sleep, SWS, REM sleep, wake after sleep onset (WASO) and sleep latency (in minutes). Adapted from Ohayon, M. M., Carskadon, M. A., Guilleminault, C., & Vitiello, M. V. (2004). Meta-Analysis of Quantitative Sleep Parameters from Childhood to Old Age in Healthy Individuals: Developing Normative Sleep Values Across the Human Lifespan. *Sleep, 27*(7), 1255-1273.

Growth hormone (GH) secretion is clearly linked with sleep onset in this age group and peaks early in the first third of the night during SWS (Lee, Song, Kim, Park, & Moon, 2004; Sheldon, 2005c). Spontaneous movements during sleep may also become shorter in duration but increase in frequency as the CNS continues to mature (Hayes & Mitchell, 1998). A low rate of polysomnographically measured arousals have been found at this age, with mean (*SD*) arousals per hour of total sleep equalling 9.3 (3.9) in 5 – 7 year olds (*N* = 15) and 9.1 (3.6) in 10 – 11 year olds (*N* = 14) (Stores & Crawford, 2000).

Previous studies have shown pre-pubescent school-aged children to be very alert and active during the day (Carskadon, et al., 1980). However, the impact on sleep time of social and environmental factors such as school schedules, family routines and television viewing, may mean that this has changed in more recent times (Dollman, Ridley, Olds, & Lowe, 2007; Gulliford, Price, Rona, & Chinn, 1990; Ohayon, Carskadon, Guilleminault, & Vitiello, 2004; Szymczak, Jasinska, Pawlak, & Zwierzykowska, 1993; Wolfson, 1996). Middle childhood is also a time when circadian sleep-wake rhythm preferences can begin to develop resulting in children becoming either more morning or evening types, although usually to a lesser degree than teenagers and adults (Achari & Pati, 2007; Lee-Chiong, 2008; Russo, Bruni, Lucidi, Ferri, & Violani, 2007; Werner, LeBourgeois, Geiger, & Jenni, 2009). This may add to the difficulty of getting enough sleep when combined with the environmental factors outlined.

Puberty brings more changes in sleep, although sleep latency and sleep efficiency remain similar to that of children aged from five years (Ohayon, et al., 2004). Across the teenage years, SWS decreases by nearly 40% (Carskadon, et al., 1980; Gander, 2003), and the percentage of REM sleep modestly, but significantly, increases from childhood to the end of adolescence (Ohayon, et al., 2004).

Circadian sleep-wake rhythms can become significantly phase delayed, resulting in later sleep start times at night and difficulty with waking in the morning when having to get up for school (Borlase, 2001; Carskadon, Vieira, & Acebo, 1993; Gander, 2003). Ohayon et al. (2004) found that total sleep time requirements did not change significantly from the age of five to the end of adolescence and that environmental factors such as school schedules had a greater impact on actual sleep time than biological factors. This has been found to commonly result in teenagers having cumulative sleep debt with negative impacts on daytime functioning (Dorofaeff & Denny, 2006; Meltzer & Mindell, 2006).

Once adulthood is reached, sleep duration tends to be approximately 7.5 – 8 hours per night (Chokroverty, 2009). Sleep architecture continues to change as adults age, resulting in earlier wake times and reduced sleep consolidation in older adults (Dijk, Duffy, & Czeisler, 2000). Sleep latency, and percentages of stage 1 and stage 2 NREM sleep increase with age and the percentage of REM sleep and SWS decreases (Ohayon, et al., 2004). In older adults sleep patterns may also become biphasic (Chokroverty, 2009), with afternoon naps making up for sleep disruptions at night (Gander, 2003).

Sleep in middle childhood is therefore one of many stages in a continuum of normal sleep changes across the lifespan. Positively, it has been identified as an ideal time for developing healthy sleep habits that may benefit children through to their later years in life, as children are considered to be particularly receptive to learning about sleep at this age (Mindell & Owens, 2003).

1.4 Measuring Children's Sleep

There are a number of ways to measure the sleep of children, both objectively and subjectively, and accurate assessment is often difficult (Quan, et al., 2003). In order to account for the complexities of sleep, which involves both biological and psychosocial/environmental factors, it is advantageous to use a multi-method approach (Harvey, et al., 2006).

1.4.1 Objective Measures

Two commonly used objective measures of children's (and adults') sleep are polysomnography and actigraphy. They have a number of advantages associated with the objective nature of data collection and analysis. Significant discrepancies can still occur, however, due to a variety of methods and devices used (Ohayon, et al., 2004).

Polysomnography

Polysomnography (PSG) is the gold standard measure of sleep. It was first described in 1937 as the monitoring of brain wave signals (Loomis, Harvey, & Hobart, 1937, as cited in Collop, 2006). Originally, signals were recorded on paper with pen and ink and reviewed page by page. Since then, a number of physiological variables have been added and PSG has become digitised (Collop, 2006; Gander, 2003).

PSG involves the placement of electrodes on the surface of the scalp and face to measure EEG, EOG and EMG (Harvey, et al., 2006). Depending on the aims of the research, additional variables can be measured including chest and abdominal wall movement, electrocardiogram (ECG), air flow, arterial oxygen saturation via pulse oximetry, and end-tidal CO_2 levels (Golan, Shahar, Ravid, & Pillar, 2004).

The standard *International 10-20 System* (see Figure 1.7) is predominantly used for electrode placement. This enables symmetrical and reproducible placement, resulting in comparable data from the same or different participants, and recordings from the same or different laboratories (Sheldon, 2005d).

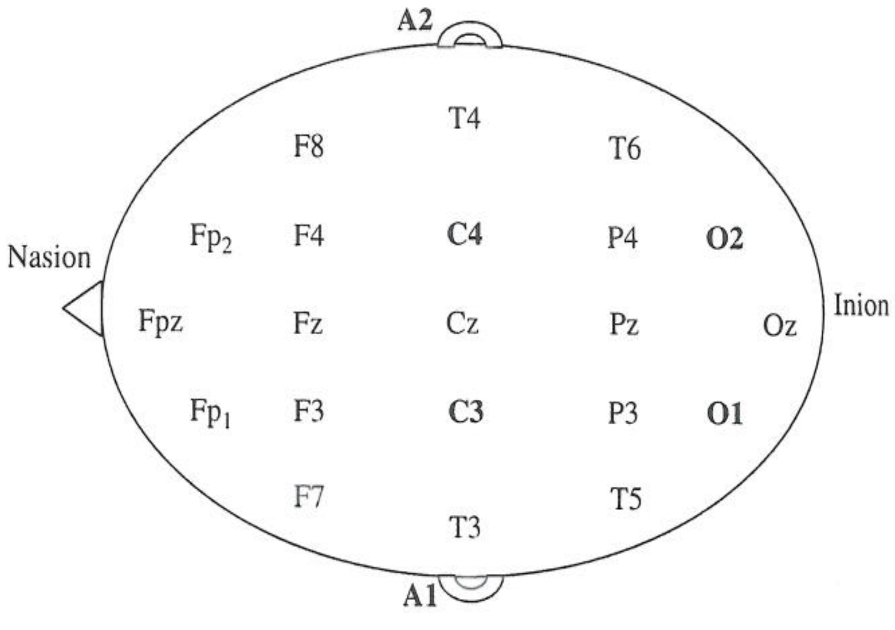

Figure 1.7. The International 10-20 system for electrode placement in PSG. EEG leads are placed 10-20% apart accordingly, using the four major landmarks. Adapted from Collop, N. A. (2006). Polysomnography. In Lee-Chiong, T. L. (Ed.), *Sleep: A Comprehensive Handbook* (p. 974). New Jersey: John Wiley & Sons.

Sleep is normally scored in 30 second epochs using standard guidelines of Rechtschaffen and Kales (1968, as cited in Carskadon & Rechtschaffen, 2005), or more recently altered guidelines published by the AASM (American Academy of Sleep Medicine, 2007), which is a time-consuming process. The scoring of standard sleep stages is usually possible for children from 6 – 12 months of age, and once middle childhood is reached all stages of sleep are usually easily identifiable (Griebel & Moyer, 2006; Sheldon, 2005d). For younger infants a breakdown of active versus quiet sleep is conducted (Griebel & Moyer, 2006).

Using PSG with children requires careful consideration of factors such as pre-study preparation, patient safety, and the sleep laboratory environment. Children and parents may feel anxious about the general process, and that the electrode placement and equipment may interfere with the child's sleep (Sheldon, 2005d; Sitnick, Goodlin-Jones, & Anders, 2008). They may also have concerns about safety due to electrical equipment being used, and children may feel uncomfortable sleeping in a laboratory setting. This can result in a 'first night effect', where the first night's recording does not represent typical sleep due to adjustment to the sleep laboratory environment (Montgomery-Downs, O'Brien, Gulliver, & Gozal, 2006). A minimum of two nights in the laboratory is therefore the usual standard.

An alternative can be home-based PSG using ambulatory monitoring systems, depending on equipment and staff availability. Better sleep quantity and quality in children have been found when using this method, resulting in the measurement of only one night due to the lack of 'first night effects' (Stores, Crawford, Selman, & Wiggs, 1998).

Although PSG is considered the gold standard measure of sleep, there are a number of associated disadvantages. These include the financial expense, potential discomfort, and the relatively intrusive and labour-intensive nature of the process (Griebel & Moyer, 2006; Harvey, et al., 2006). These need to be weighed up particularly when working with children, who are deemed a vulnerable population.

Actigraphy

An alternative means of measuring sleep objectively is actigraphy. It involves the use of a portable wristwatch-like measuring device that records body movement in order to differentiate between periods of wakefulness and sleep, and has been extensively used in the study of circadian rhythms and sleep (Harvey, et al., 2006; Morgenthaler, et al., 2007; Sadeh & Acebo, 2002).

A miniaturised acceleration sensor samples physical motion. This is translated by a processor into numerical digital data, with frequency of motion summarised into epochs of specified time duration which are then stored in the actigraph's memory (Harvey, et al., 2006; Sadeh, Hauri, Kripke, & Lavie, 1995). Data are downloaded to a computer and analysed to generate sleep variables including sleep onset latency, sleep duration, and sleep efficiency (Harvey, et al., 2006; Owens, et al., 2009).

Actigraphy has the advantages of being less expensive, minimally intrusive, and able to monitor sleep over longer periods of time (such as across school and non-school nights) compared to PSG (Harvey, et al., 2006; Sadeh, 2008; Sadeh, et al., 1995). It also enables sleep to be measured more easily in the naturalistic home environment (Aronen, Paavonen, Fjallberg, Soininen, & Torronen, 2000; Owens, et al., 2009; Sadeh, 2008), which can result in more typical sleep patterns compared to those seen in the laboratory (Ancoli-Israel, et al., 2003). It has been identified as being particularly useful for measuring the sleep of people who are less tolerant of PSG, such as children (Ancoli-Israel, et al., 2003; Morgenthaler, et al., 2007).

Actigraphy can provide reassurance to parents who may be concerned about the quantity or quality of their children's sleep, as significant discrepancies may exist between parental perception and the reality of their children's sleep (Applebee, Bingham, & Attarian, 2009). This may, in part, be due to parents being less aware of when their children wake during the night as children become more independent during middle childhood and therefore require less support to resettle (Sadeh, 2008).

The main disadvantage of using actigraphy is that it does not measure actual sleep, but rather infers sleep from activity (Morgenthaler, et al., 2007; Paavonen, Fjallberg, Steenari, & Aronen, 2002). Although it can provide useful information on behavioural aspects of sleep, it is unable to provide details of the internal structure of sleep (Harvey, et al., 2006; Sadeh, Raviv, & Gruber, 2000). Also, because it estimates sleep based only on movement, it is a relatively blunt measure particularly when identifying the precise time of sleep onset (Ancoli-Israel, et al., 2003; Harvey, et al., 2006; Tryon, 2004). Further difficulties may be experienced when using actigraphy with people who lie still for long periods, such as those with insomnia, as this may be incorrectly scored as sleep as opposed to still wakefulness (Kushida, et al., 2001; Sadeh & Acebo, 2002).

Overall, actigraphy has been found to be a reliable objective measure of sleep which has a number of advantages when working with children, including being minimally intrusive and enabling sleep to take place in the natural home environment over long periods of time. It is not as accurate or as informative as PSG, particularly in relation to sleep architecture and night waking. It is more reliable, however, than simply using sleep logs or observation and can provide useful objective information on a number of sleep-wake parameters (Ancoli-Israel, et al., 2003).

1.4.2 Subjective Measures

Subjective measures of sleep such as sleep diaries, questionnaires, and interviews can provide valuable information not only on when people are sleeping but how they believe or feel they have slept, which can affect functioning during the day (Semler & Harvey, 2005). They are commonly used in studies of children's sleep and are either completed by parents or children themselves, depending on age. Children often do not complain about problems they are experiencing with their sleep, therefore asking children and parents to report on their sleep may assist with the identification of issues that may have otherwise gone unnoticed (Goodlin-Jones, Waters, & Anders, 2009; Owens & Mindell, 2005).

Sleep Diaries

Sleep diaries prospectively measure sleep patterns and sleep quality over a number of days. They are low in cost, easy to administer, and able to capture weekday and weekend data (Meltzer, Mindell, & Levandoski, 2007), which is particularly useful when exploring whether children's sleep may be affected by school schedules (Ohayon, et al., 2004). They are widely used in clinical and research settings and have been found to have high internal consistency and reasonable face validity (Corkum, Tannock, Moldofsky, Hogg-Johnson, & Humphries, 2001). The need has been identified, however, for a standardised, validated sleep diary format which currently does not exist (Smith, et al., as cited in Meltzer, et al., 2007).

Using diaries, parents can often accurately report specific, observable problems such as bedtime resistance and night terrors; however, as already discussed, other issues such as night waking may not be noticed due to children's independence in resettling

(Acebo, et al., 2005; Aronen, et al., 2000). Limited awareness of sleep onset delays has also been found (Owens, Spirito, McGuinn, & Nobile, 2000).

In busy family lives, diaries may not be completed immediately resulting in less accurate retrospective completion (Meltzer, et al., 2007; Sadeh, et al., 2000). Parents may also exhibit poor adherence with multi-day sleep diaries or forget to return them (Smith, et al., as cited in Meltzer, et al., 2007). Including strategies in study protocols such as follow-up phone calls to parents during the data collection period may enhance the accuracy of diary data (Acebo, et al., 2005). Combining sleep diaries with objective measures, such as actigraphy, can provide a more accurate picture of children's sleep.

Questionnaires

Questionnaires are cost effective and easy to use in large scale surveys to evaluate the impact of social and other factors on sleep quantity and quality (Johns, 1971, as cited in Gulliford, et al., 1990). However, because they provide retrospective estimates of sleep, respondents (often parents in the case of studies of children) are required to average sleep values over several days or weeks which may be difficult. The retrospective nature of reporting may result in reasoning biases such as answering on the basis of saliency (the worst night) or recency (the last night) (Harvey, et al., 2006). Parents have also been found to overestimate their children's sleep duration, often basing times on going to bed and rising rather than going to sleep and waking (Goodwin, et al., 2007; Gruber, Sadeh, & Raviv, 1997; Gulliford, et al., 1990; Werner, et al., 2009). Children often fall asleep in their own room independently in middle childhood, therefore parents may be unaware of actual sleep start times (Nixon, et al., 2009).

In adults, a number of questionnaires and clinical sleep scales have been validated to measure the presence of insomnia (e.g. Insomnia Severity Index) (Bastien, Vallieres, & Morin, 2001), sleep disturbance (e.g. Pittsburgh Sleep Quality Index) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989, as cited in Barclay & Gregory, 2010), and daytime sleepiness (e.g. Stanford Sleepiness Scale) (Hoddes, Dement, & Zarcone, 1972, as cited in Short, Lack, & Wright, 2010). However, these measures have not been validated on, or specifically designed for, children (Harvey, et al., 2006; Kothare & Kaleyias, 2008).

A more recently developed sleep scale tool is the Pediatric Daytime Sleepiness Scale which is a validated measure (internal consistency Chronbach's $\alpha = 0.80$) for assessing excessive sleepiness in school children (Drake, et al., 2003). Additionally, two validated and widely used questionnaires in children are the Pediatric Sleep Questionnaire (PSQ) (Chervin, Hedger, Dillon, & Pituch, 2000) and Children's Sleep Habits Questionnaire (CSHQ) (Owens, Spirito, & McGuinn, 2000). The PSQ was developed to assist with the assessment of sleep-related breathing disorders (Chervin, et al., 2000), while the CSHQ was developed to survey both behavioural and medical sleep problems in children aged 4 – 10-years-old, primarily in community populations (Owens, Spirito, & McGuinn, 2000).

1.5 Normal Sleep in Middle Childhood

Understandably, it is common for parents to want to know how much sleep their children should be getting and what is considered to be 'normal'. The National Sleep Foundation in America (http://www.sleepfoundation.org) recommends that children aged 5 – 12-years have 10 – 11 hours sleep. Similar estimates are included on New Zealand websites including http://www.kiwifamilies.co.nz (which uses National Sleep Foundation information) and http://liveto100.everybody.co.nz (9 – 11 hours for 5 – 12-year-olds).

While guidelines can be helpful for families, it is important to realise that individual children may have differing sleep needs. Large interindividual variability has been found in children's sleep duration, with trait-like stability over time from the ages of 1 – 10 years (Jenni, Molinari, Caflisch, & Largo, 2007). Jenni and colleagues (2007) concluded that there could not be one specific optimal amount of sleep recommended for the entire child population (for example, all children should sleep for 12 hours) due to these individual differences. The recognition that some children sleep less than others is important in order for health professionals and parents to develop realistic expectations regarding bedtimes and sleep length. As a general guide, if children wake by themselves in the morning, engage in age-appropriate behaviour during the day, and do not show signs of daytime sleepiness, then it is likely they are getting enough sleep (Jenni, et al., 2007; Mindell & Owens, 2003).

Summary data from a sample of academic literature on the normal sleep of healthy school-aged children, categorised by polysomnographic, actigraphic and subjective measures, are provided in Tables A1, A2, and A3 (see Appendices Section A). Variability between findings from the three groupings can be seen, with longer sleep durations reported in the subjective (predominantly parentally-reported) data versus polysomnographic and actigraphic findings. Notably, equipment and protocols varied not only between the types of measures used but also within the three clusters. For example, PSG was carried out in both laboratory and home settings (Table A1). Although direct comparison of results in these studies is impossible due to variability in age groups, sample sizes, and conditions, it appears that in general home-based PSG resulted in longer sleep than laboratory-based PSG (see Section 1.4.1). Similarly, Table A2 shows a range of actigraphic placement, analysis sensitivity settings/algorithms and measurement periods which may have impacted on values deemed to be normal.

Importantly, the amount of sleep children had was defined in numerous ways across the studies including polysomnographically scored sleep time (Table A1), actigraphically scored sleep time (not including wake periods during the sleep interval), actigraphically scored sleep duration (the time period from sleep starting to sleep finishing including periods of wake) (Table A2), parentally reported bedtime to wake time, and parentally reported sleep onset time (as opposed to bedtime) to wake time (Table A3). This highlights some of the difficulties with being able to identify, interpret and compare normative data. However, bearing these limitations in mind, the reviewed data do provide a useful range of 'normal' sleep values. These can be used to assist parents, health professionals, teachers, and ultimately children, to identify sleep requirements, provided individual needs are taken into account.

In line with recommendations for school-aged children's sleep, the literature reviewed in Tables A1, A2 and A3 indicates that children spent approximately 9 – 12 hours in bed and 7 – 10 hours sleeping. Sleep efficiency ranged from around 84 – 98% and children took approximately 12 – 33 minutes to get to sleep (sleep onset latency).

New Zealand data are limited. However, using actigraphy with 519 children from the Auckland Birthweight Collaborative (ABC) Study, Nixon et al. (2008; 2009) found that 7-year-olds were sleeping an average of 10.1 hours, with median sleep latencies of 26 minutes (Table A2). Subjective reports indicated that 5 – 11-year-olds in New Zealand spent approximately 10 – 11.9 hours in bed (Duncan, Schofield, Duncan, & Rush, 2008; Landhuis, et al., 2008) (Table A3), which is similar to overseas findings.

Limitations of New Zealand data include the small number of studies carried out to date on school-aged children's sleep, with only one using objective measures. Objective data gathered by Nixon et al. (2008; 2009) were obtained using 24 hours of actigraphic recording, as opposed to the recommended minimum of five nights (Acebo, et al., 1999). These data were also from a homogeneous sample of children of European mothers. Additionally, subjective measurement of sleep in the longitudinal Dunedin Multidisciplinary Health and Development Study was based on parental reports of children's sleep the previous night (at ages 5, 7, and 9) (Landhuis, et al., 2008). This may not have represented typical sleep patterns and did not capture school nights versus weekend differences.

1.5.1 Psychosocial and Demographic Factors

A number of psychosocial and demographic factors can influence children's sleep quantity and/or quality including school schedules, screen time, family routines, caffeine consumption, daily activity, gender, culture, ethnicity, and socioeconomic status (SES). An understanding of modifiable sleep determinants can assist children and families to make positive lifestyle changes to enhance sleep and well-being. An awareness of factors that cannot be modified may guide targeted support services such as health and education.

School Schedules

Routines based around school and subsequent changes in sleep duration between weeknights and weekends are common in school-aged children, with some variation in timing across middle childhood (Epstein, Chillag, & Lavie, 1998). The 2004 *Sleep in America* poll (National Sleep Foundation, 2004) showed that 17% of school-aged children (N = 637) slept more on weekends and 27% slept less on weekends compared to school nights. In a study of 5 – 11-year-olds (N = 5,145) boys slept longer on school nights versus weekends until the age of 10, when they started to sleep longer on weekends. A similar pattern was found for girls except weekend sleep became longer at the age of 8-years (Gulliford, et al., 1990), which may be related to the maturation process and associated changes in circadian rhythms.

Touchette and colleagues (2008) found that 4 – 6-year-olds slept less during the weekend compared with week nights, and associated this with later bedtimes on weekends but similar rise times. Similarly, in New Zealand, Nixon et al. (2008) found that 7-year-olds (N = 519) slept an average of 29.1 minutes less on weekends compared with school nights. This was also associated with later weekend bedtimes and only slightly later rise times on weekend mornings (M weekend bedtime 20:42 vs. week night 20:11, $p < .001$). Additionally, children have been shown to sleep significantly more during school holidays compared with normal school weeks (Szymczak, et al., 1993).

Screen Time

Screen time (including television, video games, computer use and cinema viewing) was found to be inversely related ($r = -.29$, $p < .001$) to the sleep of 10 – 13-year-olds in Australia (Olds, Ridley, & Dollman, 2006). For every extra hour of screen time, sleep duration declined by approximately 10 minutes. The American Academy of Pediatrics (2001, as cited in Olds, et al., 2006), Australian national guidelines, and New Zealand Ministry of Education (2007) guidelines recommend that children have no more than 1 – 2 hours of 'quality' programming per day. However, Olds et al. (2006) found Australian children's ($N = 1,039$) daily median screen time to be 3.8 hours across the week. In New Zealand, 64.1% (62.1 – 66.2%) of 5 – 14-year-olds were found to usually watch two or more hours of television a day (Ministry of Health, 2008).

Although guidelines include not having a television in children's bedrooms, 41% of a sample of 5½-year-olds ($N = 3,165$) (Mistry, Minkovitz, Strobino, & Borzekowski, 2007), 26.0% of a sample of 4 – 10-year-olds ($N = 1099$) (Owens, et al., 1999), and 18.5% of a sample of 5 – 11-year-olds ($N = 19,299$) (Li, et al., 2007) had a television in their rooms. Forty three percent of school-aged children ($N = 637$) taking part in the *Sleep in America* poll (National Sleep Foundation, 2004) also had a television in their bedroom. They were more likely to be in the lower 25^{th} sleep percentile (31% vs. 24%), and to go to bed between 22:00 and 22:59 (16% vs. 8%) compared to children who did not have a television in their room.

Having a television in the bedroom was associated with less emotional reactivity at the age of five and a half (Mistry, et al., 2007), and sleep problems (Li, et al., 2007; Mindell, Meltzer, Carskadon, & Chervin, 2009). Owens and colleagues (1999) found increased daily television watching and viewing at bedtime to be associated with sleep issues, including bedtime resistance, sleep onset delay, anxiety in relation to sleep, and shortened sleep duration. Using PSG, Dworak and colleagues (2007) also observed a significant ($p < .05$) reduction in sleep efficiency after television exposure. In New Zealand, Nixon and colleagues (2009) found no significant association between duration of television viewing per day and sleep onset latency measured by actigraphy.

These findings, however, may have been affected by limitations of actigraphy in being able to measure sleep latency accurately (see Section 1.4.1).

Family and Home Environment

Various aspects of the family environment have been found to impact on children's sleep. It is therefore important to consider sleep within the family context (Dahl & El-Sheikh, 2007). Sleep hygiene is a term used to describe modifiable parent and child practices that enable sufficient quality sleep, and reduce daytime sleepiness. These include consistent sleep schedules and bedtime routines (Mindell, et al., 2009). Changes in routine bedtimes over the past decades have been associated with shorter sleep durations in children. Dollman and colleagues (2007) found that Australian 10 – 15-year-olds were sleeping approximately half an hour less on school nights compared with children of the same age in 1985, which was deemed to be almost entirely due to later bedtimes. Similarly, from 1979 – 1985, 10-year-olds in Switzerland went to bed 9 minutes earlier than those from 1986 – 1993 (Iglowstein, Jenni, Molinari, & Largo, 2003). In New Zealand, Nixon et al. (2008) found that children with younger siblings slept 11.7 minutes longer than the rest of the study sample (p = .03). This may be due to children with younger siblings having earlier bedtimes than those without. Additionally, children with bedtimes after 21:00 had significantly shorter sleep durations (41.1 minutes, p < .0001) than those who went to bed earlier.

Location of the family home may impact on sleep, such as urban versus rural settings. A study of 9 – 12-year-olds (N = 160) found a significant exposure-effect relationship between road traffic noise and children's sleep quality (Ohrstrom, Hadzibajramovic, Holmes, & Svensson, 2006). Problems with daytime sleepiness were also associated with noise levels. Children from urban communities in China were found to have shorter average sleep times (9.0 hours ± 1.1 vs. 11.3 hours ± 1.1), and higher rates of abnormal sleep behaviour (82.8% and 70.1% respectively, p < .05) compared to those living in rural areas (Yang, Bu, Dong, Fan, & Wang, 2009).

Sleeping arrangements in families may also influence children's sleep. In New Zealand, although sleeping practices have been studied in infants (Abel, Park, Tipene-Leach, Finau, & Lennan, 2001), it is unclear how prevalent co-sleeping and other sleeping arrangements are among school-aged children. Prevalence rates of co-sleeping vary internationally depending on cultural, familial and socioeconomic factors.

In China, Liu and colleagues (Liu, Liu, & Wang, 2003) found that 55.8% of 7-year-olds (*N* = 517) regularly shared a bed with their parents. Poorer physical health and crowded housing conditions increased the likelihood of this occurring, and increased sleep anxiety and daytime sleepiness were reported in children who shared a bed with parents. Breathing problems and parasomnias, such as sleepwalking and nightmares, were not associated with bed sharing. Li et al. (2009) also found co-sleeping to be common in Chinese children, with 21.0% of 4,108 school-aged children (*M* age 8.8 years) identified as regularly sharing a bed. Additionally, 19.1% of children shared a bedroom. Younger age, large family size, children not having their own bedroom, and parental approval of co-sleeping were factors associated with bed and room sharing.

Jenni et al. (2005) found that 44% of 2 – 7-year-olds in Switzerland shared a bed at least once a week, and bed sharing reached a maximum at 4-years of age ($\geq$ 1 times per week = 38%). Bed sharing and night waking during infancy did not predict bed sharing or night waking in childhood.

In Italy, Cortesi and colleagues (2004) found that 5% of 6 – 12-year-olds (*N* = 901) regularly co-slept. Low SES, a shiftworking parent, being a one-parent family, a parent who co-slept in childhood, prolonged breastfeeding, and previous and current sleep problems significantly predicted co-sleeping in children. They deemed co-sleeping to be related to the lifestyle of families, and a way of parents coping with children's sleep problems. Additionally, compared to other groups, 5 – 9-year-olds in Italy who co-slept were found to have significantly later bedtimes, shorter sleep durations at night, higher CSHQ bedtime resistance and sleep anxiety scores, and more emotional and behavioural problems (Cortesi, Giannotti, Sebastiani, Vagnoni, & Marioni, 2008).

The 2004 *Sleep in America* poll (National Sleep Foundation, 2004) found that, compared to those in the middle 50th or upper 25th percentiles, children in the lower 25th sleep percentile were more likely to share a room (41% vs. 32% and 28%) or a bed (19% vs. 14% and 10%). Children whose parents reported they thought their child had a sleep problem were more likely to be bed sharers compared to their counterparts (23% vs. 13%). Similarly, parents who did not think their children had a sleep problem were more likely to describe their children as solitary sleepers (65% vs. 55%).

Family stress and parenting styles may also influence children's sleep. El-Sheikh and colleagues (El-Sheikh, Buckhalt, Keller, & Granger, 2008) found that in a sample of healthy children (N = 64), higher levels of cortisol in the afternoon, which was used as an indicator of stress, were related to increased subjective sleep problems, shorter objectively measured sleep duration, and poorer quality sleep.

Greater parental warmth (measured using a warmth scale that included questions on the frequency that parents and caregivers told their child they loved them, spent time with children doing favourite activities, talked about interests, relationships, and current events, and told their child they appreciated something they did) was found by Adam, Snell, and Pendry (Adam, Snell, & Pendry, 2007) to predict more hours of sleep on weekdays in 5 – 12-year-olds. A parenting style encouraging social maturity was also associated with healthier sleep patterns in children aged 8 – 11-years (Spilsbury, et al., 2005). In a cohort of people in New Zealand who participated in the Dunedin Multidisciplinary Health and Development Study (N = 973), mean level of family conflict at ages 7 – 15-years significantly predicted insomnia at 18-years (OR [95% confidence interval] = 1.42 [1.17 – 1.73], $p < .001$) (Gregory, Caspi, Moffitt, & Poulton, 2006). Additionally, a dose-response relationship was found. A larger number of assessments that families scored in the top 25% for conflict in, was associated with a greater likelihood of the young person developing insomnia at 18-years of age, after controlling for depression at 18-years.

Analysis of longitudinal data on 658 children and families in the UK found that sleep problems in children were adversely affected by fathers being absent at the age of 8. Additionally, mothers being younger, interacting in a less sensitive manner with children, experiencing more negative emotions, and more conflict/less closeness in mother-child relationships negatively impacted on children's sleep (Bell & Belsky, 2008).

Chaotic living conditions including noise, crowding, lack of routine and structure, and instability in household location and occupants were associated with children having sleep problems and difficulties responding to academic challenge (Brown & Low, 2008). Exposure to marital conflict was found to influence children's sleep, with increased conflict associated with disruption in children's sleep quantity and quality, as well as subjective sleepiness (El-Sheikh, Buckhalt, Mize, & Acebo, 2006). Similarly, Liu et al. (2000) found significant relationships between poor parental relations and dyssomnias (*OR* = 2.68, *95% CI* 1.53 – 4.69) and parasomnias (*OR* = 2.25, *95% CI* 1.31 – 3.85) (see Section 1.6 for definitions). Crowded homes were also associated with sleep problems (dyssomnias: *OR* = 1.33, *95% CI* 1.08 – 1.62; parasomnias: *OR* = 1.27, *95% CI* 1.01 – 1.59).

Parents' sleep habits may influence children's sleep. Komada and colleagues (2009) found irregular late bedtimes of parents, particularly mothers, to be associated with sleep problems and daytime sleepiness in 1 – 11-year-old children. Shiftwork may play a particular role in familial sleep disruption, as this has been associated with poorer sleep quality in men and women (Drake, Roehrs, Richardson, Walsh, & Roth, 2004; Lee, 1992; Sekine, Chandola, Martikainen, Marmot, & Kagamimori, 2006) and may therefore potentially negatively impact children.

Childcare during the day may also influence sleep timing and duration. The 2004 *Sleep in America* poll (National Sleep Foundation, 2004) found that 4 – 5% of school-aged children attended both before- and after-school care. Of those attending before-school care, 24% of younger school-aged children arrived at school before 07:00 and mean arrival time at school was 07:01. Of those attending after-school care, 13% left school later than 17:30. Therefore, daily routine and sleep schedules may be affected by childcare. It is unclear what impact childcare has on the sleep of school-aged children living in New Zealand at present.

Caffeine

Adenosine has been found to promote sleep by playing a role in sleep homeostasis. As caffeine blocks adenosine's sleep promoting effects, it is not surprising that in adults caffeine has been found to increase sleep onset latency when consumed just prior to bedtime (Roehrs & Roth, 2008).

High doses of caffeine administered to children have resulted in increased activity, and fidgetiness in those who did not usually consume caffeine (Dews, 1982). In a survey of 12 – 15-year-olds (N = 191) over a two-week period, caffeine was used on over 70% of days surveyed (Pollak & Bright, 2003) and was associated with increased wake after sleep onset (WASO). Sleep was also found to be more disturbed on nights following increased caffeine consumption. In a sample of 10 – 12-year-olds (N = 135) Luebbe and Bell (2009) found that on average caffeinated beverages were consumed 3.7 (SD = 1.9) days per week. The *Sleep in America* poll (Mindell, et al., 2009) indicated that 41% of school-aged children consumed at least one caffeinated drink per day. These children were found, on average, to sleep nearly 20 minutes less than children who did not consume caffeine daily (F (1,630) = 17.55, p = .001).

In New Zealand, the Ministry of Health (2003) found that 43% of 5 – 14-year-olds (N = 3,275) consumed Coca Cola or other cola drinks weekly and 9% drank Mountain Dew. To date, there appears to be no information on the relationship between New Zealand children's caffeine consumption and sleep.

Daily Activity

A limited number of studies have been carried out exploring the relationship between activity levels during the day and children's sleep. Dworak and colleagues (2008) found that intense exercise resulted in an increased proportion of SWS, less sleep in stage 2, higher sleep efficiency, and shorter sleep onset latency in 11 school-aged children (12.6 ± 0.8 years old). In New Zealand, Nixon et al. (2009) also found a significant relationship between children's activity during the day and sleep latency. Mean actigraphically-measured activity counts from one 24 hour period were inversely associated with sleep latency (p = .05). Time spent in vigorous activity was associated with decreased sleep latency (p = .07), and sedentary activity was associated with increased sleep latency (p = .01). Additionally, sleep duration was found to be inversely associated with sleep latency (p < .001), that is, longer sleep duration was associated with shorter sleep latency.

Some associations have been reported between exercise during daylight and sleep quality in adults (Fox, 1999). In a meta-analysis of 38 studies looking at the effects of exercise on adult sleep, Youngstedt, O'Connor, and Dishman (1997) found that exercise did not affect sleep onset latency (g = -0.05, p = .10), but did produce small increases in total sleep time (g = 0.42, p < .001) and SWS (g = 0.19, p = .005). Additionally, a significant reduction in REM sleep was found after exercise (g = -0.49, p < .001), as well as delayed REM latency (g = 0.42, p < .001). Exercise did not appear to affect WASO (g = 0.07, p = .302). Conversely, in a study of adults with normal sleep, no association was found between sleep duration and physical activity (Youngstedt, et al., 2003).

A variety of behaviours have been associated with levels of daily activity and well-being, although these do not appear to have been explored in relation to the sleep of children in New Zealand. Regular active travel to school (such as walking) has been associated with greater moderate to vigorous activity during the week (van Sluijs, et al., 2009). Spending more time engaged in organised leisure activities has been significantly associated with fewer symptoms of depression in children and adolescents

(Desha & Ziviani, 2007). Additionally, skipping meals, and in particular breakfast, has been associated with a higher BMI (p = .002) in New Zealand children (Utter, Scragg, Mhurchu, & Schaaf, 2007).

Gender

While some studies have found no gender differences in sleep during middle childhood (Aronen, Paavonen, Soininen, & Fjallberg, 2001; Goodwin, et al., 2007; Guerin, et al., 2001; Wolfson, 1996), others indicate that girls sleep longer than boys (Liu, Liu, Owens, & Kaplan, 2005; Spruyt, O'Brien, Cluydts, Verleye, & Ferri, 2005). In a cross-sectional analysis of 8 – 11-year-olds (N = 755), Spilsbury et al. (2004) found that the mean [*SD*] sleep duration of boys (9.57 [0.71] hours) was 7 minutes shorter than girls (9.68 [0.72]). Similarly, in a group of 7 – 8-year-olds (N = 50) boys' mean (*SD*) sleep time of 8.55 (0.60) hours was 7 minutes shorter than girls' mean (*SD*) sleep time of 8.67 (0.60) hours (Sadeh, et al., 2000). Boys were found by Russo et al. (2007) to have later bedtimes than girls (main effect of gender: F (1,1056) = 4.2; $p < .05$), and girls woke up significantly later in the weekends compared with boys (Russo, et al., 2007; Spruyt, et al., 2005). Higher percentages of motionless sleep were also observed in girls compared with boys (69.1% [7.2] vs. 62.7% [9.4]) (Sadeh, et al., 2000). In New Zealand, Landhuis and colleagues (2008) found small but significant differences in mean sleep times of boys and girls; however, no significant difference was found by Nixon and colleagues (2008) in relation to gender and sleep duration.

Culture, Ethnicity and Socioeconomic Status

It is impossible to separate children's sleep from the cultural context in which they live (Jenni & O'Connor, 2005). While many paediatric sleep issues are common in both Western and Eastern cultures, a number of sleep variables and the perception of whether or not they are a problem appear to be particularly influenced by cultural factors such as co-sleeping, napping, and bedtimes (Owens, 2005).

Internationally, variation has been found in the sleep of children with different ethnicities and socioeconomic backgrounds (Buckhalt, El-Sheikh, & Keller, 2007; Crabtree, et al., 2005; Crosby, LeBourgeois, & Harsh, 2005; Goodwin, et al., 2003; Liu, Liu, et al., 2005; O'Brien, Holbrook, Jones, & Gozal, 2007). In adult New Zealanders, socioeconomic factors and ethnicity were found to be significant independent predictors of symptoms of insomnia (Paine, Gander, Harris, & Reid, 2004; Paine, Gander, Harris,

& Reid, 2005). Māori self-reported more insomnia symptoms and sleep problems than non-Māori, and unemployment and socioeconomic deprivation were associated with insomnia symptoms and sleep problems lasting longer than six months. However, there is minimal information on whether such differences exist in school-aged children in New Zealand.

1.6 Sleep Problems in Childhood

Historically, sleep problems were thought to have been rare in school aged children; however, recent studies do not support this. Figures vary, but overall prevalence of significant parentally-reported sleep problems have been noted in approximately 20 – 40% of children (e.g. Blunden, et al., 2004; Liu, Ma, et al., 2005; Liu, et al., 2000; Mindell, 1993; Mindell & Owens, 2003; Owens, 2008b; Paavonen, et al., 2000). This may be a conservative estimate due to under-reporting by parents (Blunden, et al., 2004; Gregory, Rijsdijk, & Eley, 2006).

The *International Classification of Sleep Disorders* (American Sleep Disorders Association, 1997) describes dyssomnias as being disorders that result in excessive daytime sleepiness or difficulty initiating or maintaining sleep. In children, common issues include bedtime resistance (15 – 25%), significant sleep onset delay and bedtime anxiety (10%), and parent- and teacher-reported daytime sleepiness (10%) (Mindell & Owens, 2003). Problems with sleep initiation or maintenance have been identified as a potential problem in as many as 30 – 40% of school-aged children (Fricke-Oerkermann, et al., 2007; Owens, Spirito, McGuinn, et al., 2000; Spruyt, et al., 2005). In general, studies suggest that children are not getting enough sleep, with an estimated 15 million children in America affected by inadequate sleep (Smaldone, Honig, & Byrne, 2007). The 2004 *Sleep in America* poll (National Sleep Foundation, 2004) also found that 27% of school-aged children were getting fewer hours sleep than their parents' thought they should be having.

Parasomnias are defined in the *International Classification of Sleep Disorders* (American Academy of Sleep Medicine, 2005, p. 137) as "undesirable physical events or experiences that occur during entry into sleep, within sleep, or during arousals from sleep". These include sleep walking, night terrors, sleep enuresis and sleep bruxism. Sleep walking and night terrors occur during NREM sleep, typically during the first two-thirds of the night (Capp, Pearl, & Lewin, 2005) and have been reported to occur regularly in approximately 1 - 6% and 3 - 6% of children respectively (Agargun, et al., 2004; Mindell, 1993). Sleep bruxism, or teeth grinding, has been observed in approximately 6 - 35% of children and sleep enuresis, or bedwetting, in 1 – 10% of school-aged children (Liu, Ma, et al., 2005; Mindell, 1993; Ng, et al., 2005; Serra-Negra, Ramos-Jorge, Flores-Mendoza, Paiva, & Pordeus, 2009; Smedje, Broman, & Hetta, 1999; Wang, et al., 2007).

Obstructive sleep apnoea syndrome (OSAS) affects approximately 1 – 4% of children and is one of the most common respiratory disorders of childhood (Bixler, et al., 2009; Goldstein, et al., 2004; Kaditis, et al., 2004; Liu, Ma, et al., 2005; Robinson & Waters, 2008). It involves repeated episodes of upper airway obstruction during sleep (Mindell, 1993) and prevalence may be on the rise due to increasing rates of obesity and decreasing adenoid-tonsillectomy procedures (Capp, et al., 2005).

New Zealand prevalence data are sparse. Fergusson, Hons, Horwood, and Shannon (1986) reported 7.4% of 8-year-olds (N = 1,092) experienced nocturnal enuresis. Edwards, Hsiao, and Nixon (2005) reviewed paediatric home ventilator support in Auckland, indicating that over a 12-year period 160 children (89 boys) received home respiratory support for a number of conditions including (but not exclusively) OSAS. Notably, the availability and accessibility of services, as well as prevalence of conditions, may have influenced these figures.

1.6.1 Impact of Sleep Problems in Middle Childhood

Poor quality and insufficient quantity of sleep can result in children experiencing daytime sleepiness, decreased alertness and impairment of daily functioning (Figure 1.8). However, unlike in adults, sleepiness may present as disturbed mood, hyperactivity, poor impulse control and inattention. This may negatively impact social functioning, school performance and family relationships as well as increasing the risk of unintentional injury (Mindell & Owens, 2003).

Sleep problems have been associated with school attendance issues (OR = 2.53, *95% CI* 1.45 – 4.41) and a greater number of teacher-reported psychiatric symptoms in 8 – 9-year-olds (N = 5,813) living in Finland (Paavonen, Almqvist, et al., 2002). Parents were more likely to report problems at school when children experienced inadequate sleep (Smaldone, et al., 2007), and a number of studies have found suboptimal sleep to affect school performance (Bruni, et al., 2006; Buckhalt, Wolfson,

& El-Sheikh, 2009; Quach, Hiscock, Canterford, & Wake, 2009; Ravid, Afek, Suraiya, Shahar, & Pillar, 2009; Taras & Potts-Datema, 2005). Conversely, better sleep was identified as a protective factor for children, moderating the effects of emotional insecurity and parental attachment difficulties and resulting in improved academic performance (El-Sheikh, Buckhalt, Keller, Cummings, & Acebo, 2007; Keller, Ei-Sheikh, & Buckhalt, 2008).

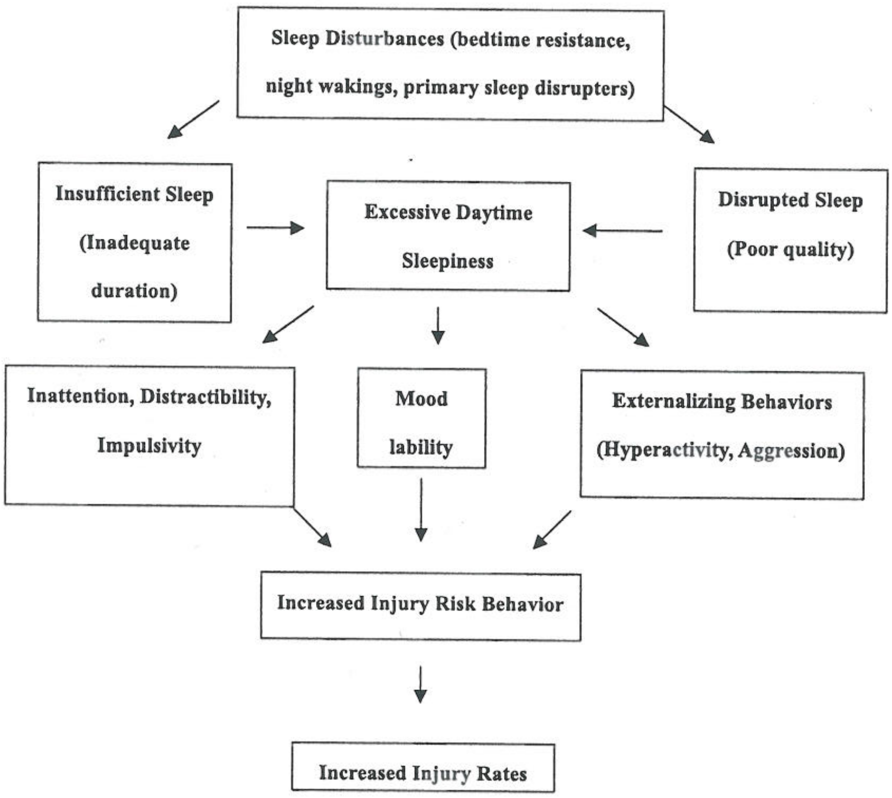

Figure 1.8. Relationship between sleep disturbance, daily functioning and injury. Adapted from Owens, J. A., Fernando, S. & McGuinn, M. (2005). Sleep Disturbance and Injury Risk in Young Children. *Behavioral Sleep Medicine 3*(1), 18 – 31.

Childhood sleep difficulties have been associated with anxiety and depression (Chorney, Detweiler, Morris, & Kuhn, 2008; Gregory & Eley, 2005; Gregory, Rijsdijk, Dahl, McGuffin, & Eley, 2006), with anxiety having a stronger association with sleep problems in children aged 6 – 11-years and depressive symptoms with teenagers aged 12 – 17-years (Alfano, et al., 2009). Overall, Paavonen and colleagues (2003) found current sleep difficulties in preadolescent children to be associated with an increased risk of psychiatric problems (*OR* = 2.92, *95% CI* 1.58 – 5.38).

Behaviour has also been linked to sleep problems (Paavonen, Porkka-Heiskanen, & Lahikainen, 2009), particularly hyperactivity and inattention (Melendres, Lutz, Rubin, & Marcus, 2004; Urschitz, et al., 2004). Associations were found between hyperactivity and bedtime resistance, restless sleep, and sleep walking. Bedtime resistance was also associated with conduct problems (Bos, et al., 2009; Smedje, Broman, & Hetta, 2001). Actigraphically measured short sleep duration (< 7.7 hours) was a significant predictor of hyperactivity and impulsivity in 7 – 8-year-olds (*N* = 280) (Paavonen, Raikkonen, et al., 2009). Additionally, sleep problems at the age of 4-years were found to predict emotional and behavioural problems in mid-adolescence, highlighting the importance of the detection of sleep issues early in life (Gregory & O'Connor, 2002).

In an analysis of children attending an emergency centre in Italy due to injury, Valent, Brusaferro, and Barbone (2001) found a direct association between injury and sleeping < 10 hours for boys (*RR*: 2.33, *95% CI* 1.07 – 5.09) but not girls (*RR*: 1.00, *95% CI* 0.29 – 3.45). A significant association was also found between injuries occurring between 16:00 and midnight (girls and boys, *RR*: 4.00, *95% CI* 1.13 – 14.17). Additionally, a circadian pattern in childhood traumas with an afternoon peak at 16:00 was found by Reinberg, Reinberg, Téhard, and Mechkouri (2002). In a study of 6 – 13-year-olds (*N* = 389), CSHQ subscale scores for parasomnias and daytime sleepiness were positively associated with injury, as was shorter sleep duration (< 9 hours) (Li, et al., 2008). Owens, Fernando and McGuinn (2005) also found that 3 – 7-year-olds who were reported to be more injury-prone by their parents had significantly more sleep disturbance than their counterparts.

Overall, sleep problems have been associated with poorer quality of life of children (Crabtree, Varni, & Gozal, 2004; Hart, Palermo, & Rosen, 2005). It is not surprising that negative effects are experienced not just by individuals, but also by other family members. Poorer parental health, and in particular maternal mental health, has been associated with children’s sleep issues, (Fauroux, Aubertin, & Clement, 2008; Martin, Hiscock, Hardy, Davey, & Wake, 2007; Meltzer & Mindell, 2007). Maladaptive behaviours have been found to occur in parents of children with sleep problems (Simard, Nielsen, Tremblay, Boivin, & Montplaisir, 2008) which may also impact siblings. Given the difficulties outlined regarding mood, behaviour and school problems, children's sleep issues may impact community services and members such as teachers and health professionals.

1.7 Sleep and Obesity

The World Health Organization has identified obesity as an escalating global epidemic (World Health Organization, 2008). New Zealand prevalence data indicate that 20.9% (*95% CI* 19.2 – 22.6) of children (2 – 14-years) are overweight and 8.3% (*95% CI* 7.4 – 9.3) are obese (Ministry of Health, 2008). Similarly, in Australia 20 – 25% of children and young people are estimated to be overweight or obese (Batch & Baur, 2005). Internationally, the epidemic has affected a wide range of ethnic and socioeconomic groups and appears to be consistently increasing, as illustrated in Figure 1.9.

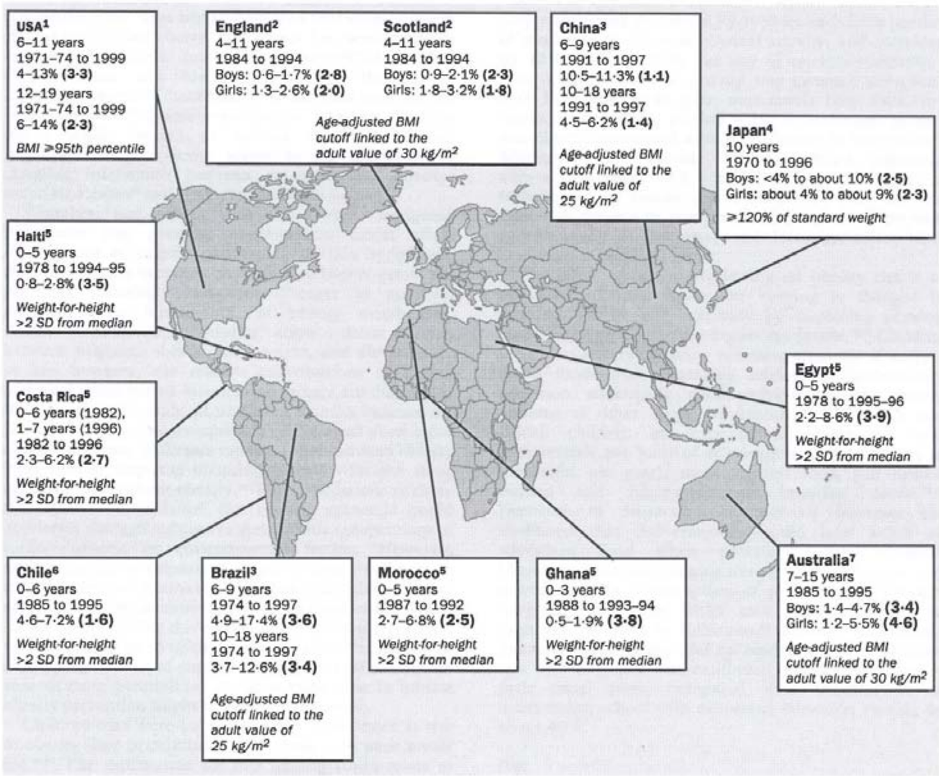

Figure 1.9. Global prevalence of childhood obesity. Definitions of overweight and obesity are in italics, increases in prevalence over time are in bold. Adapted from Ebbeling, C. B., Pawlak, D. B., & Ludwig, D. S. (2002). Childhood obesity: public-health crisis, common sense cure. *The Lancet 360*, 473 – 482.

As well as having an impact on health, including morbidity and mortality (James, 2009), obesity has been found to create a significant economic burden on society (Wang & Dietz, 2002). A number of factors have been identified as determinants of obesity in children. These include parental body mass index (BMI), increased television viewing, sedentary activity, increased consumption of foods with high fat content, decreased fruit and vegetable consumption, and rapid weight gain in infancy (Agras, Hammer, McNicholas, & Kraemer, 2004; Blair, et al., 2007; Butte, Puyau, Adolph, Vohra, & Zakeri, 2007; Carter, 2006; Davy, Harrell, Stewart, & King, 2004; Kleiser, Rosario, Mensink, Prinz-Langenohl, & Kurth, 2009; Must, et al., 2007; Must & Parisi, 2007; O'Callaghan, Williams, Andersen, Bor, & Najman, 1997; Sekine, et al., 2002; Sugimori, et al., 2004).

Importantly, short sleep duration in children has been identified as an independent risk factor for being overweight and obese. In New Zealand, Nixon and colleagues (2008) found that short sleep duration (< 9 hours) was associated with 7-year-old children being overweight or obese (BMI: *OR* = 3.32, *95% CI* 1.40 – 7.87), with a 3.34% increase in body fat (p = .03), which was not explained by television viewing or physical activity. Duncan et al. (2008) also found that insufficient sleep during the week significantly related to the fat status of children in New Zealand aged 5 – 11-years (N = 1,229).

Duration of sleep was found to be significantly associated with obesity in German children (5 – 6-years). The prevalence of obesity decreased in relation to sleep duration: ≤ 10 hours, 5.4% (*95% CI* 4.1 – 7.0); 10.5 – 11.0 hours, 2.8% (*95% CI* 2.3 – 3.3); and≥ 11.5 hours, 2.1% (*95% CI* 1.5 – 2.9) (von Kries, Toschke, Wurmser, Sauerwald, & Koletzko, 2002). Chaput and Tremblay (2007) found that sleep duration had an independent effect on children’s waist circumference after adjusting for BMI and other covariates (r = -.17, p < .001).

Internationally, a review of literature by Cappuccio et al. (2008) found that, in children, the pooled OR for short sleep duration and obesity was 1.89 (1.46 – 2.42, p < .0001). Marshall, Glozier, and Grunstein (2008a; 2008b) and Patel and Hu (2008) also systematically reviewed literature and found that short sleep duration was consistently associated with higher body mass in children, although not always in adults. On reviewing laboratory-based studies, Van Cauter and Knutson (2008) concluded that partial chronic sleep restriction may increase adults’ and children’s risk of weight gain, and thereby play a role in the obesity epidemic. However, in an evaluation of time use diaries over one weekday and one weekend day for 1,459 5 – 18-year-olds, Forshee, Anderson, and Storey (2009) did not find an association between time spent sleeping and children's BMI. Additionally, Horne (2008a, 2008b) noted that few obese children are short sleepers and only a relatively small amount of weight gain is seen over many years in relation to habitually short sleep.

Interestingly, a number of studies have shown shorter sleep duration to be significantly associated with the risk of obesity in boys but not girls (Biggs & Dollman, 2007; Eisenmann, Ekkekakis, & Holmes, 2006; Ievers-Landis, Storfer-Isser, Rosen, Johnson, & Redline, 2008; Kaluski, Mazengia, Shimony, Goldsmith, & Berry, 2009; Ozturk, et al., 2009). There also appears to be an effect across time. In New Zealand, Landhuis and colleagues (2008) found more time spent sleeping in childhood (ages 5 – 11-years) to be associated with lower odds of obesity at the age of 32-years (OR = 0.73, *95% CI* 0.53 – 1.00). Sleep time at 32-years was not, however, associated with adult BMI (unstandardised regression coefficient: -.01, *95% CI* -0.31 – 0.29, p = .95).

In Britain, short sleep duration (< 10.5 hours) at the age of 3-years was identified as a significant risk factor for obesity at 7-years (Reilly, et al., 2005). Other studies found that shorter sleep duration at 9-years was independently associated with being overweight at 11 (Lumeng, et al., 2007), persistently short sleep duration (< 10 hours) at 2½-years significantly increased the risk of excess weight at 6-years (Touchette, Petit, et al., 2008), and sleeping problems at 6 months and 2 – 4-years increased the risk of obesity at 21-years (Mamun, et al., 2007). Later bedtimes, earlier rise times and shorter sleep durations in children aged 3 – 12 were also associated with higher BMIs five years later (Snell, Adam, & Duncan, 2007).

The exact mechanisms behind shorter sleep and potential increased risk of obesity are still being debated. However, hormonal changes may at least partially explain the relationship (Figure 1.10). Alterations in the hormones leptin and ghrelin have been observed during sleep loss. Leptin decreases appetite and increases energy expenditure, and is reduced during sleep restriction. Conversely, levels of ghrelin, which stimulates appetite, have been found to increase in short sleepers. Changes in leptin and ghrelin may, therefore, result in increased appetite and eating (Bayer, Rosario, Wabitsch, & von Kries, 2009; Currie & Cappuccio, 2007; Hart & Jelalian, 2008; Knutson & van Cauter, 2008; Taheri, 2007). An alternative view is that reduced REM sleep during short sleep duration in children and adolescents may attribute to higher BMI. It is proposed that REM sleep loss may alter the balance of energy expenditure and intake, resulting in decreased activity and increased food consumption (Liu, et al., 2008).

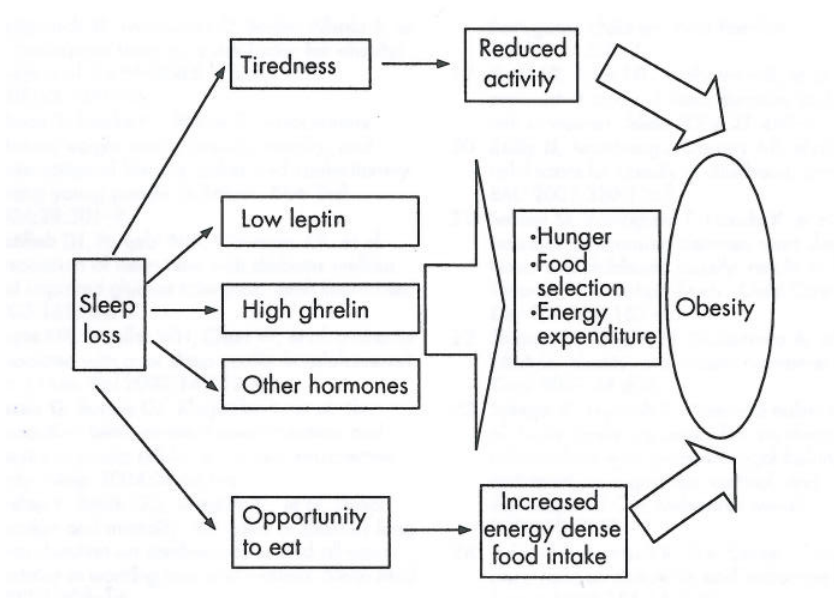

Figure 1.10. Possible mechanisms of short sleep duration and obesity. Adapted from Taheri, S., (2006). The link between short sleep duration and obesity: we should recommend more sleep to prevent obesity. *Archives of Disease in Childhood, 91,* 881 – 884.

Obesity is a public health priority. The evidence suggests that supporting children to get enough good quality sleep may be a low-cost strategy that could be utilised to not only improve children's mood, behaviour and daily functioning, but also their body size, thereby reducing the strain on health services and the financial burden of obesity on society (Chen, Beydoun, & Wang, 2008; Willms, 2004; Young, 2008).

1.8 Thesis Aims

In response to the review of literature outlined, thesis aims were identified. Data are limited, on both average sleep duration and the stability of sleep patterns, of New Zealand children. This highlights the need to accurately gather and analyse objective sleep data across weekdays and weekends, to gain a better understanding of 'normal' sleep in children.

Study Aims

1. To collect normative data on the sleep of children in New Zealand aged 6 – 8-years across school and non-school nights.
2. To identify modifiable factors that impact on children's sleep.
3. To explore the relationship between children's sleep and BMI.
4. To pilot study design and methodology for potential future research.

Objectives

1. Collect seven days and nights of continuous actigraphy data from 50 children, aged 6 – 8-years in Year 3 at school.
2. Collect sleep/wake diary data from parents to corroborate actigraphy recording and identify daily activity patterns of children.
3. Gather questionnaire data to identify environmental and lifestyle factors that may impact on children's sleep, as well as parental report and perception of children's sleep.
4. Collect parental feedback on participation in the study.

Hypotheses

Based on the review of literature, the following were hypothesised:

1. Children's sleep on school nights will be longer than on non-school nights.
2. Girls will have earlier bedtimes and longer sleep durations than boys.
3. Parental estimation of sleep duration will be longer than objectively measured sleep duration.
4. Children with BMI scores indicating they are overweight or obese will have shorter sleep duration than those in the 'normal' BMI range.
5. Children considered by their parents to have a sleep problem will have shorter sleep duration and/or poorer quality sleep than those not considered to have a problem.
6. Modifiable psychosocial and behavioural factors, such as screen/technology use, caffeine consumption, and skipping breakfast, will have a negative association with children's sleep quality and/or quantity.

7. Environmental factors including increased number of people sharing a bed and/or bedroom, greater time in childcare, and shift-working adults living in the home will have a negative relationship with children's sleep quality and/or quantity.
8. Children living with younger siblings will have longer sleep duration and earlier sleep start times than those with older or no siblings.
9. Children's level of activity during the day will positively correlate with sleep duration and be inversely proportionate to sleep onset latency.

2. Method

In response to the review of literature and subsequent hypotheses regarding the sleep of school aged children, a study protocol was developed. Importance was placed on using reliable, validated measures when possible, whilst ensuring children's and families' safety and comfort were not compromised. Methodology was guided by previous work carried out at the Sleep/Wake Research Centre, Massey University, Wellington. Chapter Two outlines the measures, ethical considerations, data collection process and procedures carried out with families who participated. A brief summary of data analysis methods is also provided.

2.1 Measures

A multi-method approach was used to capture objective and subjective sleep and wake data of children, within the family context. This involved using a combination of actigraphy, sleep diaries and questionnaires, as outlined below.

2.1.1 Actigraphy

Actigraphy has been shown to be a reliable and valid measure of sleep and wake activity. High agreement rates (AR) have been found between actigraphy and PSG (81 - 96%) in studies measuring sleep duration and sleep-wake activity of adults (Ancoli-Israel, et al., 2003; Morgenthaler, et al., 2007; Signal, Gale, & Gander, 2005). Actigraphy has been shown to be less reliable, however, in estimating sleep onset and offset latencies, sleep efficiency, and night waking. In general, it appears to overestimate total sleep time and sleep efficiency, and underestimate sleep latency compared with PSG (Ancoli-Israel, et al., 2003; Paquet, Kawinska, & Carrier, 2007; Pollak, Tryon, Nagaraja, & Dzwonczyk, 2001; Signal, et al., 2005). Actigraphy has been found to be less reliable with people who experience more disturbed or fragmented sleep (Ancoli-Israel, et al., 2003; Johnson, et al., 2007; Kushida, et al., 2001; Sadeh, et al., 1995).

In studies with children, actigraphs were able to distinguish between a control group and sleep disturbed children, with an AR of 85 – 90% between actigraphy and

PSG (Corkum, et al., 2001). Overall AR between wrist actigraphy and PSG were found to be high (85.1 - 88.6%), when four activity threshold settings (low, medium, high and auto) were analysed by Hyde and colleagues (Hyde, et al., 2007). The predictive value for sleep (91.6 - 94.9%) and sensitivity (the ability of the actigraph to predict true sleep) was also high (90.1 - 97.7%). However, ranges were much lower for predictive value for wake (46.7 - 65.6%) and specificity (the ability of the actigraph to predict true wake) (39.4 - 68.9%). Additionally, Werner and colleagues (2008) found satisfactory agreement between actigraphy and parental reports of sleep start (± 28 minutes), sleep end (± 24 minutes), and assumed sleep (± 32 minutes); however, AR were low for actual sleep time (± 106 minutes) and nocturnal wake time (± 55 minutes).

Although one of the major advantages of actigraphy is that it can be used in the home setting, a disadvantage associated with this is reduced control over factors that may impact on data collection, and therefore results. Issues such as illness, technical problems and noncompliance of participants mean that not all data is likely to be usable. Acebo et al. (1999) found that up to 28% of weekly recordings may be unusable for these reasons. As well as supporting the need for diaries and manual screening of data alongside the use of computer-based algorithmic scoring, this highlights the importance of obtaining enough nights of actigraphic recordings to be able to reliably measure children's sleep. Acebo and colleagues (1999) found that reliability for values aggregated over five nights was adequate (≥ 0.70) for sleep start time, wake minutes, and sleep efficiency, but sleep minutes and sleep period may require at least seven nights to provide reliable results. Data aggregated over one or two nights showed poor reliability for all sleep measures.

Actigraphs can be worn on the wrist, waist, or in young infants the ankle or calf (Sadeh, 2008; Sadeh & Acebo, 2002; Sung, Adamson, & Horne, 2009). When comparing actigraph placement on the non-dominant wrist versus waist of 7 – 12-year-olds, Paavonen and colleagues (2002) found the overall minute-by-minute AR of sleep-wake variables to be 92.5% (82.3 - 97.7%). None of the mean sleep estimates (sleep duration, latency, percentage, and efficiency) were found to be significantly affected by placement; however, when attached to the waist, actigraphs detected less diurnal activity compared to non-dominant wrist placement (75.3% AR) (Paavonen, Fjallberg, et al., 2002).

For these reasons, for the purposes of this study, actigraphy was deemed to be an appropriate objective measure of children's sleep and wake activity. The protocol involved seven consecutive days and nights of recording in order to measure school and non-school sleep and waking acitivity, as well as allowing for potential loss of data. Non-dominant wrist placement was chosen, to minimise intrusion for children taking part without compromising data collection.

The model of actigraph used was the Actiwatch-2™ (AW-2™) (Philips Respironics™ Mini Mitter, www.philips.com/respironics), as pictured in Figure 2.1. These activity monitors are lightweight (16 grams including the band), waterproof (to 1 metre for 30 minutes per IPX7 IEC 60529), and resistant to dust, heat, perspiration and cold (Philips Respironics, 2009). They are fitted with a standard wrist band made of elastollan, and a titanium buckle which could be adjusted to the wrist circumference of children who participated. AW-2™s are powered by rechargeable lithium batteries, which enable 30 consecutive days of activity logging at 1-minute epoch lengths, with a non-volatile memory of 1 Mbit. Solid-state 'piezo-electric' accelerometers in the AW-2™s have a bandwidth of 0.35 – 7.5 Hz, sensitivity of 0.025 G, and a sampling rate of 32 Hz (Philips Respironics, 2009).

Figure 2.1. The Actiwatch-2™ (Source: http://www.sleepreviewmag.com)

An event marker is located on the side of the AW-2™ which, when pushed, produces a triangular mark on the actigraphic data output (actogram). Children were asked to push the button when they started to try to sleep, woke up, and times when the actigraph was removed and replaced.

2.1.2 Child's Sleep/Wake Diary

The Child's Sleep/Wake Diary (Appendix B2) was developed to complement actigraphic data collection, as well as to provide additional daily activity information. When completed immediately upon waking, significant correlations have been found between sleep diaries and objective measures of sleep timing and duration, but less so with sleep onset latency and nocturnal awakenings (Harvey, et al., 2006; Lockley, Skene, & Arendt, 1999; Wilson, Watson, & Currie, 1998). When comparing actigraphy with sleep logs in adults, Lockley and colleagues (1999) found good correlations in sleep onset (r = .77), sleep offset (r = .88), and to a lesser degree sleep duration (r = .57). However, sleep variables relating to the transition between sleep and wake showed poor correlation including sleep latency (r = .12), number of night awakenings (r = .06), and duration of night awakenings (r = .22). A moderate correlation (r = .47) was also found between self-reported and actigraphically measured sleep duration of young adults by Lauderdale et al. (2008).

The use of daily diaries and manual screening of data is important to complement automatic scoring of actigraphy by computer algorithms, thus enhancing the accuracy and reliability of results (Acebo, et al., 1999; Sadeh, 2008; Sadeh & Acebo, 2002). Diary information can assist with the management of artifacts such as actigraphs being temporarily removed while showering, sedentary activity such as quietly watching television before bed (that may be erroneously interpreted as sleep by computer algorithms), being unwell or taking medication that may affect sleep, children sleeping in a moving vehicle (which may be interpreted as wakefulness), and actigraphs accidentally being left off or misplaced. Diaries should therefore include information about bedtimes, risetimes, times when the actigraph has been removed, times of external motion, and unusual events (Sadeh & Acebo, 2002).

Sleep/Wake Timeline

The Child's Sleep/Wake Diary (Appendix B2) was designed using a timeline format previously incorporated in a number of studies at the Sleep/Wake Research Centre, Massey University, Wellington (Gander, van den Berg, & Signal, 2005; Gibson, 2009; Signal, et al., 2007). As outlined in Section 2.5, the diary was used to record times when children started and finished trying to sleep, and when actigraphs were removed.

Daily Activity

In addition to the sleep/wake timeline, a number of questions were included on each diary page relating to daily activity. These were designed to capture the level and type of activity children were engaged in during the day, to enable analysis of the potential relationship between waking behaviour and sleep (see Section 1.5.1).

School Attendance

The diary captured whether or not children went to school each day, to enable analysis of school versus non-school sleep and wake activity.

Transport To and From School

Questions on the type of transport used to and from school were included, to measure the prevalence of active and passive travel.

Screen Time

As screen time has been associated with sleep difficulties, shorter sleep durations, and later bedtimes (Section 1.5.1), the diary captured whether or not children engaged in screen-based activities, and for how long each day.

Organised Activity

In order to explore the potential relationship between organised activity and sleep, a question was included as to whether or not children took part in an organised activity and, if so, what it was.

Level of Activity

Parental report of children's physical activity has been found to be significantly associated with actigraphic activity counts ($p < .05$) (Purslow, van Jaarsveld, Semmler, & Wardle, 2009). Questions were therefore included on parental estimation of 'quiet', 'moderate', and 'physical' play to collect subjective data on activity levels for analysis.

Meal Consumption

A question on meal consumption was designed to identify the prevalence of children skipping meals, and in particular breakfast.

Typical and Atypical Events

Lastly, parents were asked to record whether or not it had been a typical day. This was to ensure that data were excluded if, for example, children had been sick or took medication which may have affected their sleep (Sadeh & Acebo, 2002).

2.1.3 Child/Family Questionnaire

The Child/Family Questionnaire (Appendix B3) combined a number of demographic, lifestyle and environmental questions with a modified version of the Children's Sleep Habits Questionnaire (CSHQ) (Owens, Spirito, & McGuinn, 2000).

Age, Gender and School

Basic parental contact details were collected. Additionally, children's date of birth, gender, school and school year (e.g. Year 3) were requested. Date of birth data were used to calculate children's age (age = date of first day of actigraphic recording – date of birth/365.25). The name of the school was checked against Ministry of Education decile data to categorise responses into high (decile 8 – 10) and low (decile 1 – 3) groupings for analysis (Ministry of Education, 2009).

Ethnicity

Ethnicity details on children and parents were requested, using the Statistics New Zealand 2001 Census ethnicity question (Statistics New Zealand, 2002). As per the Ministry of Health ethnicity collection protocol (Ministry of Health, 2004), parents could either answer on behalf of their children, or decide that they were capable of understanding the concept of ethnicity and allow them to answer for themselves.

Due to the small sample size, these data were gathered for descriptive purposes only and not with the intention of stratifying data by ethnicity. As this was a pilot, the method for gathering ethnicity data was trialled with the potential for a future, large-scale study to be developed that could recruit 50% Māori and 50% non-Māori participants.

Height and Weight

In order to analyse sleep in relation to children being overweight or obese, height and weight details were gathered so that BMI could be calculated (BMI = weight [kg]/height^2[m^2]). Parental obesity has been identified as a potential risk factor for obesity in children (Lee, 2007). Parents' height and weight information was therefore requested as well as children's, so that parental BMI could be controlled for in analyses.

Health

Parents were asked to indicate if their child had been diagnosed with a developmental disorder and whether there were any ongoing health problems that may affect their child's sleep. These questions were included for screening purposes.

Caffeinated Drinks

Two questions were used regarding caffeinated and energy drinks. Parents were asked to indicate how often caffeinated/energy drinks were consumed by their child, with four options ranging from 'never' to 'often – more than three cups or cans a day'. These questions were previously used in a study of teenage sleep carried out at the Sleep/Wake Research Centre (Borlase, 2001).

Family Home

The number of people living in the house was requested. This was broken down into adults, children and teenagers, and children younger than the participant.

Child's Room

Families were asked whether children shared a bedroom and, if so, with how many children and/or adults. They were also asked to specify where children slept – in their own bed, parent(s) bed, sibling(s) bed, or 'other'. Additionally, a question was asked regarding technology in children's bedrooms. Parents were requested to tick as many boxes that related to items in their children's room, such as TVs, computers and cell phones (Borlase, 2001).

Childcare

This section asked whether or not children spent any time in after-school or childcare (‘yes’ or ‘no’ options). If the response was ‘yes’, details of days and times were requested.

Employment

Two employment questions were included. The first was taken from the Statistics New Zealand 2001 Census (Statistics New Zealand, 2002), to ascertain if any adults in the home were currently in paid employment. If there were, numbers were requested. The second question used employment categories outlined in the New Zealand Blood Donors Survey (Fransen, et al., 2006) to identify work patterns of adults living in the house. Again, as participant numbers in the pilot study were small, it was acknowledged that there may not be enough statistical power to carry out analyses. Piloting the questions was important, however, to ensure data collection methods were tested with the view to a larger study potentially being implemented in the future.

Children’s Sleep Habits Questionnaire (CSHQ)

The CSHQ was chosen because it was designed to be used with children aged 4 - 10 years, primarily in community populations. Additionally, it surveys both behavioural and medical sleep problems. In comparison, some paediatric sleep assessment tools have a more narrow focus, such as the Pediatric Sleep Questionnaire (PSQ) which assesses sleep-related breathing disorders (Chervin, et al., 2000).

The CSHQ is based on common clinical presentations of the most prevalent diagnoses in children according to the *International Classification of Sleep Disorders* (1997). This parent-report sleep screening tool consists of 35 items that yield a total CSHQ score as well as eight subscale scores (Bedtime Resistance, Sleep Duration, Parasomnias, Sleep Disordered Breathing, Night Waking, Daytime Sleepiness, Sleep Anxiety and Sleep Onset Delay) (Owens, Spirito, & McGuinn, 2000; Owens, Spirito, McGuinn, et al., 2000). Parents are asked to think of a recent ‘typical’ week of their children’s sleep and indicate how often sleep behaviours occur. A three-point scale is used for rating: ‘usually’ if the sleep behaviour occurred 5 – 7 times per week, ‘sometimes’ for 2 – 4 times per week and ‘rarely’ for once or not at all during the week (Owens, Spirito, & McGuinn, 2000).

The CSHQ has been shown to be a comprehensive and valid tool for screening school-aged children in the community for a variety of behaviourally-based and medical sleep problems. Owens and colleagues (2000) tested psychometric properties of the CSHQ using a community and a clinical sample of children aged 4 – 10 years. Adequate internal consistency was found for both groups (community = 0.68, clinical = 0.78). Alpha coefficients for the subscales in the community sample ranged from 0.36 (Parasomnias) to 0.70 (Bedtime Resistance) and from 0.56 (Parasomnias) to 0.93 (Sleep Disordered Breathing) for the sleep clinic group. Acceptable test-retest reliability (0.62 – 0.79) was also found. Validity was demonstrated as individual CSHQ items, as well as subscale and total scores, consistently differentiated between the clinical sleep disordered and community groups. Using a total CSHQ score of 41 yielded a sensitivity of 0.80 and specificity of 0.72 for identifying children with clinically identified sleep problems (Owens, Spirito, & McGuinn, 2000).

CSHQ Modifications

The following adaptations to the CSHQ (Question 13 in the Child/Family Questionnaire, Appendix B3) were piloted. The original format of the CSHQ is available in Appendix F1 for comparison.

Bedtime

The CSHQ asks if the child goes to bed at the same time each night. In order to capture school and non-school data, this was changed to two questions about going to bed at the same time each night – one on school nights (Sunday to Thursday night) and one on weekend nights (Friday and Saturday nights).

Sleep Behaviour

The CSHQ asks for the child's usual amount of sleep each day. This was amended to the child's usual amount of sleep each school night (Sunday to Thursday night) and weekend night (Friday and Saturday night).

Morning Waking

The CSHQ asks for the time of day the child usually wakes in the morning. This was changed to the time the child usually gets up on school mornings (Monday to Friday morning) and weekend mornings (Saturday and Sunday mornings).

Problem Sleep

The CSHQ asks parents to indicate if they consider their child's sleep to be a problem (yes, no, or N/A), for each sleep behaviour listed. After pre-testing the CSHQ with colleagues, some of whom are parents, it was decided that one question would be placed at the end of the questionnaire on problem sleep instead. The sleep problem column was removed, so as not to cause anxiety in parents.

The 'General Sleep' question was therefore added, asking parents to indicate if they considered their child's sleep to be a problem (a very serious problem, a small problem, or not a problem at all). This question was taken directly from the Brief Infant Sleep Questionnaire (BISQ) (Sadeh, 2004). It had also been incorporated into a pilot study measuring the sleep of one year old infants, carried out at the Sleep/Wake Research Centre (Gibson, 2009).

2.1.4 Parental Feedback

A letter requesting completion of a feedback form (Appendix E3) was posted to parents once data collection was completed (Gibson, 2009). Responses were anonymous to encourage honest comments that could be used to critically analyse the study design. This was broken down into the following sections:

Recruitment Sites

Parents were asked to indicate how they heard about the study ('flyer sent home from school', 'community notice board' or 'other').

Study Information

Feedback was sought on how clear the information was prior to taking part. If parents ticked the 'no' response regarding clarity, details of what else should have been included were requested.

Support

Parents were asked whether or not enough support was provided if they had any questions or concerns during the study. Clarification of other support that would have been useful was sought if they responded 'no'.

Actiwatch™, Diary and Questionnaire Use

Three category options ('easy', 'OK' and 'difficult') were provided in relation to the ease of using the Actiwatch™, Child's Sleep/Wake Diary and Child/Family Questionnaire.

Timeframe Estimates

Time estimates provided in the study information were checked against the actual time taken by families to complete the Child's Sleep/Wake Diary and Child/Family Questionnaire. Clarification was sought regarding how much time the questionnaire and diary took if families responded 'no' regarding the accuracy of time estimates.

Comments

The final section provided the opportunity to make additional comments. This was to enable study design amendments to be made in response to families' experiences of participating in the pilot study.

2.2 Ethics

An ethics application was submitted to the Massey University Human Ethics Committee (MUHEC): Southern A and was unconditionally approved on 23rd April, 2009 (Appendix C1). Minor amendments were made to study documentation which was approved by the committee on 17th July, 2009 (Appendix C2). Families were advised, both verbally and in writing, that they could withdraw from the study at any time, and did not have to answer any questions they were not comfortable with. Generously, paediatrician Dr Dawn Elder offered to provide a free consultation if serious concerns were raised by parents during the study. This resulted in one child being seen clinically.

2.3 Participant Criteria

After consultation with the study's supervisors and paediatric advisor, Dr Elder, criteria for inclusion in the study were defined as children aged 6 – 8-years and in Year 3 at school. The combination of age range and school year was in order to have a sample of children at a similar developmental stage, thereby minimising the impact of developmental variability on sleep. Additionally, due to the small sample size, children were excluded if they had a known major developmental delay or existing diagnosed sleep disorder. It was envisaged that if a large-scale study were carried out in the future these exclusion criteria would not be used, as increased statistical power would enable more in-depth analysis of the potential impact of developmental issues on sleep, and differences in children with and without diagnosed sleep disorders.

To explore potential differences in children's sleep associated with SES, high and low decile schools were targeted, with the aim of having 50% of the sample from low decile schools (1 – 3) and 50% from high decile schools (8 – 10). Decile 1 schools are the 10% of schools with the largest proportion of children from low socio-economic communities, whereas decile 10 schools are the 10% with the smallest proportion of students from low socio-economic communities (Ministry of Education, 2009).

Census information is used to calculate school deciles, by using student addresses to identify the number and percentage of students from different meshblocks. Meshblocks consist of approximately 50 households, and the census collects information relating to five socio-economic factors affecting school aged children – household income, crowding, adult occupation, educational qualifications, and income support. These factors are weighted by the number of students in each meshblock. The five scores are added to form a total for each school, and schools are then categorised into deciles. Decile ratings determine the level of funding that schools receive, with lower decile schools receiving more funding than higher decile schools. This system was designed to assist students to overcome learning barriers that are associated with living in low-economic communities (Ministry of Education, 2009).

2.4 Recruitment

Participants were recruited via schools and community facilities in the Wellington region. Printed flyers (Appendix C3) were used to inform parents and caregivers of the study, inviting anyone interested in taking part to make contact via freephone or email. Principals of 31 low decile (1– 3) and 33 high decile (8 – 10) schools were contacted and permission was requested to distribute study flyers to Year 3 pupils. A total of 46 principals agreed, with flyers being sent home with pupils from 21 low and 25 high decile schools. A letter was prepared requesting permission from Boards of Trustees for flyer distribution (Appendix C4). All of the principals that approved study recruitment did so, however, without consultation with trustee board members.

Flyers were placed on notice boards in a variety of community settings, including public libraries, swimming pools, community centres, art centres, and cafes. Additionally, a one-off stall was set up at North City shopping mall in Porirua for study information distribution during the school holidays at the end of term two.

2.5 Procedure

The researcher was contacted by 89 parents requesting further information about the study. Eight families were excluded, as four made contact after recruitment had closed and four children did not meet the study criteria. After an initial verbal outline of what the study entailed, 81 written information packs were posted out. These consisted of an introductory letter (Appendix D1), information sheets for parents (Appendix D2) and children (Appendix D3), a participant consent form (Appendix D4), and future research consent form (Appendix D5).

Seventy nine percent of parents who were sent information packs responded, with 64 signed consent forms returned. Of these, five were excluded due to receipt after recruitment had closed and one due to not meeting study criteria. The remaining 58 families were given the option of being visited by the researcher or having study packs delivered without a face-to-face meeting. Thirty nine families (67%) opted to meet and have the study material explained in person, with the rest having study packs delivered to letterboxes.

Study packs consisted of an information sheet on how to use the Actiwatch™ (Appendix B1), the Child's Sleep/Wake Diary (including an example sheet) (Appendix B2), the Child/Family Questionnaire (Appendix B3), a pre-paid courier bag, an instruction sheet for returning study material (Appendix B4), and an AW-2™ actigraph in a plastic case. Prior to delivery, the Actiwatch™ was initialised using Actiware® 5.0 software (Respironics® Mini Mitter, Bend, Orgeon, USA). Each participant was allocated an identification number which was entered, along with date of birth and gender. Epoch length was set at one minute. Initially, actigraphs were set up for delayed recording, to align with when children would be commencing data collection. This was done to minimise battery usage. Technical difficulties occurred with three participants, however, resulting in recording not starting at the time set. It was therefore decided to commence recording just prior to delivering Actiwatches™, to ensure data was collected correctly and families were not inconvenienced.

During the meetings with families, a demonstration was given on how to wear the Actiwatch™ and use the event marker. It was reiterated that the actigraph could measure movement only, to ensure children and parents were not unduly worried about additional information being collected. Details were provided in the information sheet (Appendix B1) about how the Actiwatch™ worked, when and how to wear it, and when to use the event marker.

The request was made for actigraphy data to be collected continuously for seven days and nights during the school term, in order to capture school and weekend sleep and wake activity. If children were sick, parents were asked to wait until they were well before wearing the Actiwatch™ and completing the diary.

To enhance the accuracy of actigraphic data collection, children were asked to push the event marker when starting to try to sleep, when finishing trying to sleep, and when removing or replacing the actigraph, such as when showering. Documentation of these events was requested, by placing a mark on the diary timeline and writing the code for the event, as per the written diary instructions (Appendix B2). The example diary page was discussed, as an illustration of what to do. So as not to cause undue concern for participants, it was stressed that children were asked to do their best, but that it did not matter if they forgot to press the event marker at any of these times.

Seven diary sheets were provided, along with the instructions and sample diary page. Families could begin the seven days and nights recording on the day that best suited them, and were asked to record the date and day on each sheet in order to ensure the correct diary page was used when manually screening actigraphic data and entering values into databases.

The questionnaire was discussed (Appendix B3). An explanation was given of how to complete the front section that incorporated demographic, lifestyle and environmental factors. Additionally, the researcher drew attention to the request to think of the most recent week of children's typical sleep behaviour when answering the CSHQ questions.

Children and parents were encouraged to ask about anything they were unsure of. Families were advised that they could contact the researcher at any time, as the study phone number was diverted to the researcher's mobile phone. For families who chose to have study material delivered, this was explained over the phone or via email.

To further ensure that families were supported whilst taking part in the study, a follow up phone call or email took place half way through the week of data collection.

When families had completed the questionnaire and seven days and nights of actigraphic recording and diary entries, they were given the option of returning study material in a pre-paid courier bag provided in the study pack or contacting the researcher to collect the paperwork and Actiwatch™. Once study material was received, Actiwatch™ data were downloaded using Actiware® 5.0 software (Respironics® Mini Mitter, Bend, Orgeon, USA). A printout of the actigraphic recording was sent to the family, with a letter summarising the week of sleep/wake activity (Appendix E1). Children were sent a certificate of appreciation for taking part in the study (Appendix E2), along with a Sleep/Wake Research Centre pen and a sheet of stickers. Feedback from parents was also requested (Appendix E3).

Of the 58 children who received study material, four did not complete data collection (two temporarily misplaced Actiwatches™ and two chose not to finish), and two sets of data were excluded due to criteria not being met. Four families were requested to repeat actigraphy recording and diary entries for another week, due to technical faults occurring with three of the Actiwatches™ and the wristband breaking on one. All of the families kindly did so. Data from the 52 families who completed the study were used for analyses.

2.6 Scoring of the CSHQ

The CSHQ section of the Child/Family Questionnaire (Appendix B3) was scored according to guidelines provided by Dr Judith Owens (2008a) (Appendix F1). For the majority of items included in the questionnaire, responses were scored as ‘usually’ = 3, ‘sometimes’ = 2, ‘rarely’ = 1. The exceptions were reversed items, considered to be sleep behaviours that were desirable. Scoring for these was in the opposite direction. Sleepiness responses at the end of the questionnaire were scored as ‘not sleepy’ = 1, ‘very sleepy’ = 2 and ‘falls asleep’ = 3. On advice from Dr Owens (personal communication, January 19, 2010), non-responses were scored as zero and a note was made of how many occurred. The resulting Total CSHQ scores, as well as subscale scores for Bedtime Resistance, Sleep Onset Delay, Sleep Duration, Sleep Anxiety, Night Wakings, Parasomnias, Sleep Disordered Breathing, and Daytime Sleepiness were entered into an SPSS database for analysis (see Section 2.8.2).

2.7 Scoring of Actigraphy

Once Actiwatches™ were returned, data were downloaded using Actiware® 5.0 software (Respironics® Mini Mitter, Bend, Oregon, USA). Using guidelines adapted from those used at the Sleep/Wake Research Centre (Appendix F2), files were manually screened. Computer-based scoring by the validated Actiware® algorithm was completed and variables downloaded into databases (see Section 2.8.2).

2.7.1 Manual Actigraphy Screening

Manual screening of actigraphy involved viewing the downloaded actogram for each participant and identifying the start and finish of rest and excluded intervals (see Figure 2.2). As per the *Guidelines for Actigraphy Screening* document (Appendix F2) that was developed for this study, three pieces of information were considered – changes in actigraphic movement, the event marker, and diary entry. In line with what families were requested to write in the diary and use of the event marker, the beginning of a rest interval was when the child started trying to sleep (as opposed to being in bed reading but not yet attempting to sleep). The end of the rest interval was when they had finished trying to sleep. As outlined in the screening guideline, if the three information sources did not match, then change in activity was used as the predominant factor, followed by the event marker and diary, in that order.

Excluded intervals were marked to ensure analysis was carried out only on the period during which actigraph was worn and diary data were recorded. Therefore periods leading up to the Actiwatch™ being put on, and following the final removal of the actigraph, were excluded. Any time that the diary and event marker indicated that the actigraph was temporarily taken off (such as when swimming) was marked as an excluded interval, as well as periods of more than one hour where there was a clear total cessation of activity.

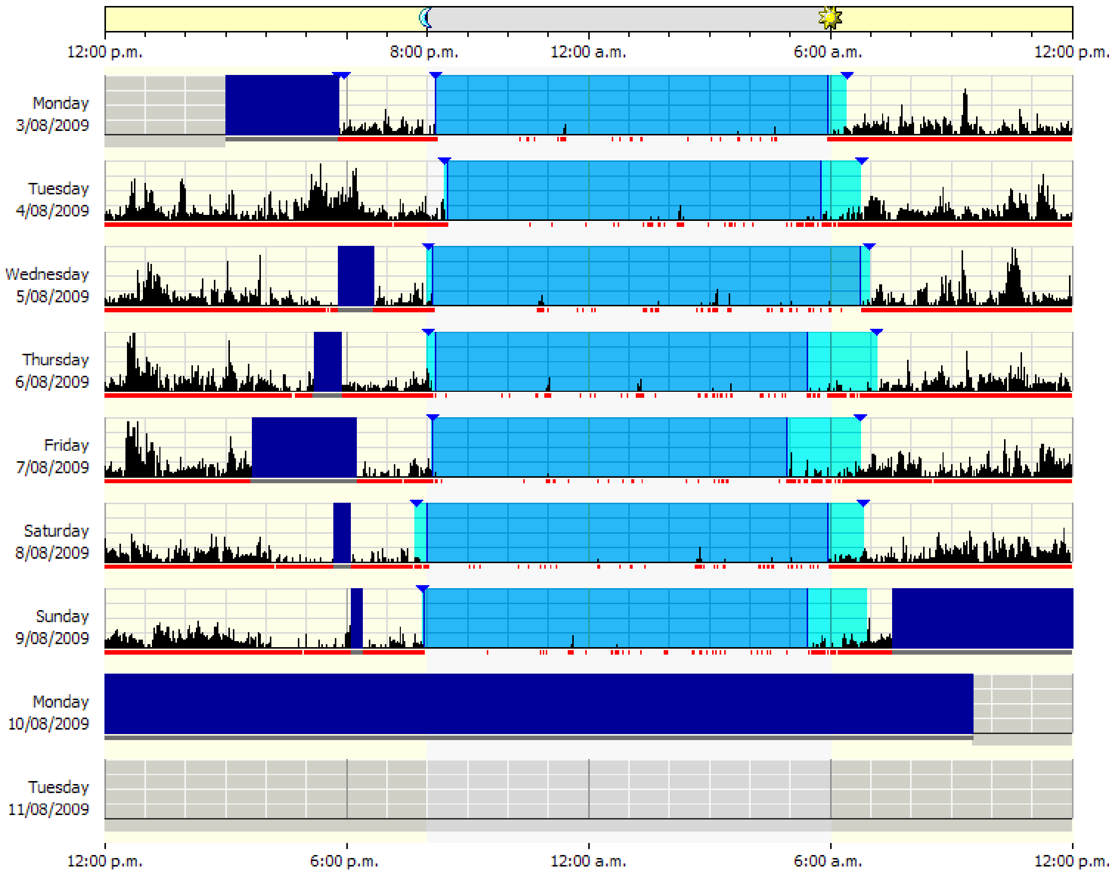

Figure 2.2. Example of a scored actogram, running from mid-day to mid-day. Black vertical lines underscored in red represent waking activity. Blue triangles indicate when the event marker was pushed. Dark blue sections are manually identified excluded intervals. Manually identified rest intervals contain turquoise sections at the beginning and end, which are automatically scored sleep onset latency and snooze time periods. Medium blue sections are sleep intervals within the rest period.

2.7.2 Computer-Based Actigraphy Scoring

The following properties were set for all actigraphic recordings in the study:

Epoch length:	1 minute
Wake threshold:	Medium
Wake threshold value:	40.00 activity counts
Sleep interval detection algorithm:	By minutes scored as immobile
Sleep onset setting:	10 minutes
Sleep end setting:	10 minutes
Actogram start hour:	12.00pm

The Actiware® 5.0 software scores each epoch as being either sleep or wake (Respironics Mini Mitter, 2005). This is determined by comparing activity counts in the epoch and those immediately surrounding it, to the threshold value selected (therefore in the case of this study, 40 activity counts). If the number of counts exceeds the threshold then the epoch is scored as wake. Alternatively, if the counts are equal to, or below the threshold, the epoch is scored as sleep.

Total activity counts (AC) are calculated based on sampling epochs (Respironics Mini Mitter, 2005). A one minute sampling epoch uses activity data from the one minute epoch in question plus a proportion of the values of the two (one minute) epochs either side, as illustrated in Figure 2.3.

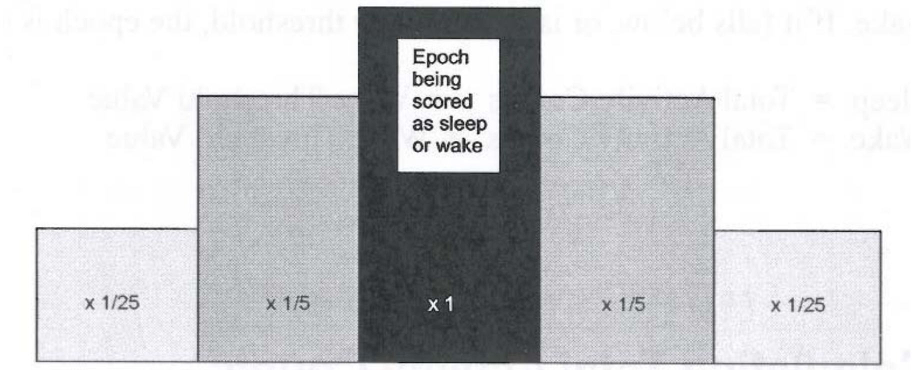

Figure 2.3. Activity count calculation using one minute sampling epochs. Adapted from Respironics, Mini Mitter (2005). *Actiwatch instruction manual: Software version 5.0.* Oregon: Mini Mitter.

2.7.3 Inter-Rater Reliability

To ensure accuracy of actigraphic scoring, 11 files (21.2%) were double scored by a second independent trained researcher. Discrepencies between scoring were cross-checked and all errors were minor and readily resolved. Differences greater than 15 minutes occurred in 1.2% of rest end times, and 4.9% of rest start times. These were double checked by a third independent person and resolved. An overall agreement of 93.9% was found, resulting in the decision not to double score the remaining files.

2.7.4 Actigraphy Variables

Once all actigraphy files were scored, variables that were to be used for analyses were selected and data were exported into databases. Table 2.1 summarises the night time sleep variables and daily activity variables used.

2.8 Data Management

2.8.1 Confidentiality

Participants were each allocated an identification number, which was written on questionnaires and diaries once returned. Page two of the Child/Family Questionnaire (Appendix B3) containing personal information was removed and securely stored separately. A database with families' contact details, Actiwatch™ serial numbers and documentation tracking information was encrypted to ensure confidentiality. Variables were entered into databases using identification numbers only.

2.8.2 Data Entry

Questionnaire, diary and actigraphic data were initially entered into separate databases using SPSS 16.0 (SPSS Inc. Chicago, Illinois, USA). All questionnaire and diary data were double entered. A total of three (5.8%) questionnaires had incorrect entries, with the remaining 49 (94.2%) requiring no amendments. Double entry of daily diary data resulted in 358 days (98.4%) of matching data and errors on six days (1.6%). Any figures erroneously entered were corrected prior to analyses being carried out.

Diary and actigraphy databases were created for school days and non-school days, and school nights and non-school nights, based on the following criteria:

- School day = child attended school that day
- Non-school day = child did not attend school that day
- School night = child attended school the following day
- Non-school night = child did not attend school the following day

These data were then screened. Criteria for exclusion were if children were reported as being sick or taking medication on the day, or if the duration of time scored by the algorithm as invalid actigraphic activity counts (AC) during the daytime were greater than 180 minutes in total. One hundred and eighty minutes would represent

≥20% of invalid activity for daily periods based on children sleeping for approximately 10 hours per day, and it was deemed unacceptable to have 20% or more of data in a day missing.

Table 2.1

Actigraphy Variables Selected for Analyses

Actigraphy Variable	Definition
Sleep Variables:	
Rest start time	Start time of the first epoch in the rest interval.
Sleep start time	Start time of the first epoch in the sleep interval.
Sleep onset latency	Time elapsed between rest start time and the following sleep start time.
Rest duration	Time elapsed between rest start and rest end time.
Sleep duration	Time elapsed between sleep start time and final wake time (sleep end).
Total sleep time	Total number of epochs between the start and end of the sleep duration period scored as sleep by the Actiware® software multiplied by the epoch length in minutes.
Sleep efficiency (% sleep)	Percentage of scored total sleep time within the sleep duration period.
Sleep end time	Time at the end of the last epoch in the sleep interval.
Snooze time	Time elapsed between wake time and rest end time.
Rest end time	Time at the end of the last epoch in the rest interval.
Percentage wake	Percentage of scored total wake time for the sleep interval.
Wake after sleep onset (WASO)	Total number of epochs between the start and end of the sleep interval multiplied by epoch length in minutes.
Sleep fragmentation index	Sum of percent mobile and immobile bouts that are less than 1 minute duration to the number of immobile bouts in the sleep interval.
Wake Variables:	
Activity start time	Start time of the first epoch in the active interval (i.e. beginning of waking activity for the day, following rise time).
Activity end time	Time at the end of the last epoch in the active interval (i.e. the end of activity prior to rest interval).
Activity duration	Time elapsed between the activity start and end times.
Total activity count (AC)	Sum of all valid physical activity counts for all epochs from the start to the end of the active interval.
Average AC per minute	Average of all valid physical activity counts for all epochs from the start to the end of the active interval divided by the epoch length in minutes.
Invalid activity time	Total number of epochs between the start and end of the active interval exceeding the maximum possible value (invalid data due to hardware error or data corruption) plus the total number of epochs manually excluded multiplied by the epoch length in minutes.

Of the potential 364 daytime periods of data (52 participants x 7 days), 26 days (7.1%) were excluded due to illness. A further 44 (12.1%) were not used due to invalid AC >180 minutes. Therefore 80.8% of daily data were usable. As some families completed seven nights of recording and others eight, there was a total of 379 potentially usable nights. Of these, 26 (6.9%) were excluded due to illness and one (0.3%) due to the actigraph being left off the child's wrist at bedtime and being replaced at around midnight. This resulted in 92.9% of recordings at night being available for analysis. Resulting school and non-school data were averaged for each child and databases were set up with raw and averaged data (see Section 3.1).

2.9 Data Analysis

Data were analysed using SPSS 16.0 software and graphs were produced with PRISM 4.0 software (Graphpad Software, United States of America). *P* values < .05 were considered to be significant. The Shapiro-Wilk test of normality was applied to variables prior to identifying appropriate parametric or non-parametric statistical tests. The Shapiro-Wilk test was selected, as it yields exact significance values and has therefore been found to be more accurate than the Kolmogorov-Smirnov test (Field, 2005). Sleep propensity curves for school and non-school nights were calculated using purpose-built Excel software (Microsoft Office Excel 2007). Descriptive statistics (*M* and *SD* if normally distributed, or *Mdn* and range) and frequency distributions were produced for questionnaire, diary and actigraphy variables. Hypotheses (see Section 1.8) were investigated using statistical methods outlined below and parental feedback was summarised.

2.9.1 Hypothesis 1: School versus Non-School Sleep

Averaged school and non-school night actigraphy sleep variables were analysed using parametric dependent t-tests or non-parametric Wilcoxon signed-rank tests, depending on normality of distribution. School day and non-school day actigraphic activity variables were analysed in the same manner.

2.9.2 Hypothesis 2: Girls' versus Boys' Sleep

Independent t-tests were run on school and non-school night actigraphy variables, categorised by gender. An independent t-test was also carried out to evaluate whether boys and girls in the sample differed in age.

2.9.3 Hypothesis 3: Parental Report versus Objectively Measured Sleep

Parental report of usual school and weekend sleep from the CSHQ section of the questionnaire was compared to averaged actigraphically measured sleep variables, on school and non-school nights. Independent t-tests and Wilcoxon signed-rank tests were used, depending on normality of distribution.

2.9.4 Hypothesis 4: Relationship between Body Size and Sleep

Children were categorised as being overweight/obese or normal/thin, according to Ministry of Health (2008) BMI cut-off values for boys and girls by age. As data were not normally distributed, Mann-Whitney tests were run to analyse potential differences in actigraphic sleep variables, total CSHQ scores and CSHQ sleep disordered breathing scores of children in the two categories.

2.9.5 Hypothesis 5: Normal versus Problem Sleepers

Four dichotomous categories were developed for 'problem' sleep:

- Parental report in the CSHQ (last question) of their child's sleep being a small or serious problem.
- Total CSHQ score >41 (Owens, Spirito, & McGuinn, 2000).
- Actigraphic sleep duration < 9 hours, as defined by Nixon (2008).
- Actigraphic sleep duration < 10 hours.

For each definition of 'problem' sleep, children were placed in either a 'problem' or 'no problem' category. Mann-Whitney U tests were used to compare childrens' actigraphic sleep variables and total CSHQ scores. Additional analyses were carried out, comparing actigraphic sleep durations of children who went to bed after 21:00 with those who went to bed on or before 21:00 (Nixon, 2008).

2.9.6 Hypotheses 6 and 7: Psychosocial, Behavioural and Environmental Factors in Relation to Sleep

Questionnaire and diary data were considered, as follows:

Categorical

- Technology in bedrooms (yes/no)
- Screens in bedrooms (yes/no)
- Caffeine consumption (yes/no)
- Bedroom share (yes/no)
- Bed share (yes/no)
- Crowded housing (> 6 people living in the house)
- Childcare use (yes/no)
- Daily childcare (yes/no)
- Skipped breakfast (yes/no)

Continuous

- Screen time – averaged and daily minutes
- Childcare – averaged and daily minutes
- Childcare – daily finishing time

Actigraphic sleep variables, on school and non-school nights, were compared using Mann-Whitney U tests for dichotomous variables, and Spearman's signed-rank tests for continuous independent variables. Simple linear regression analyses were carried out on continuous variables that were significantly correlated. Multiple linear regression analyses were run using daily screen time, childcare minutes and childcare finishing times as independent variables.

2.9.7 Hypothesis 8: Younger Siblings and Sleep

Questionnaire data were used to categorise participants as either having a younger child living in the home or not. Mann-Whitney U tests were run, using actigraphic sleep variables as independent variables.

2.9.8 Hypothesis 9: Waking Activity and Sleep

Independent variables, from diary and actigraphic daytime data, were as follows:

Categorical

- Engaged in an organised activity (yes/no) – daily data
- Mode of transport to school (active/passive)
- Mode of transport from school (active/passive)

Continuous

- Activity duration
- Total AC
- Average AC/minute

Actigraphic sleep quantity and quality variables were examined. Categorical data were analysed using Mann-Whitney U tests, and Spearman's rank-correlations were run on continuous data. Simple linear regression analyses were carried out on continuous variables with significant correlations.

2.9.9 Parental Feedback

Percentages were calculated for responses to questions 1 – 5 on the feedback form (Appendix E3) and parental comments were summarised.

3. Results

Data are presented from the 52 families who met the inclusion criteria (Section 2.3) and completed the study. Descriptive statistics from questionnaire, diary and actigraphic data are summarised to illustrate child and family demographics, environmental and lifestyle factors, as well as sleep and wake behaviour. Findings are presented from the specific analyses that were conducted to examine hypotheses, followed by an outline of parental feedback on the experience of participating in the study.

3.1 Description of the Sample

Table 3.1 summarises the available diary data from 52 participants and actigraphy data from 51 participants (one child was unwell across the entire week of recording).

Table 3.1
Child's Sleep/Wake Diary and Actigraphy Database Sample Sizes

Measure	School Day	Non-School Day	School Night	Non-School Night
Child Sleep/Wake Diary:				
Daily data	229	107		
Averaged data	51	50		
Actigraphy:				
Daily/nightly data	205	90	241	111
Averaged data	51	47	51	51

Note. School day = child attended school that day. Non-school day = child did not attend school that day. School night = child attended school the following day. Non-school night = child did not attend school the following day.

3.1.1 Sample Characteristics: Child/Family Questionnaire

The Child/Family Questionnaire (Appendix B3) was completed by all 52 families in the study. Shapiro-Wilk test of normality values for questionnaire variables can be seen in Appendix G1. These were used, along with the viewing of frequency distributions of data, to ascertain if variables were normally distributed (Field, 2005).

The sample consisted of 52 children living in the Wellington region. All children were in Year 3 at school and were reported by parents to not have any form of diagnosed developmental disorder. One set of monozygotic twins took part in the study.

Age and Gender

Children's ages ranged from 6.9 to 8.4 years (M = 7.6 years, SD = 0.3), as illustrated in Figure 3.1, and they included 22 (42%) boys and 30 (58%) girls.

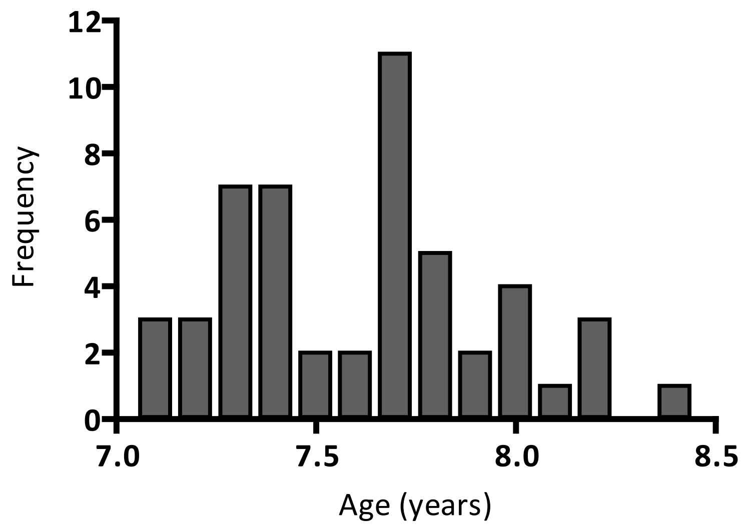

Figure 3.1. Frequency distribution of children's age (questionnaire data, N = 52).

School Deciles

Although the aim was to recruit 50% of the study sample from low decile schools (deciles 1 – 3) and 50% from high decile schools (deciles 8 – 10), this was not achieved. Figure 3.2 illustrates the skewed sample, with the majority of participants (90.4%) being children who attended schools with decile ratings of 8 – 10, and the highest proportion (63.5%) going to a decile 10 school. Five children (9.6%) who took part were enrolled in low decile schools.

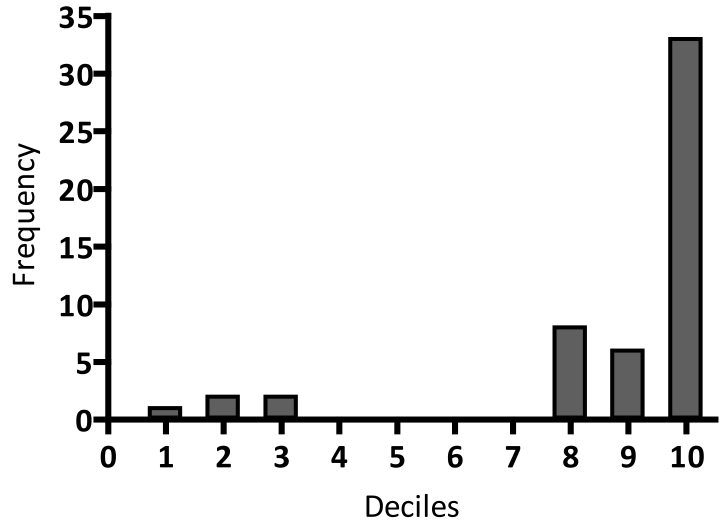

Figure 3.2. Frequency distribution of school decile ratings (questionnaire data, *N* = 52).

Ethnicity

The Child/Family Questionnaire (Statistics New Zealand, 2002), was used to ascertain the ethnicity of children and parents in the sample. Participants were asked to tick as many boxes as applied, in relation to ethnic identification. As per Ministry of Health (2004) guidelines, a total response output method was used. This involved participants being counted in each of the ethnic groups they reported. As some children and parents indicated more than one ethnic group, the totals exceeded 100%.

Of the 51 responses to the question on children's ethnicity (Figure 3.3), the majority of children were identified as NZ European. Māori and Indian were the next largest groups.

Identification with the New Zealand European ethnicity group was reported by 82.4% of mothers and 73.1% of fathers (Appendix G2). Māori and Indian were the next largest groups for mothers at 5.8%, and Indian was the next largest group for fathers at 5.8%. A total of 3.8% of fathers identified as Māori.

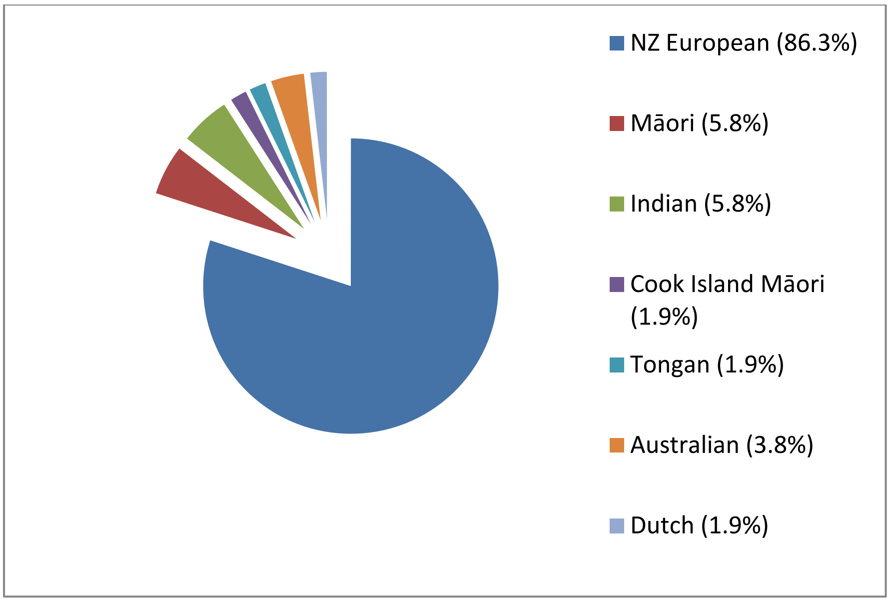

Figure 3.3. Ethnic identification of children in the sample (questionnaire data, *N* = 51).

Health

Three parents (5.8%) reported that their child had health problems that may have affected their sleep. These were anxiety (*n* = 1, 1.9%), ear infections (*n* = 1, 1.9%) and mild hayfever (*n* = 1, 1.9%). One child from the sample was followed up clinically by Dr Elder due to sleep-related concerns raised by the family.

Family Home Environment

Table 3.2 describes the composition of participating households, sleeping environments, and numbers of adults in paid employment. The majority (86.5%) of children lived in homes with two adults. Single parent households made up 5.8% of the sample and 3.8% of children lived in a house with either three or five adults. Most (71.2%) families had two children living at home, whilst 13.5% had three children and 3.8% four children. Study participants who were the only child living in the house made up 11.5% of the sample. Under half (44.3%) of the families had siblings younger than the participant, 20 (38.5%) had one younger child and three (5.8%) had two.

In regards to sleeping environments, 67.3% of children did not share a bedroom, 30.8% shared a room with one other child, and one participant (1.9%) regularly shared a bedroom with two adults and one sibling. Whilst the majority (96.2%) of children slept in their own bed by themselves, one child (1.9%) regularly shared a bed with their sibling and one (1.9%) shared a bed with their mother sometimes. Additionally, one participant was reported to be sharing a bed and bedroom with their parents, but this was temporary due to house renovations.

Most (96.2%) families had at least one adult living in the house who was in paid employment, whilst two (3.8%) did not. Approximately two thirds of families (67.3%) had two adults in some form of paid employment and one quarter (25.0%) with one adult in paid work. One (1.9%) family had three adults and one (1.9%) had five adults in paid employment. The predominant work pattern was 'daytime with no shifts (full-time)' (80.8%), followed by 'daytime with no shifts (part-time)' (42.3%). Figure 3.4 illustrates the distribution of employment patterns reported by families.

Table 3.2

Family and Home Environment Descriptive Statistics (Questionnaire Data)

	Median	Range	*N*
Adults in house	2	1 – 5	52
Children in house	2	1 – 4	52
Younger children in house	0	0 – 2	51
Bedroom sharing – other children	0	0 – 1	52
Bedroom sharing – adults	0	0 – 2[a]	52
Bed sharing – children	0	0 – 2[a]	52
Bed sharing – adults	0	0 – 2	52
Adults in paid employment	2	0 – 5	52

Note. Values reported as medians and ranges, as data were not normally distributed.
[a]Two families reported their child shared a bedroom/bed with adults. For one family this was temporary due to house renovations.

Childcare

Approximately three quarters (78.8%) of children were not in childcare or after school care of any sort (*Mdn* = 0). The 21.2% who were, ranged from having 1.25 – 17.50 hours of childcare per week. One child had regular morning care from 07:30 – 08:30.

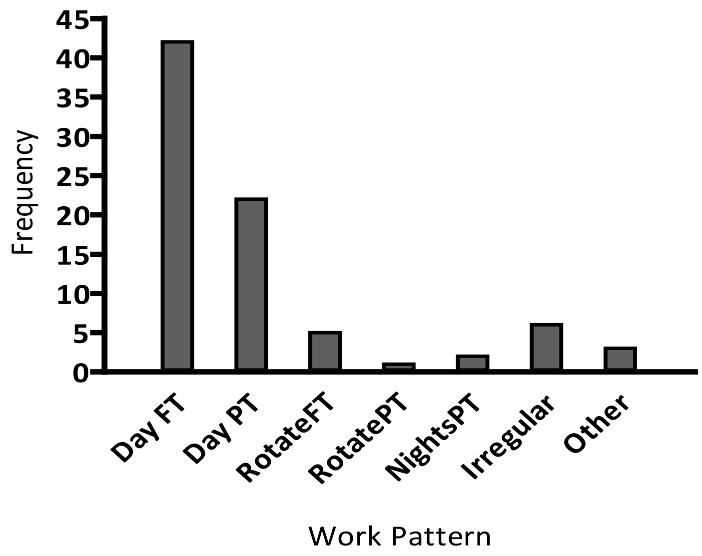

Figure 3.4. Frequency distribution of family work patterns (questionnaire data, *N* = 52). FT=fulltime, PT=part-time, Day=daytime no shifts, Rotate=rotating shifts, Nights=night shifts, Irregular=irregular or variable hours, Other=the option selected by parents when work patterns did not fit into other categories.

Technology in Bedrooms

Figure 3.5 illustrates the distribution of technology in children's bedrooms. Over half (55.8%) of the children who took part in the study did not have any of the technologies in their rooms. Of those who did, stereos or similar technology such as iPods were most prevalent (36.5%), followed by televisions (9.6%), computers (3.8%) and Play Stations (3.8%). Children with screens in their rooms (televisions, computers or Play Stations) accounted for 11.5% of the total sample.

Caffeine Consumption

Around two thirds (67.3%) of children were reported to never consume caffeinated beverages such as tea, coffee, cola drinks or Mountain Dew (excluding energy drinks). Fifteen (28.8%) did so sometimes (once or twice a week at most) and two (3.8%) drank one or two cups or cans per day. The majority of the sample (98.1%) never consumed energy drinks and one child (1.9%) did so sometimes.

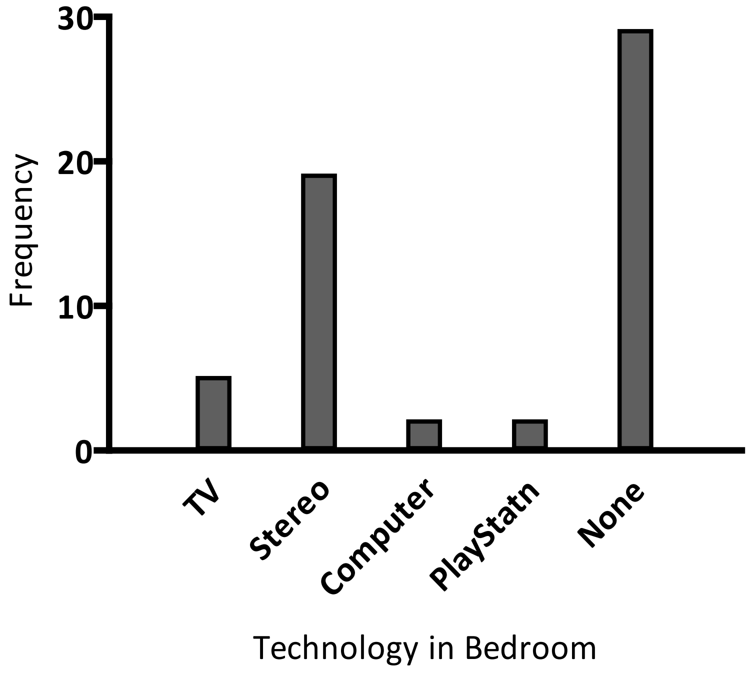

Figure 3.5. Frequency distribution of technology in bedrooms (questionnaire data, *N* = 52).

Body Size

Appendix G3 provides data on height, weight and BMI of children and parents, broken down by the children's age and gender. As height and weight data were not reported for all participants, BMI values were produced for 42 (80.8%) children, 47 (90.4%) mothers and 40 (76.9%) fathers. Average BMI for children was 16.22 (*SD* = 1.56) and ranged from 13.91 – 20.40. BMI ranged from 18.00 – 35.16 (*Mdn* = 22.86) for mothers and 20.18 – 39.08 (*Mdn* = 25.07) for fathers. Figure 3.6 illustrates the frequency distribution of BMI for the 42 children for whom both height and weight details were available.

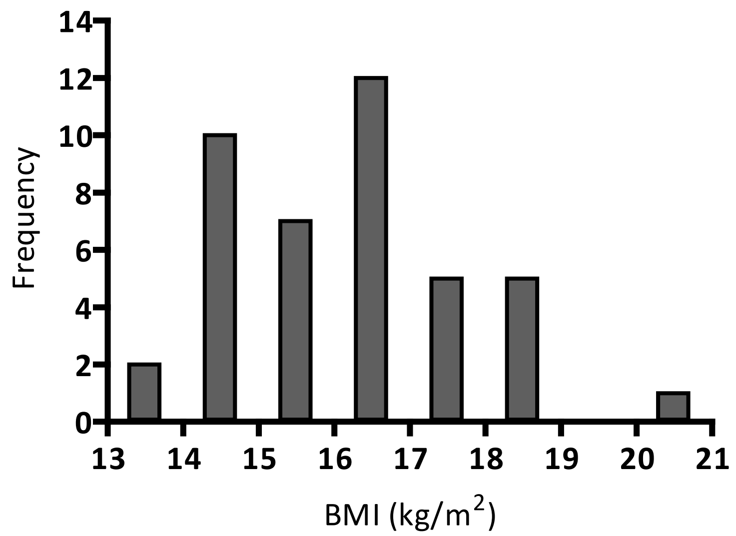

Figure 3.6. Frequency distribution of children's BMI (kg/m^2) (questionnaire data, N = 42).

Using Ministry of Health (2008) BMI cut-off values for age and gender, Figures 3.7 and 3.8 illustrate the distribution of children falling into normal, overweight and thinness categories. In total, six children (14.3%) met criteria for being overweight, two (4.8%) for being thin and 34 (81.0%) for normal body size. None of the children were obese.

The majority of mothers (68.1%) in the sample were of normal body size, whilst three (6.4%) met criteria for thinness, six (12.8%) for being overweight and six (12.8%) for being obese. Half (50.0%) of fathers were of normal body size, thirteen (32.5%) were in the overweight range and seven (17.5%) were considered to be obese.

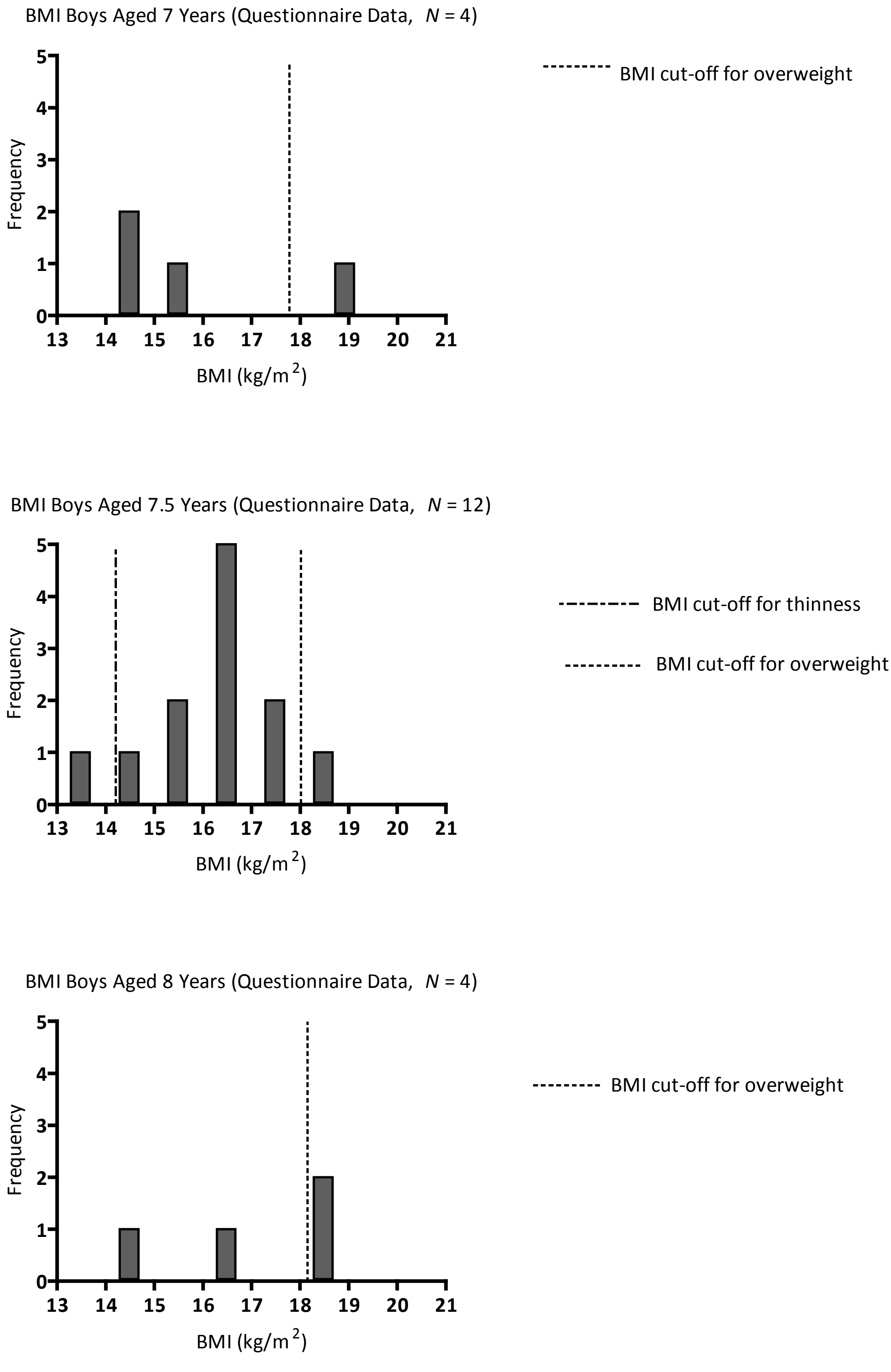

Figure 3.7. Frequency distributions of boys' BMI (kg/m^2) by age (questionnaire data).

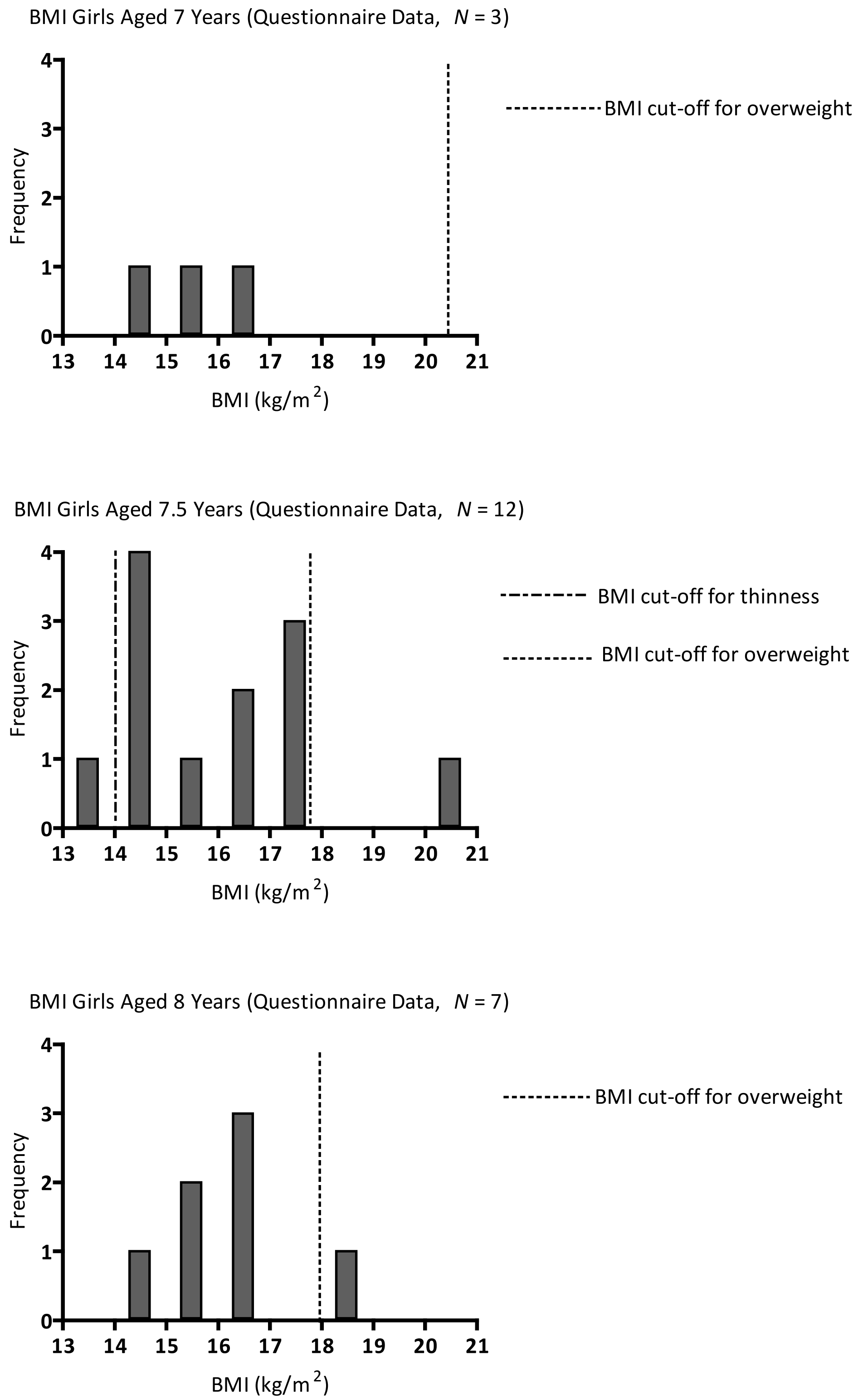

Figure 3.8. Frequency distributions of girls' BMI (kg/m^2) by age (questionnaire data).

3.1.2 Parental Reports of Sleep Behaviour: CSHQ

Children's typical sleep behaviour, as reported by parents, was scored using standardised criteria (see Section 2.6 and Appendix F1). The distribution of CSHQ responses can be found in Appendix G4. Data were not normally distributed, except for parental estimation of school night sleep (see Appendix G5 for Shapiro-Wilk values).

Figure 3.9 presents distribution data for the Total CSHQ scores of the entire sample. A cut-off of 41 is normally used to identify the potential need for further evaluation of sleep disturbance (Owens, Spirito, & McGuinn, 2000) (see Section 2.1.3). Nineteen (36.5%) participants had scores above this threshold.

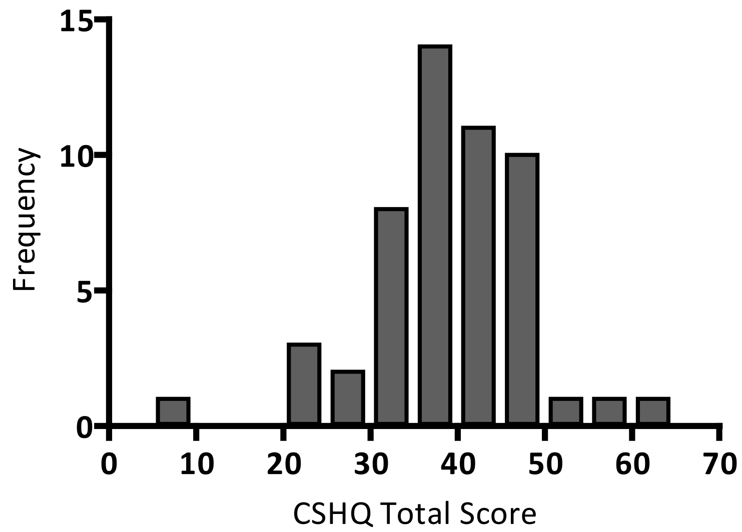

Figure 3.9. Frequency distribution of CSHQ Total Score (questionnaire data, *N* = 52).

Table 3.3 provides descriptive statistics for the total and subscale scores in the CSHQ, including the number of non-responses to questions which were scored as zero, as discussed in Section 2.6. This illustrates the broad range of responses within the reasonably small sample size.

Fifty parents indicated how much sleep their child usually had on school and weekend nights. Estimates were similar for both, at approximately ten and a half hours, (school nights: *M* = 10.49 hours, *SD* = 0.75; weekend nights: *Mdn* = 10.50 hours, range = 8.25 –

11.25), however the range was greater by 25 minutes on school nights (9.00 – 12.42 hours).

The final question in the CSHQ asked parents if they considered their child's sleep to be a problem. Fourteen (26.9%) responded that they thought their child had a 'small' or 'very serious' problem with their sleep. Analyses of 'problem sleepers' compared with the rest of the sample are discussed further in Section 3.6.

Table 3.3

Descriptive Statistics for CSHQ Scores (Questionnaire Data, N = 52)

	Median	Range
Total CSHQ:		
Total score	38	6 – 60
Total non-responses	0	0 – 27
Sub-scales:		
1. Bedtime Resistance (6 questions)		
Score	6	1 – 16
Non-responses	0	0 – 5
2. Sleep Onset Delay (1 question)		
Score	1	1 – 3
Non-responses	0	0
3. Sleep Duration (3 questions)		
Score	3	1 – 8
Non-responses	0	0 – 2
4. Sleep Anxiety (4 questions)		
Score	4	0 – 10
Non-responses	0	0 – 4
5. Night Wakings (3 questions)		
Score	3	1 – 8
Non-responses	0	0 – 2
6. Parasomnias (7 questions)		
Score	8	0 – 15
Non-responses	0	0 – 7
7. Sleep Disordered Breathing (3 questions)		
Score	3	0 – 11
Non-responses	0	0 – 3
8. Daytime Sleepiness (8 questions)		
Score	10	1 – 16
Non-responses	0	0 – 7

Note. Medians and ranges reported, as data not normally distributed. Values are not set for subscale score cut-offs.

3.1.3 Daily Activity: Diary Data

School and Non-School Days

Children were recorded as being sick on a total of 26 days (7.1%). These were removed from the dataset, due to the potential impact that illness has on normal sleep and wake behaviour (Sadeh & Acebo, 2002). Diary data for a total of 229 school days and 107 non-school days were analysed in relation to daily activity.

Transport to and from School

Passive transport was used more often than active transport for travel to and from school. As illustrated in Table 3.4, cars were the most prevalent mode of transport, followed by walking. In total, passive transport (car or bus) was used to go to school on just over half (53.7%) of school days, as opposed to active transport (walking, biking or scootering) which was used 46.3% of the time. Children also came home from school using predominantly passive transport (car or bus = 58.5%), compared with active transportation means (walking, biking or scootering = 41.5%).

Table 3.4
Distribution of Transport To and From School (Diary Data, N = 229)

	Frequency	%
To School		
Car	116	50.7
Bike or scooter	7	3.1
Walked	99	43.2
Bus	7	3.1
Total	229	100.0
From School		
Car	131	57.2
Bike or scooter	4	1.7
Walked	91	39.7
Bus	3	1.3
Total	229	100.0

Screen Time

Variables were not normally distributed for screen use and screen time on school and non-school days (see Appendix G5 for Shapiro-Wilk details). On days that children went to school, nearly three quarters of participants spent some time watching television, using a computer or playing video games (Table 3.5). This increased on weekends and days that school was not attended, such as teacher-only days.

Figure 3.10 illustrates the increase in time use of screens on non-school days. Children spent approximately one hour (daily data: *Mdn* = 60 minutes, range 10 – 210 minutes; averaged school day data: *Mdn* = 63 minutes, range 20 – 156 minutes) on school days using screens, compared with two hours on non-school days (daily data: *Mdn* = 120 minutes, range 30 – 360 minutes; averaged non-school day data: *Mdn* = 120 minutes, range = 35 – 300 minutes).

Table 3.5
Distribution of Parentally Reported Screen Use (TV, Computer, Video Games)

	Frequency	%
Screen Use on School Days:		
Yes	163	71.2
No	57	24.9
Total	220	96.1
Screen Use on Non-School Days:		
Yes	92	86.0
No	10	9.3
Total	102	95.3

Participation in Organised Activities

Table 3.6 provides a summary of children’s engagement in organised activities throughout the week. Participation in structured activity occurred on approximately one third of school and non-school days, and sports and swimming were the most popular activities.

Table 3.6

Distribution of Parentally Reported Organised Activities on School and Non-School Days (Diary Data)

	Frequency	%
School Days:		
Organised Activity		
Yes	77	33.6
No	147	64.2
Total	224	97.8
Type of Activity		
Brownies/Cubs/Pippins	3	1.3
Dance/disco	13	5.7
Gym	4	1.8
Martial arts	3	1.3
Maths/language tuition	3	1.3
Music/drama/singing	12	5.2
Sport	17	7.4
Swimming	19	8.3
Total	74	32.3
Non-School Days:		
Organised Activity		
Yes	35	32.7
No	68	63.6
Total	103	96.3
Type of Activity		
Art/activity programme	3	2.8
Birthday party	1	0.9
Dance	2	1.9
Language tuition	1	0.9
Music/drama/singing	4	3.7
Sport	14	13.1
Sunday school	1	1.9
Swimming	7	6.5
Total	33	30.8

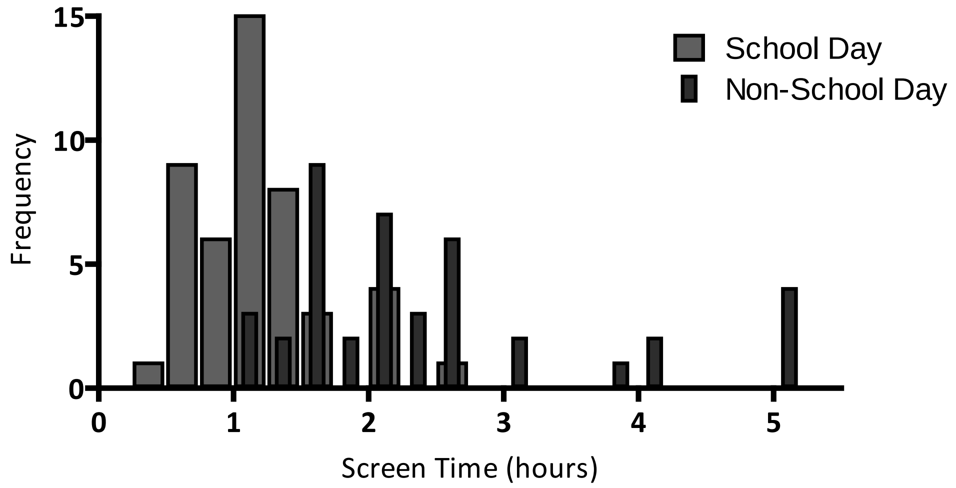

Figure 3.10. Frequency distribution of average screen time use on school and non-school days (diary data, *N* = 47).

Parentally Reported Levels of Activity

Parental reports of the duration of children's 'physical', 'moderate' and 'quiet' play were not normally distributed (see Appendix G6 for Shapiro-Wilk values). Table 3.7 summarises school and non-school day activity. On school days, children engaged in approximately one hour of sedentary, moderate and physically active play, whereas on non-school days they appear to have spent more time engaged in quiet and moderately physical activities. A greater variance in activity time was apparent between participants on non-school days, as indicated by the range of values in Table 3.7.

Meal Consumption

Parental report of children's breakfast, lunch and dinner consumption showed that the majority of children did not skip meals. On school days, breakfast was not eaten on four (1.8%) out of 227 days reported. Similarly, children were reported as missing breakfast on two (1.9%) of the non-school days.

Table 3.7

Descriptive Statistics for (Averaged) Parental Report of Activity on School and Non-School Days (Diary Data)

	Median (hours)	Range (hours)	*N*
School Days:			
‘Physical’ play	1.00	0.33 – 2.33	45
‘Moderate’ play	1.00	0.25 – 3.83	49
‘Quiet’ play	1.07	0.17 – 2.83	50
Non-School Days:			
‘Physical’ play	1.00	0.38 – 6.75	39
‘Moderate’ play	1.58	0.29 – 6.50	48
‘Quiet’ play	2.00	0.46 – 10.00	44

Note. Medians and ranges reported, as data were not normally distributed.
‘Physical’ play = lots of running/fast moving. ‘Moderate’ play = some running/moving. ‘Quiet’ play = mostly sitting/small amount of moving.

Atypical Days

Unusual events were reported by parents on school and non-school days, with 21 (9.4%) of a total of 223 school days reported as being atypical and 29 (29%) of 100 non-school days. Besides children being sick on 26 of these days, events that affected bedtimes and wake times are summarised in Table 3.8.

3.1.4 Objective Sleep and Waking Activity: Actigraphy

Actigraphy data collected over seven days and nights for each participant were split into school and non-school days and nights. Results of the Shapiro-Wilks test of normality for actigraphy variables are provided in Appendices G7 and G8. Descriptive statistics for averaged school and non-school night sleep and rest variables (see Section 2.7.4 for definitions) are summarised in Tables 3.9 and 3.10.

On average children slept at least nine and a half hours per night (including wake time during sleep periods) throughout the week (Tables 3.9 and 3.10). Sleep occurred almost exclusively at night, with one child in the sample napping on one occasion.

Table 3.8

Parentally Reported Events that Impacted on School and Non-School Sleep and Wake Times (Diary Data, School Days N = 223, Non-School Days N = 100)

	Frequency	%
School Days:		
Later Bedtimes		
Having a baby sitter	2	0.9
Birthday dinner	1	0.4
School show	2	0.9
School disco	2	0.9
Wearable Arts show	1	0.4
Sleepover at friend's house	1	0.4
Earlier Wake Times		
Excited about the study	2	0.9
Woken by sibling	1	0.4
Non-School Days:		
Later Bedtimes		
Diwali celebrations	1	1.0
Family/birthday dinner	3	3.0
All Blacks test	2	2.0
Sleepover at home	2	2.0
No school (parent/teacher conferences) so stayed up later watching a movie	1	1.0
Earlier Wake Times		
Woken by sibling	1	1.0

Table 3.9

Descriptive Statistics for Averaged School Night Rest and Sleep (Actigraphy Data, N = 51)

	Mean	Standard Deviation	Range
Rest start time	20:19	00:39	19:01 – 21:47
Sleep start time	20:43	00:39	19:24 – 22:06
Sleep end time	06:35	00:29	05:17 – 07:37
Rest end time	07:01	00:24	06:09 – 07:54
Rest duration (hours)	10.70	0.54	9.73 – 11.81
Sleep duration (hours)	9.86	0.53	8.74 – 11.03
Total sleep time (hours)	8.62	0.45	7.73 – 9.39
Sleep efficiency (% sleep)	87.5	2.8	79.3 – 93.2
Percentage wake	12.5	2.8	6.8 – 20.6
Sleep onset latency (minutes)	21.4[a]		0.0 – 65.6
Snooze time (minutes)	22.2[a]		5.8 – 61.6
WASO (minutes)	74.6[a]		39.5 – 128.0
Sleep fragmentation	32.0	7.9	16.6 – 49.0

[a]Median reported, as data were not normally distributed.

Table 3.10

Descriptive Statistics for Averaged Non-School Night Rest and Sleep (Actigraphy Data, N = 51)

	Mean	Standard Deviation	Range
Rest start time	20:42	00:52	18:53 – 23:06
Sleep start time	21:10	00:53	19:10 – 23:21
Sleep end time	06:41	00:48	05:06 – 08:20
Rest end time	07:11	00:39	05:56 – 08:39
Rest duration (hours)	10.48	0.65	9.19 – 11.83
Sleep duration (hours)	9.51	0.73	8.31 – 11.35
Total sleep time (hours)	8.33	0.59	7.27 – 9.64
Sleep Efficiency (% sleep)	88.3[a]		76.5 – 93.0
Percentage wake	11.7[a]		7.0 – 23.5
Sleep onset latency (minutes)	22.5[a]		0.0 – 122.0
Snooze time (minutes)	28.0[a]		1.5 – 109.7
WASO (minutes)	66.3[a]		40.0 – 154.0
Sleep fragmentation	32.8	9.3	12.8 – 63.2

[a]Median reported, as data were not normally distributed.

Figures 3.11 and 3.12 illustrate the distribution of average bedtimes, and times that children started sleeping, on school and non-school nights. The distribution of sleep duration and total amount of sleep that children obtained is represented in Figures 3.13 and 3.14. (Note: sleep duration was the amount of time between sleep onset and final wake up, including wake time within the sleep period. In comparison, total sleep time did not incorporate periods of waking).

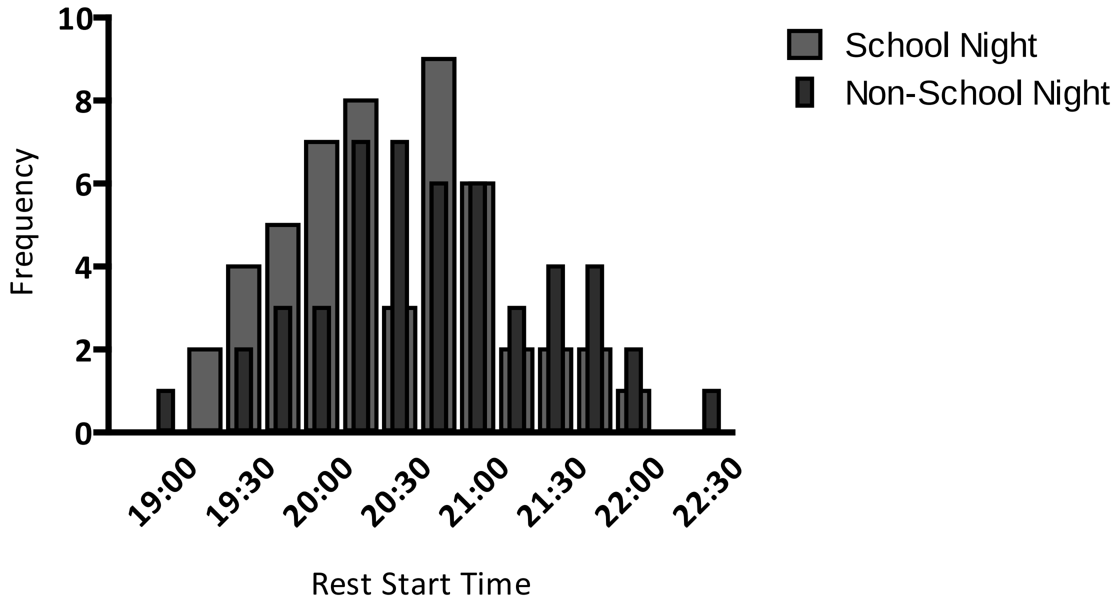

Figure 3.11. Frequency distribution of average rest start times on school and non-school nights (actigraphy data, *N* = 51).

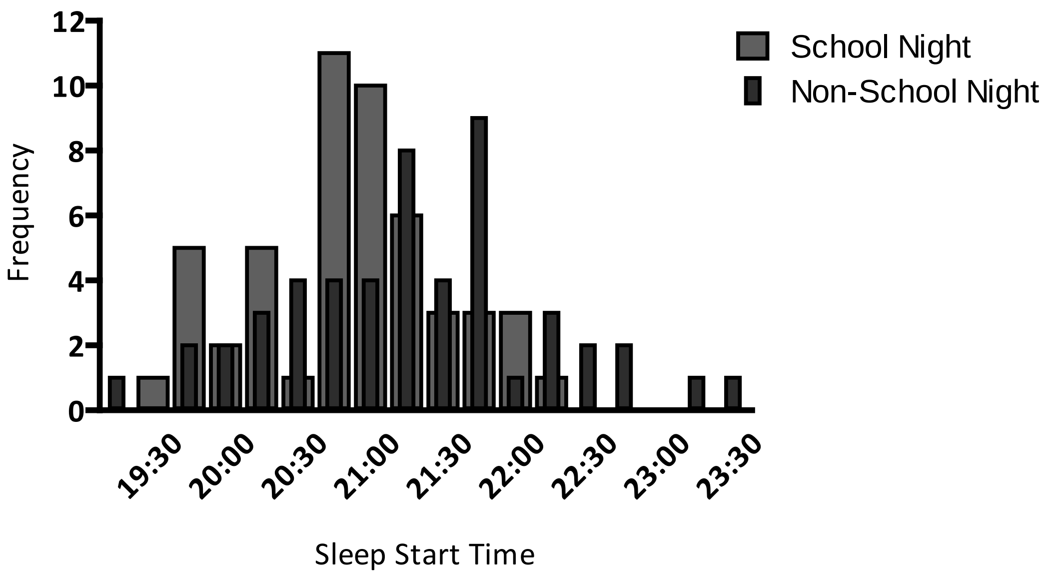

Figure 3.12. Frequency distribution of average sleep start times on school and non-school nights (actigraphy data, *N* = 51).

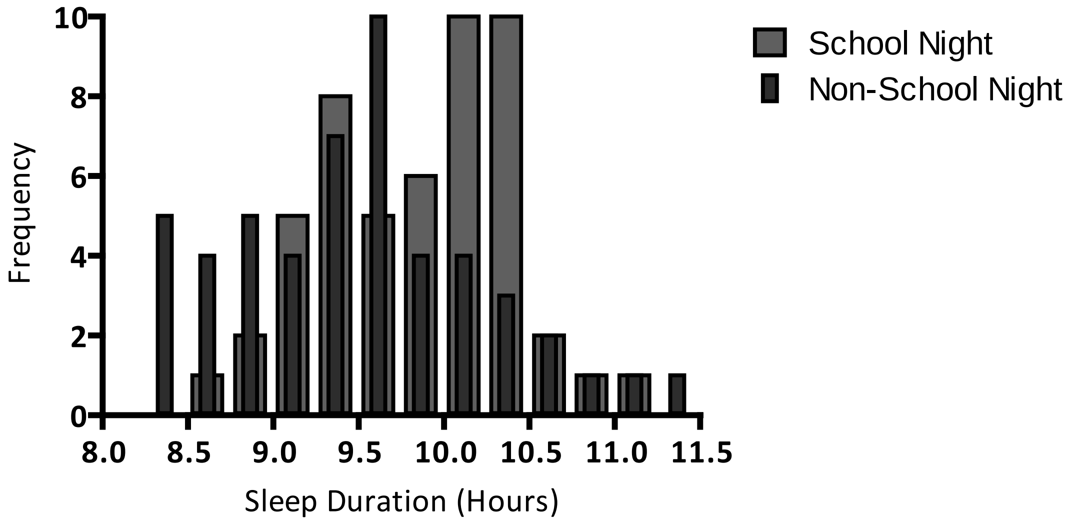

Figure 3.13. Frequency distribution of average sleep duration on school and non-school nights (actigraphy data, *N* = 51).

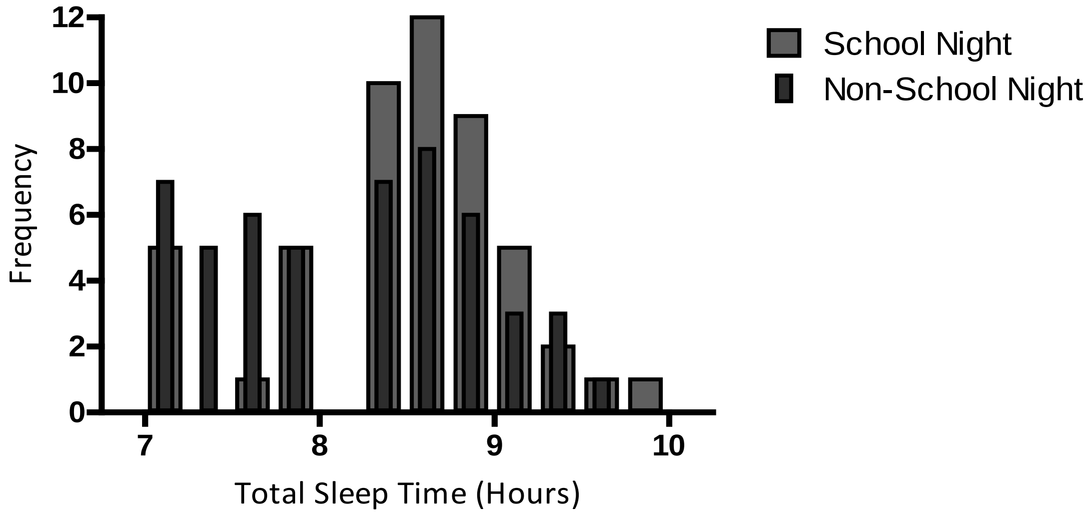

Figure 3.14. Frequency distribution of average total sleep time on school and non-school nights (actigraphy data, *N* = 51).

The distribution of average sleep efficiencies on school and non-school nights can be seen in Figure 3.15, with 82.4% of children recording efficiencies of at least 85% on both school and non-school nights. The time it took for children to fall asleep, and before getting out of bed (snooze time), is illustrated in Figures 3.16 and 3.17. There was more variability in both sleep onset latencies and snooze times on non-school nights compared with school nights.

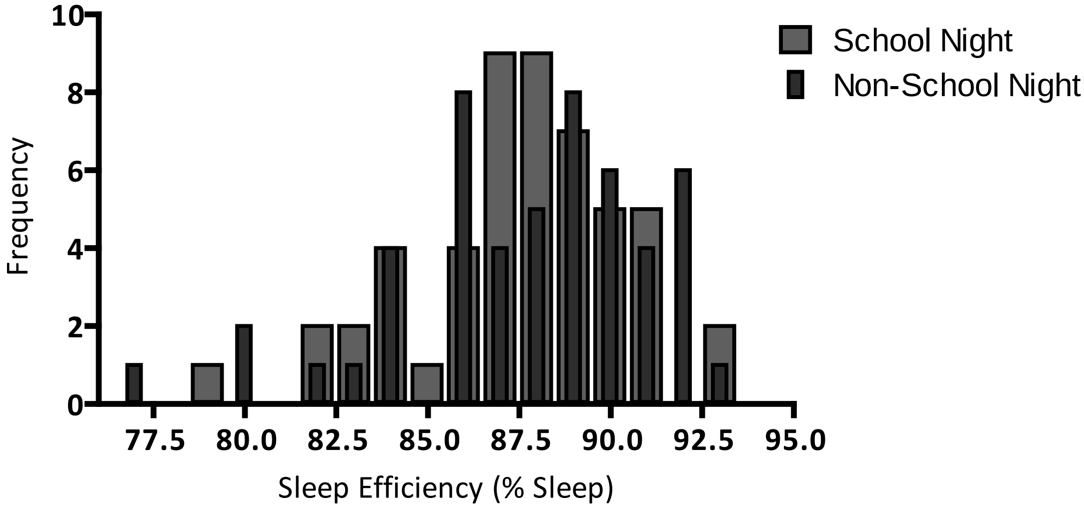

Figure 3.15 . Frequency distribution of average sleep efficiency on school and non-school nights (actigraphy data, *N* = 51).

Actigraphy data were used to create sleep propensity curves of children on school and non-school nights, as shown in Figures 3.18 and 3.19. These show a broader range of sleep and wake times occurring on non-school nights. Results of statistical analyses of differences in school and non-school night sleep are presented in Section 3.2.

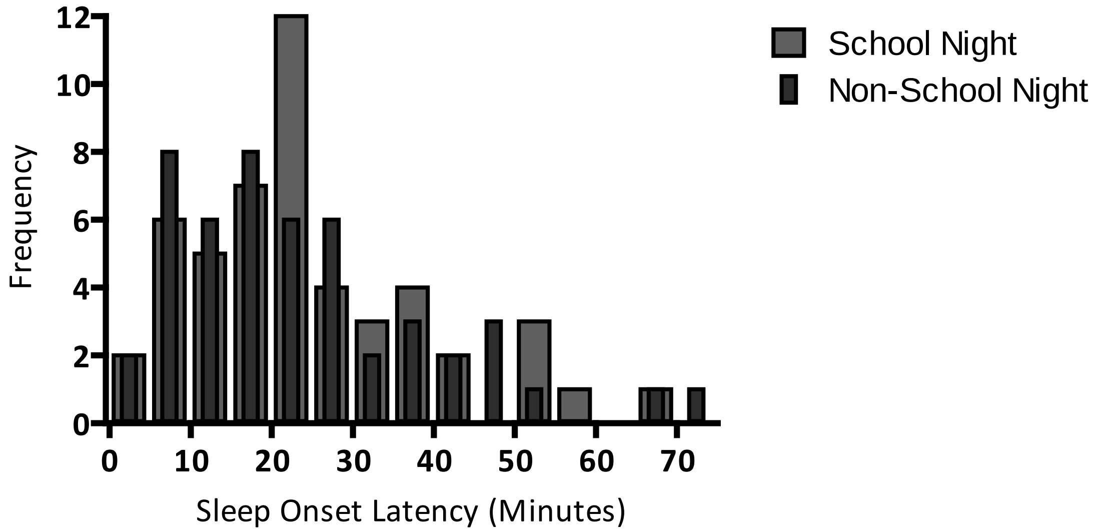

Figure 3.16. Frequency distribution of average sleep onset latency on school and non-school nights (actigraphy data, *N* = 51).

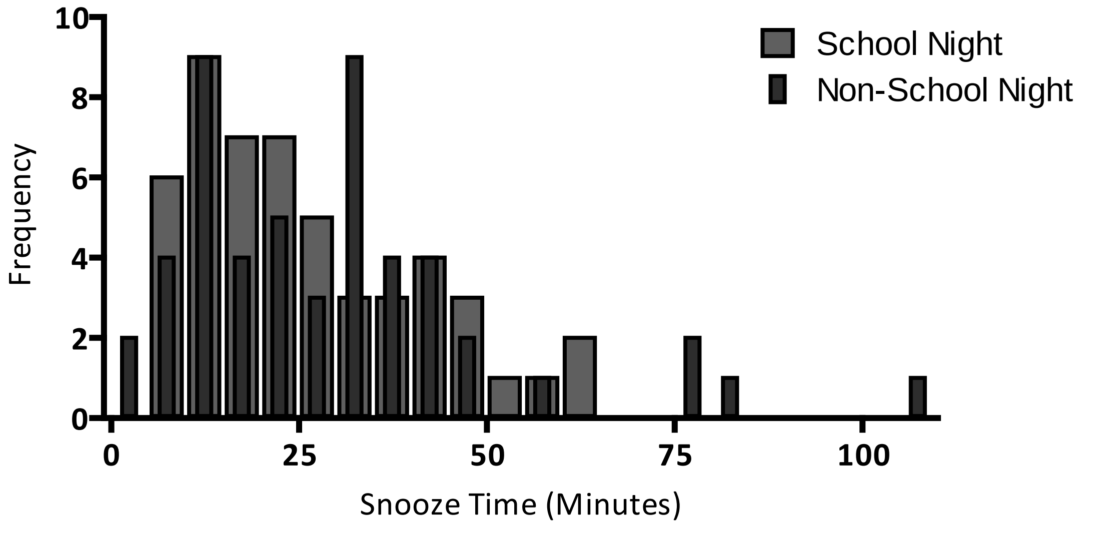

Figure 3.17. Frequency distribution of average snooze time on school and non-school nights (actigraphy data, *N* = 51).

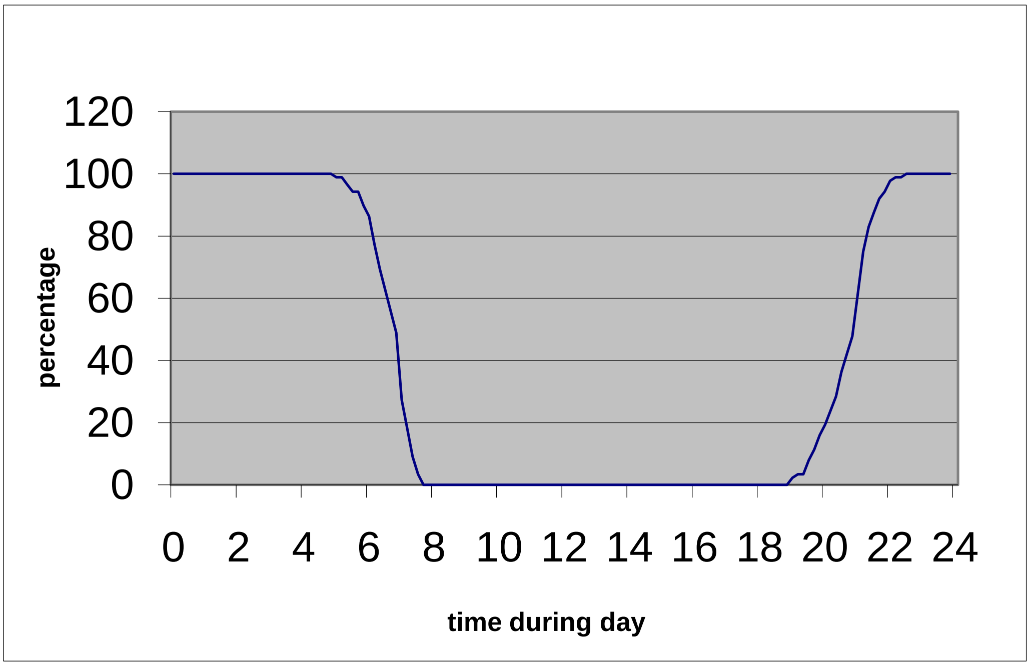

Figure 3.18. Average percentage of children asleep across 24 hours on school nights (N = 44).

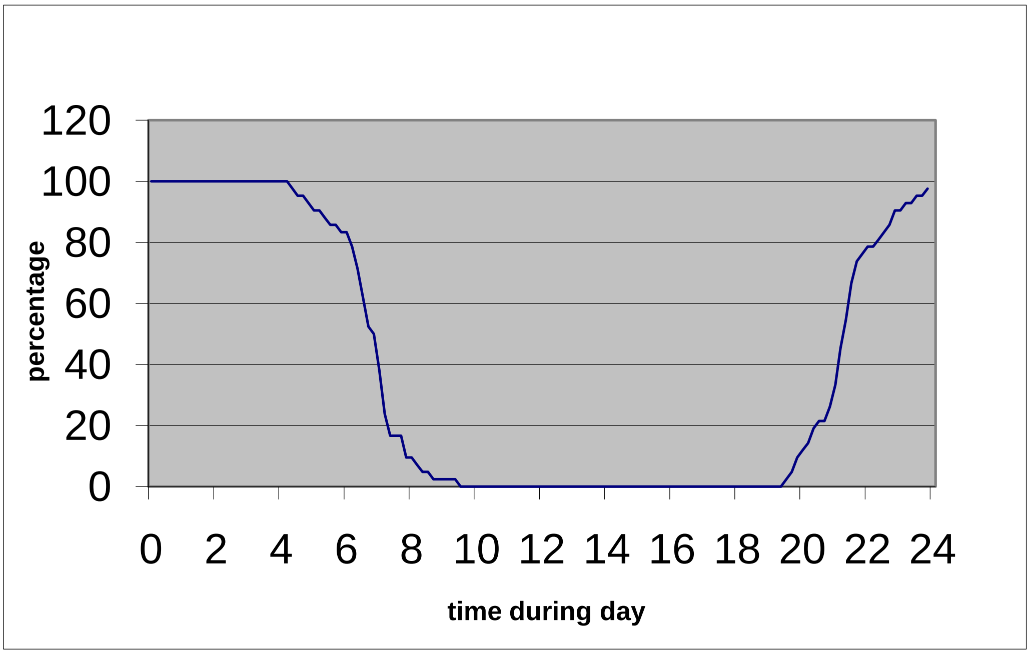

Figure 3.19. Average percentage of children asleep across 24 hours on non-school nights (N = 42).

Table 3.11 summarises descriptive statistics for averaged school and non-school waking activity. Activity start times were, on average, quarter of an hour later on non-school days than school days. Figures 3.20, 3.21 and 3.22 illustrate the duration of children's daily activity, as well as total activity counts and average activity counts per minute. Statistical analyses of differences in school and non-school day activity are discussed further in Section 3.2.

Table 3.11

Descriptive Statistics for Averaged School Day and Non-School Day Activity (Actigraphy Data)

	Mean	Standard Deviation	Range	*n*
School Day:				
Activity start time	07:00	00:24	06:02 – 07:46	51
Activity end time	20:20	00:47	17:59 – 21:53	51
Activity duration (minutes)	803.8[a]		630.2 – 875.8	51
Activity duration (hours)	13.39[a]		10.50 – 14.60	51
Average AC per minute	664[a]		445 – 940	51
Total AC	508805[a]		345152 –732811	51
Non-School Day:				
Activity start time	07:15	00:47	05:33 – 09:30	47
Activity end time	20:25[a]		17:17 – 23:01	47
Activity duration (minutes)	809.0[a]		467.3 – 933.0	47
Activity duration (hours)	13.48[a]		7.79 – 15.55	47
Average AC per minute	640	160	383 – 968	47
Total AC	491869	1	263364 – 746499	47

[a]Median reported as data not normally distributed.

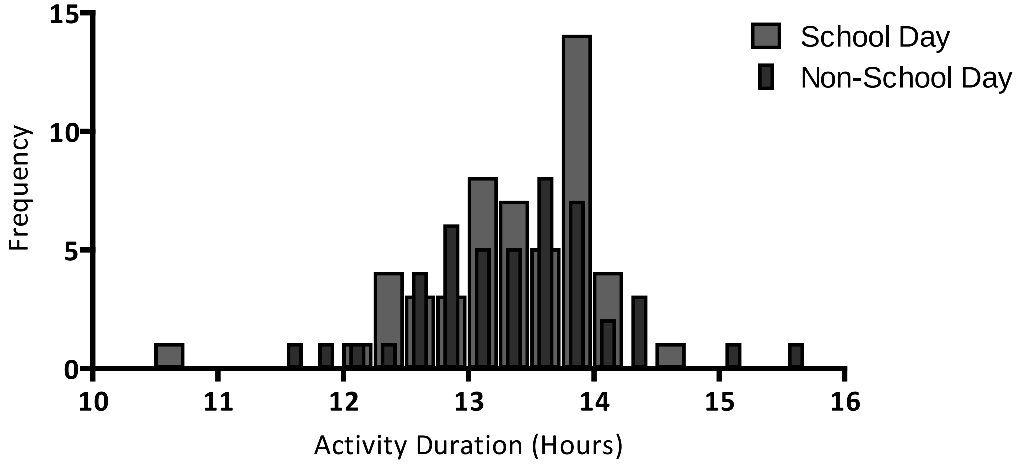

Figure 3.20. Frequency distribution of average activity duration on school and non-school days (Actigraphy data, School Day n = 42, Non-School Day N = 47).

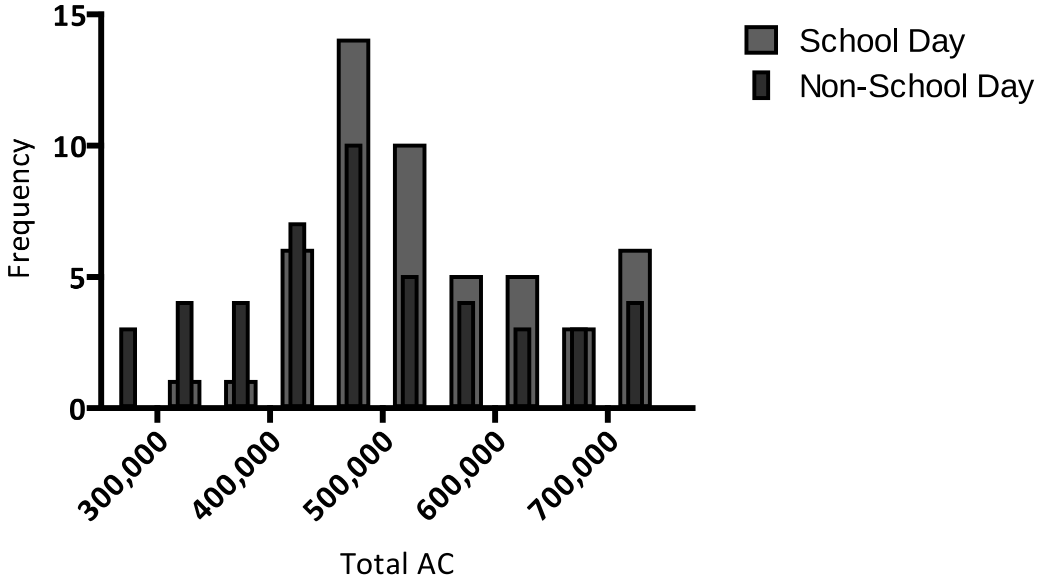

Figure 3.21. Frequency distribution of total activity counts on school and non-school days (Actigraphy data, School Day N = 42, Non-School Day N = 47).

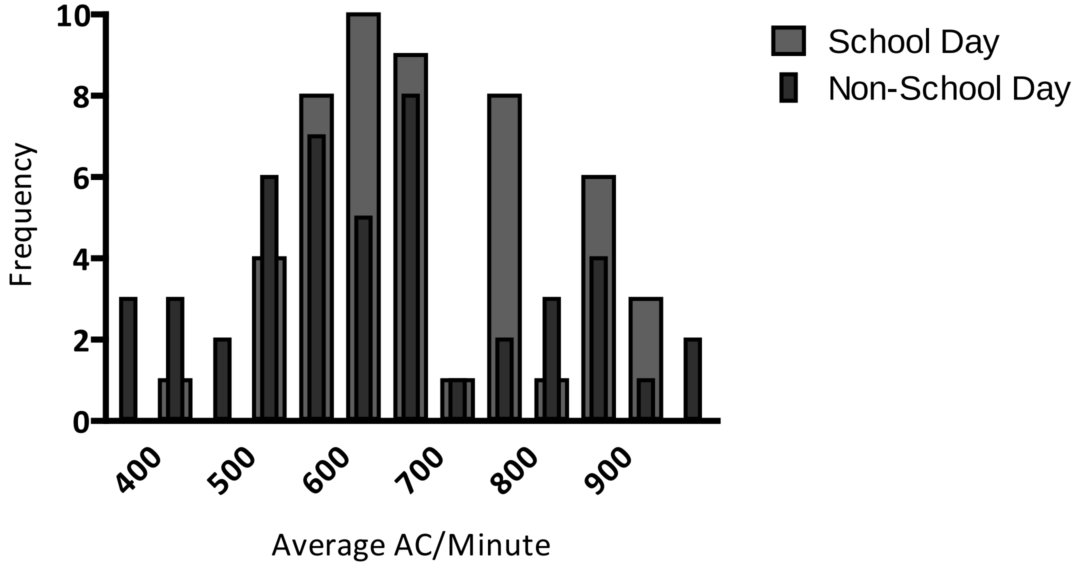

Figure 3.22. Frequency distribution of average activity counts per minute on school and non-school days (Actigraphy data, School Day N = 42, Non-School Day N = 47).

3.2 Comparison of School and Non-School Sleep and Waking Activity

Results presented in Tables 3.12 and 3.13 show that on average, children spent significantly more time in bed resting and sleeping, and obtained more sleep on school nights compared with non-school nights. Bedtimes and sleep start times were later on nights when there was no school the next day. Additionally children got up, and therefore commenced activity, later on non-school mornings. Average activity levels (average AC/minute and total AC) on non-school days were significantly lower than days when children went to school.

Table 3.12

Comparison of School and Non-School Sleep/Wake Activity (Actigraphy Data, Dependent t-test, Sleep N = 51, Wake N = 47)

Variable	School: Mean (Std Error)	Non-School: Mean (Std Error)	*t*	*df*	*p*	*r*
Rest start time	20:19 (00:05)	20:42 (00:07)	-4.49	50	< .001	.54
Rest end time	07:00 (00:03)	07:10 (00:05)	-2.65	50	.011	.35
Sleep start time	20:43 (00:05)	21:10 (00:07)	-5.74	50	< .001	.63
Sleep end time	06:35 (00:04)	06:41 (00:06)	-1.34	50	.185	.19
Rest duration (hours)	10.70 (0.08)	10.48 (0.09)	2.67	50	.010	.35
Sleep duration (hours)	9.86 (0.07)	9.51 (0.10)	3.87	50	< .001	.48
Total sleep time (hours)	8.33 (0.08)	8.62 (0.06)	-3.51	50	.001	.44
Sleep fragmentation	32.02 (1.11)	32.77 (1.30)	-0.88	50	.381	.12
Activity start time	06:58 (00:03)	07:15 (00:06)	-2.75	46	.008	.38

Table 3.13

Comparison of School and Non-School Sleep/Wake Activity (Actigraphy Data, Wilcoxon signed-rank test, Sleep N = 51, Wake N = 47)

Variable	School: Median (Range)	Non-School: Median (Range)	*T*	*z*	*p*	*r*
Sleep onset latency (minutes)[a]	21.4 (0.0 – 65.6)	22.5 (0.0 – 122.0)	543.00	-0.91	.362	-.09
Snooze time (minutes)[a]	22.2 (5.8 – 61.6)	28.0 (1.5 – 109.7)	526.00	-1.28	.199	-.13
Sleep efficiency (% sleep)[a]	88.1 (79.4 – 93.2)	88.3 (76.5 – 93.0)	541.00	-1.14	.253	-.11
Activity end time[a]	20:18 (17:59 – 21:53)	20:25 (17:17 – 23:01)	501.50	-0.66	.508	-.07
Activity duration (hours)[a]	13.40 (10.50 – 14.60)	13.48 (7.79 – 15.55)	456.50	-1.14	.255	-.12
Average AC/minute[a]	664 (445 – 941)	626 (383 – 969)	303.00	-2.76	.006	-.28
Total AC[a]	508,805 (345,152 – 732,811)	479,138 (263,364 – 746,499)	274.00	-3.07	.002	-.32

There was no difference in the amount of time to fall asleep, or to get up after waking, across the week. There were no significant differences found between average sleep end time, activity duration and activity end time on school and non-school days and nights.

In relation to sleep quality, wake after sleep onset (WASO) was not analysed. This was because it is a variable that is dependent on the duration of sleep, which was significantly different on school and non-school nights as already discussed.

3.3 Gender Differences in Sleep Duration and Timing

Potential differences in boys' and girls' sleep duration and timing were examined. The results (Appendix G9) showed no significant differences between the average start and end times of rest and sleep of boys and girls in the sample, on both school and non-school nights ($p > .05$). The average rest duration, sleep duration and total sleep times also did not differ significantly ($p > .05$).

To ensure that age was not a confounding factor, an independent t-test was used to compare age between boys and girls. No significant difference in the average age of girls ($M = 7.67$ years, $SE = 0.06$) and boys ($M = 7.52$ years, $SE = 0.07$) was found $t(50) = -1.55$, $p = .128$.

3.4 Comparison of Subjective and Objective Sleep

Parents' responses to the CSHQ question (Appendix B3) regarding estimation of children's usual school night and weekend night sleep were compared with averaged actigraphy variables of rest duration, sleep duration and total sleep time. Tables 3.14 and 3.15 provide a summary of results.

Table 3.14

Comparison of Parental Report and Actigraphic Sleep Duration on School Nights (Dependent t-test, N = 50)

Variable	Actigraphy: Mean (Std Error)	CSHQ Parental Report: Mean (Std Error)	*t*	*df*	*p*	*Effect Size, r*
Rest duration (hours)	10.69 (0.08)	10.48 (0.11)	2.50	48	.016	.34
Sleep duration (hours)	9.86 (0.08)	10.48 (0.11)	-6.62	48	< .001	.69
Total sleep time (hours)	8.62 (0.07)	10.48 (0.11)	-18.78	48	< .001	.94

Table 3.15

Comparison of Parental Report and Actigraphic Sleep Duration on Non-School Nights (Wilcoxon Signed-Rank Test, N = 50)

Variable	Actigraphy: Median (Range)	CSHQ Parental Report: Median (Range)	*T*	*z*	*p*	*Effect Size, r*
Rest duration (hours)	10.46 (9.19 – 11.83)	10.50 (8.25 – 11.25)	396.50	-1.77	.076	-.18
Sleep duration (hours)	9.53 (8.31 – 11.35)	10.50 (8.25 – 11.25)	84.00	-5.16	< .001	-.52
Total sleep time (hours)	8.30 (7.27 – 9.64)	10.50 (8.25 – 11.25)	0.00	-6.09	< .001	-.61

Findings indicate that parents' report of the amount of sleep that children usually had on school nights (Table 3.14), was significantly less than objectively measured time in bed. However, sleep was overestimated by parents when compared with actigraphic sleep duration and total sleep time. Similarly, on non-school nights (Table 3.15) parents overestimated the amount of sleep that children had, compared with objectively measured sleep duration and total sleep time. No significant difference was apparent between objective time in bed (rest duration) and subjective sleep estimates on non-school nights.

3.5 Relationship between Body Size and Sleep

Fewer children (14.2%) were categorised as being overweight compared to being thin or of normal body size. As no children in the sample were identified as being obese, the relationship between parental obesity and children's obesity was unable to be examined.

Analysis results (Appendices G10 and G11) indicate that there were no significant differences between children who were of thin or normal body size and those who were overweight, in objectively measured sleep quantity (sleep duration and total sleep time), or sleep quality (sleep efficiency, sleep fragmentation and sleep onset latency) on school and non-school nights. Subjective sleep measures (CSHQ total score and sleep disordered breathing score) also did not differ significantly.

3.6 Subjectively and Objectively Defined Problem Sleepers

Category membership of problem sleepers varied depending on criteria, with 37.3% of children in the > 41 CSHQ score group, 25.5% in the parentally reported problem group, 5.9% in the < 9 hour sleep duration group on school nights and 27.5% on non-school nights, and 29.4% in the < 10 hours sleep duration category on school nights and 76.5% on non-school nights.

Variables relating to sleep problem criteria were skewed (CSHQ > 41: $W(51) = .61$, $p < .001$; parental report CSHQ: $W(51) = .54$, $p < .001$; sleep duration < 9 hours: school nights $W(51) = .25$, $p < .001$, non-school nights $W(51) = .558$, $p < .001$; sleep duration < 10 hours: school nights $W(51) = .64$, $p < .001$, non-school nights $W(51) = .53$, $p < .001$). The decision was therefore made to compare problem and non-problem groups by using Mann-Whitney U tests. Comparisons were made between groups in relation to actigraphic sleep quantity, quality and timing variables, and total CSHQ scores, depending on the criteria used for problem sleep (Tables 3.16 – 3.19).

Using subjective measures of problem sleep, children with total CSHQ scores over 41 (Table 3.16) had significantly shorter amounts of sleep on school nights than those with lower scores. They also woke up later on non-school mornings. Additionally, participants whose parents reported they had a small or serious problem with sleep (Table 3.17), scored significantly higher in the CSHQ compared to those not considered to have a problem. They also went to sleep earlier, and obtained shorter amounts of total sleep on school nights than their counterparts.

Results from objectively measured problem sleep categories showed that on school nights, children with average sleep durations of less than nine hours (Table 3.18) had less fragmented sleep than those who slept longer. Shorter sleepers went to bed, and started sleeping, later on non-school nights. They were also found to take more time to fall asleep on non-school nights, compared to longer sleepers. When sleep duration of less than 10 hours was used (Table 3.19), shorter sleepers had significantly more efficient sleep on both school and non-school nights, and less fragmented sleep on school nights, in comparison to those who slept longer. There was a trend towards later bedtimes on non-school nights for shorter sleepers, as well as significantly later sleep start times.

Additional analyses were carried out, to explore whether children who went to bed after 21:00 had shorter sleep durations than those with earlier bedtimes, as per the findings of Nixon and colleagues (2008). In this sample of children, no significant difference was found between the sleep duration of children with bedtimes before and after 21:00 on school nights ($U = 229.00$, $p = .917$, $r = -.02$) and non-school nights ($U = 260.00$, $p = .691$, $r = -.06$).

Table 3.16

Comparison of Problem and Non-Problem Sleepers Defined by Total CSHQ Score > 41 (Mann-Whitney U test)

Variable	Problem: Median (Range)	Non-Problem: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
School Night:						
Rest start time	20:15 (19:16 – 21:45)	20:24 (19:00 – 22:14)	283.50	-0.40	.696	-.06
Sleep start time	20:46 (19:38 – 21:54)	20:51 (19:00 – 22:35)	299.00	-0.10	.927	-.01
Rest end time	07:08 (06:10 – 07:54)	07:00 (06:09 – 07:38)	260.50	-0.85	.927	-.12
Sleep end time	06:27 (05:59 – 07:37)	06:37 (05:17 – 07:18)	280.00	-0.47	.647	-.07
Sleep duration (hours)	9.67 (9.04 – 10.90)	10.03 (8.74 – 11.03)	248.00	-1.091	.280	-.15
Total sleep time (hours)	8.39 (7.73 – 9.51)	8.74 (7.81 – 9.78)	195.00	-2.124	.034	-.30
Sleep efficiency (% sleep)	86.82 (79.38 – 92.55)	88.16 (81.87 – 93.24)	234.00	-1.364	.176	-.19
Sleep fragmentation	32.67 (19.62 – 47.28)	31.63 (16.64 – 49.08)	291.00	-.253	.809	-.04
Sleep onset latency	21.3 (0.0 – 52.4)	21.5 (2.5 – 65.6)	275.00	-.565	.579	-.08
Non-School Night:						
Rest start time	20:48 (18:53 – 23:06)	20:27 (19:18 – 21:43)	227.50	-1.49	.138	-.21
Sleep start time	21:14 (19:10 – 23:21)	21:03 (19:40 – 22:30)	234.00	-1.36	.176	-.19
Rest end time	07:29 (05:56 – 08:39)	06:56 (06:04 – 08:27)	226.00	-1.52	.131	-.21
Sleep end time	07:05 (05:42 – 08:20)	06:22 (05:06 – 08:16)	181.50	-2.39	.016	-.33
Sleep duration (hours)	9.56 (8.39 – 11.35)	9.49 (8.31 – 10.66)	275.00	-.565	.579	-.08
Total sleep time (hours)	8.35 (7.43 – 9.64)	8.27 (7.27 – 9.28)	284.50	-.380	.710	-.05
Sleep efficiency (% sleep)	88.97 (76.49 – 93.03)	87.93 (83.09 – 92.10)	304.00	0.00	1.00	.00
Sleep fragmentation	28.44 (18.41 – 63.15)	33.66 (12.84 – 49.00)	245.00	-1.149	.257	-.16
Sleep onset latency	17.3 (0.0 – 122.0)	24.3 (3.0 – 96.5)	237.00	-1.306	.195	-.18

Table 3.17

Comparison of Problem and Non-Problem Sleepers Defined by Parental Report of a Small or Serious Problem (Mann-Whitney U test)

Variable	Problem: Median (Range)	Non-Problem: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
School Night:						
Rest start time	20:15 (19:16 – 21:45)	20;24 (19:00 – 22:14)	171.00	-1.64	.102	-.23
Sleep start time	20:46 (19:38 – 21:54)	20:51 (19:00 – 22:35))	151.50	-2.06	.038	-.29
Rest end time	07:08 (06:10 – 07:54)	07:00 (06:09 – 07:38)	219.50	-0.59	.560	-.08
Sleep end time	06:27 (05:59 – 07:37)	06:37 (05:17 – 07:18)	213.00	-0.74	.471	-.10
Sleep duration (hours)	9.52 (9.04 – 10.38)	9.99 (8.74 – 11.03)	183.50	-1.373	.174	-.19
Total sleep time (hours)	8.39 (7.73 – 9.16)	8.68 (7.81 – 9.78)	154.00	-2.010	.045	-.28
Sleep efficiency (% sleep)	86.50 (79.38 – 90.89)	88.02 (81.87 – 93.24)	230.00	-.367	.721	-.05
Sleep fragmentation	32.67 (19.62 – 46.59)	31.90 (16.64 – 49.08)	244.00	-.065	.957	-.01
Sleep onset latency	21.3 (6.0 – 52.4)	21.5 (0.0 – 65.6)	230.50	-.357	.729	-.05
Non-School Night:						
Rest start time	20:48 (18:53 – 23:06)	20:27 (19:18 – 21:43)	231.50	-0.34	.745	-.05
Sleep start time	21:14 (19:10 – 23:21)	21:03 (19:40 – 22:30)	220.00	-0.58	.568	-.08
Rest end time	07:08 (06:10 – 07:54)	07:00 (06:09 – 07:38)	215.00	-0.69	.497	-.10
Sleep end time	07:05 (05:42 – 08:20)	06:22 (05:06 – 08:16)	205:00	-0.91	.371	-.13
Sleep duration (hours)	9.48 (8.31 – 11.18)	9.55 (8.38 – 11.35)	244.50	-.054	.962	-.01
Total sleep time (hours)	8.30 (7.42 – 9.64)	8.33 (7.27 – 9.28)	230.50	-.357	.729	-.05
Sleep efficiency (% sleep)	89.25 (76.49 – 92.10)	88.02 (81.74 – 93.03)	231.00	-.346	.741	-.05
Sleep fragmentation	28.44 (17.91 – 63.15)	33.66 (12.84 – 51.68)	183.00	-1.383	.172	-.19
Sleep onset latency	18.5 (0.0 – 122.0)	22.5 (3.0 – 96.5)	236.50	-.227	.827	-.03
Total CSHQ score	46 (23 – 60)	36 (6 – 49)	75.50	-3.713	< .001	-.52

Table 3.18

Comparison of Problem and Non-Problem Sleepers Defined by Actigraphic Sleep Duration < 9 Hours (Mann-Whitney U test)

Variable	Problem: Median (Range)	Non-Problem: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
School Night:						
Rest start time	19:41 (19:07 – 21:54)	20:20 (19:00 – 22:14)	54.50	-0.70	.509	-.11
Sleep start time	20:03 (19:27 – 22:04)	20:51 (19:00 – 22:35)	54.00	-0.72	.497	-.10
Rest end time	06:50 (06:19 – 06:57)	07:04 (06:09 – 07:54)	37.50	-1.38	.179	-.19
Sleep end time	06:07 (05:17 – 06:42)	06:37 (05:44 – 07:37)	35.00	-1.48	.151	-.21
Sleep efficiency (% sleep)	88.91 (88.02 – 89.38)	87.77 (79.38 – 93.24)	49.50	-.901	.387	-.13
Sleep fragmentation	23.71 (16.70 – 24.45)	32.96 (16.64 – 49.08)	11.00	-2.442	.008	-.34
Sleep onset latency	16.4 (14.0 – 53.4)	21.5 (0.0 – 65.6)	71.50	-.020	.989	-.002
Total CSHQ score	34 (33 – 36)	39.5 (6 – 60)	39.50	-1.303	.209	-.18
Non-School Night:						
Rest start time	20:47 (20:02 – 23:06)	20:21 (18:53 – 22:15)	164.00	-2.01	.045	-.28
Sleep start time	21:38 (20:20 – 23:21)	21:01 (19:10 – 22:30)	124.00	-2.85	.004	-.40
Rest end time	06:58 (05:56 – 08:28)	07:08 (06:21 – 08:39)	220.50	-0.81	.424	-.11
Sleep end time	06:26 (05:06 – 08:20)	06:36 (05:26 – 08:16)	199.50	-1.26	.214	-.18
Sleep efficiency (% sleep)	89.07 (85.62 – 91.19)	88.00 (76.49 – 93.03)	229.00	-.633	.538	-.09
Sleep fragmentation	29.08 (12.84 – 49.00)	34.04 (17.91 – 63.15)	178.00	-1.710	.089	-.24
Sleep onset latency	34.8 (3.0 – 96.5)	18.5 (0.0 – 122.0)	149.50	-2.312	.020	-.32
Total CSHQ score	36.5 (23 – 49)	40 (6 – 60)	235.00	-.507	.619	-.07

Table 3.19

Comparison of Problem and Non-Problem Sleepers Defined by Actigraphic Sleep Duration < 10 Hours (Mann-Whitney U test)

Variable	Problem: Median (Range)	Non-Problem: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
School Night:						
Rest start time	20:20 (19:07 – 22:14)	20:21 (19:00 – 21:38)	314.00	-0.19	.855	-.03
Sleep start time	20:58 (19:27 – 22:35)	20:41 (19:00 – 22:03)	276.00	-0.91	.371	-.13
Rest end time	07:01 (06:10 – 07:39)	07:07 (06:09 – 07:54)	318.50	-0.10	.922	-.01
Sleep end time	06:36 (05:17 – 07:25)	06:39 (05:44 – 07:37)	318.00	-0.11	.914	-.02
Sleep efficiency (% sleep)	88.77 (82.07 – 93.24)	86.99 (79.38 – 92.55)	190.50	-2.519	.011	-.35
Sleep fragmentation	27.02 (16.64 – 41.23)	35.08 (20.14 – 49.08)	153.00	-3.227	.001	-.45
Sleep onset latency	20.7 (0.0 – 52.4)	21.8 (7.2 – 65.6)	274.50	-.934	.356	-.13
Total CSHQ score	37 (6 – 60)	38 (24 – 57)	309.50	-.274	.789	-.04
Non-School Night:						
Rest start time	20:44 (19:38 – 23:06)	20:04 (18:53 – 21:49)	147.00	-1.93	.053	-.27
Sleep start time	21:17 (19:57 – 23:21)	20:22 (19:10 – 21:49)	124.50	-2.43	.014	-.34
Rest end time	06:57 (05:56 – 08:39)	07:19 (06:21 – 08:27)	185.50	-1.08	.288	-.15
Sleep end time	06:32 (05:06 – 08:20)	07:12 (05:54 – 08:16)	160.50	-1.63	.104	-.23
Sleep efficiency (% sleep)	89.17 (79.87 – 93.03)	85.94 (76.49 – 89.39)	98.00	-3.020	.002	-.42
Sleep fragmentation	32.14 (12.84 – 49.00)	36.44 (20.64 – 63.15)	160.00	-1.643	.103	-.23
Sleep onset latency	27.0 (3.0 – 122.0)	17.9 (0.0 – 26.5)	165.50	-1.521	.131	-.21
Total CSHQ score	37 (6 – 57)	41.5 (28 – 60)	181.50	-1.168	.249	-.16

3.7 Family Demographic, Environmental and Lifestyle Factors

Non-parametric tests were used to explore factors relating to children's sleep within the family context, as the majority of data were skewed. Variables that were not analysed due to limited numbers included bed sharing (3.8%), skipping breakfast (1.8%) and crowded housing (3.8% > 6 people living in the house).

3.7.1 Caffeine Consumption

Mann-Whitney test results (summarised in Table 3.20) indicate that the third (33.3%) of children in the sample who drank caffeinated beverages at least sometimes, went to bed and to sleep at significantly later times on school nights than those who never consumed caffeinated drinks. They also awoke later on school mornings. Similarly on non-school nights, children who consumed caffeine went to sleep later, awoke later, and got up later than children who did not drink caffeinated drinks. Higher sleep efficiencies and less fragmented sleep were also found in this group.

3.7.2 Shiftworking Adults

For the 28% of children living with at least one shiftworking adult, results (Appendix G12) indicate a trend towards later bedtimes on school nights (*Mdn* = 20:35 vs. *Mdn* = 20:08). Children from shiftworking households also took less time to fall asleep (*Mdn* = 15.9 minutes) than their counterparts (*Mdn* = 22.4 minutes). On non-school nights, children slept longer if they lived with a shiftworking adult (sleep duration: *Mdn* = 9.82 hours; total sleep time: *Mdn* = 8.74 hours) than if they did not (sleep duration: *Mdn* = 9.45 hours; total sleep time: *Mdn* = 8.24 hours).

Table 3.20

Comparison of Children Who Did or Did Not Drink Caffeinated Beverages (Mann-Whitney U test, N = 51)

Variable	Caffeinated Drinks at Least Sometimes: Median (Range)	Never Drink Caffeinated Drinks: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
School Night:						
Sleep duration (hours)	9.89 (8.98 – 10.42)	9.97 (8.74 – 11.03)	266.50	-0.45	.660	-.06
Total sleep time (hours)	8.70 (7.73 – 9.51)	8.63 (7.81 – 9.78)	280.00	-0.18	.868	-.03
Sleep onset latency (minutes)	22.3 (0.0 – 65.6)	20.6 (2.5 – 57.0)	263.50	-0.51	.618	-.07
Sleep efficiency (% sleep)	88.02 (82.07 – 92.55)	88.15 (79.38 – 93.24)	263.50	-0.51	.618	-.07
Sleep fragmentation	31.99 (20.14 – 38.48)	33.25 (16.64 – 49.08)	260.00	-0.58	.574	-.08
Rest start time	20:34 (19:34 – 21:47)	20:03 (19:01 – 21:35)	179.00	-2.20	.027	-.31
Sleep start time	20:57 (20:05 – 22:06)	20:34 (19:24 – 21:53)	173.00	-2.14	.020	-.30
Rest end time	07:10 (06:39 – 07:45)	06:57 (06:09 – 07:54)	199.00	-1.80	.073	-.25
Sleep end time	06:55 (06:04 – 07:25)	06:28 (05:17 – 07:37)	163.50	-2.51	.011	-.31
Non-School Night:						
Sleep duration (hours)	9.53 (8.39 – 10.53)	9.53 (8.31 – 11.35)	271.50	-0.35	.734	-.05
Total sleep time (hours)	8.68 (7.28 – 9.27)	8.25 (7.27 – 9.64)	234.50	-1.09	.282	-.15
Sleep onset latency (minutes)	22.50 (7.50 – 122.00)	22.25 (0.00 – 67.67)	258.00	-0.62	.544	-.09
Sleep efficiency (% sleep)	89.29 (85.74 – 93.03)	87.47 (76.49 – 92.10)	182.00	-2.14	.032	-.30
Sleep fragmentation	29.34 (18.41 – 38.70)	34.07 (12.84 – 63.15)	189.00	-2.00	.046	-.28
Rest start time	20:41 (19:58 – 23:06)	20:30 (18:53 – 21:49)	234.00	-1.01	.277	-.14
Sleep start time	21:29 (20:15 – 23:21)	21:02 (19:10 – 22:30)	184.50	-2.09	.036	-.29
Rest end time	07:15 (06:38 – 08:39)	06:56 (05:56 – 08:21)	179.00	-2.20	.027	-.31
Sleep end time	06:53 (05:37 – 08:20)	06:26 (05:06 – 07:50)	181.00	-2.16	.030	-.30
CSHQ total score	40 (6 – 60)	37 (23 – 51)	215.50	-1.47	.072	-.21

3.7.3 Bedroom Sharing

On the whole, no difference was found between the sleep of children who shared a bedroom and those who slept in a room of their own (see Appendix G13 for results). On non-school nights, however, children who shared a bedroom took significantly less time to fall asleep (*Mdn* = 14.4 minutes) than those who did not share (*Mdn* = 24.0 minutes), although their bedtimes were not significantly different.

3.7.4 Technology

Children's sleep was examined in relation to technology in the bedroom environment, as well as the level of screen use that occurred on a daily basis. Mann-Whitney U test results (summarised in Appendix G14) indicate that children with technology in their rooms had less efficient sleep on school nights (*Mdn* = 86.87) compared with the rest of the sample (school night: *Mdn* = 88.36). There was also a trend towards higher total CSHQ scores for children with technology in bedrooms (*Mdn* = 42) compared with those without technology (*Mdn* = 36).

In order to explore the impact of screen technology in particular, Mann-Whitney U tests were carried out to compare the sleep of children with and without screens (televisions, computers, play stations) in their bedrooms. Results summarised in Table 3.21 show that on school nights, children with screens in their rooms went to bed, and started sleeping, later. They also obtained less sleep (sleep duration and total sleep time). On non-school nights, the sleep of children with screens in rooms was generally not significantly different to the rest of the sample. However, their sleep did appear to be less fragmented than their peers and there was a trend towards later bedtimes. Additionally, children with screens in their bedrooms had higher total CSHQ scores.

Daily diary data on minutes of screen use were used to investigate the association between screen time and sleep. Results of Spearman's rank correlations in Table 3.22, indicate that on school nights there was a positive relationship between screen use duration and the time that children went to bed, and to sleep. A negative trend was found between screen use and the time it took for children to fall asleep (p = .056).

Table 3.21

Comparison of Children With and Without Screens in their Bedroom (Mann-Whitney U test, N = 51)

Variable	Screen in Bedroom: Median (Range)	No Screen in Bedroom: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
School Night:						
Sleep duration (hours)	9.45 (8.97 – 9.89)	10.01 (8.74 – 11.03)	53.00	-2.40	.014	-.34
Total sleep time (hours)	8.06 (7.73 – 8.58)	8.66 (7.81 – 9.78)	31.00	-3.04	.002	-.43
Sleep onset latency (minutes)	21.8 (0.0 – 52.4)	21.4 (2.5 – 65.6)	123.50	-0.34	.748	-.05
Sleep efficiency (% sleep)	86.50 (82.07 – 88.91)	88.03 (79.38 – 93.24)	75.00	-1.75	.082	-.25
Sleep fragmentation	27.43 (19.62 – 38.48)	32.67 (16.64 – 49.08)	87.00	-1.40	.170	-.20
Rest start time	20:45 (20:31 – 21:47)	20:10 (19:01 – 21:35)	53.00	-2.40	.014	-.34
Sleep start time	21:21 (20:31 – 21:56)	20:40 (19:24 – 22:06)	60.50	-2.18	.027	-.31
Rest end time	07:08 (06:39 – 07:39)	07:02 (06:09 – 07:54)	115.50	-0.57	.291	-.08
Sleep end time	06:46 (06:11 – 07:25)	06:35 (05:17 – 07:37)	108.00	-0.79	.444	-.11
Non-School Night:						
Sleep duration (hours)	8.91 (8.39 – 10.13)	9.56 (8.31 – 11.35)	97.50	-1.10	.284	-.15
Total sleep time (hours)	7.82 (7.43 – 9.06)	8.35 (7.27 – 9.64)	94.00	-1.20	.240	-.17
Sleep onset latency (minutes)	17.9 (8.0 – 47.5)	22.5 (0.0 – 122.0)	117.00	-0.53	.612	-.07
Sleep efficiency (% sleep)	87.66 (85.62 – 89.80)	88.30 (76.49 – 93.03)	116.00	-0.56	.598	-.08
Sleep fragmentation	26.51 (18.41 – 35.38)	33.56 (12.84 – 63.15)	65.00	-2.05	.040	-.29
Rest start time	21:18 (20:04 – 23:06)	20:32 (18:53 – 22:15)	68.50	-1.94	.051	-.27
Sleep start time	21:46 (20:15 – 23:21)	21:04 (19:10 – 22:30)	77.00	-1.70	.093	-.24
Rest end time	07:13 (06:30 – 08:28)	07:00 (05:56 – 08:39)	119.50	-0.45	.663	-.06
Sleep end time	06:58 (06:23 – 08:20)	06:34 (05:06 – 08:16)	87.00	-1.40	.167	-.20
CSHQ total score	45.5 (33 – 60)	37 (6 – 57)	62.50	-2.12	.016	-.30

Table 3.22

Association Between Daily Screen Time and Sleep (Spearman's Rank Correlation)

Sleep Variable	Screen Time: School Night	Screen Time: Non-School Night
Rest start time	.26**	.14
Sleep start time	.15*	.08
Sleep duration	-.12	.03
Total sleep time	-.11	.04
Sleep onset latency	-.13	-.04
Sleep efficiency (% sleep)	.06	-.02
Sleep fragmentation	-.09	-.05

*$p < .05$ **$p < .001$

A simple linear regression model was used to further investigate screen use duration and school night rest start time, sleep start time and sleep onset latency. Significant associations were not found for sleep start time ($\beta = .11$, $t(208) = 1.57$, $p > .05$). However, increased screen time was associated with later bedtimes ($\beta = .19$, $t(208) = 2.75$, $R^2 = .04$, $F(1,208) = 7.55$, $p < .05$). Children were also found to fall asleep faster when they spent more time using screen-based technology ($\beta = -.17$, $t(208) = -2.43$, $R^2 = .03$, $F(1,208) = 5.92$, $p < .05$).

3.7.5 Childcare

Averaged actigraphic sleep variables, and total CSHQ scores, were compared between children who had some childcare throughout the week and those who had no childcare (Appendix G15). On school nights, children who used childcare during the week had shorter sleep onset latencies (*Mdn* = 15.8) than those who never had childcare (*Mdn* = 22.3). On non-school nights, children who had childcare during the week went to sleep earlier (*Mdn* = 20:32) than those not in care (*Mdn* = 21:19). They also woke up earlier (*Mdn* = 06:06 vs 06:36) and got up earlier (*Mdn* = 06:50 vs 07:09) than the rest of the sample.

Associations between children's sleep and the duration of childcare, and finishing time of childcare, were analysed using Spearman's rank correlations of daily data, as summarised in Table 3.23. A negative relationship was identified between the amount of time children spent in childcare during the day and the length of time it took to fall asleep that night. Negative relationships were also found between the time that childcare finished for the day and children's total sleep time. Negative trends were associated between childcare finishing time and sleep efficiency (p = .060) and sleep fragmentation (p = .051) that night.

Table 3.23

Association between Childcare and Sleep on School Nights (Spearman's Rank Correlation)

Sleep Variable	Childcare Duration	Childcare Finishing Time
Rest start time	-.02	.27
Sleep start time	-.11	.23
Sleep duration	.05	-.37
Total sleep time	-.003	-.48**
Sleep onset latency	-.17**	-.14
Sleep efficiency (% sleep)	-.08	-.35
Sleep fragmentation	.03	-.37

*p < .05 **p < .01

Simple linear regression analyses were carried out on the variables identified in Table 3.22 as being significantly correlated, and those with trends. Increased time in childcare was associated with decreased sleep onset latencies (β = -.18, t(239) = -2.84, R^2 = .03, F(1,239) = 8.08, p < .01). Later finishing times of care were associated with decreased total sleep time (β = -.50, t(27) = -3.00, R^2 = .25, F(1,27) = 9.00, p < .01), and lower sleep efficiency (β = -.37, t(27) = -2.07, R^2 = .14, F(1,27) = 4.29, p < .05). No significant relationship was found between childcare finishing times and sleep fragmentation (β = -.34, t(227) = -1.85, R^2 = .11, F(1,27) = 3.43, p > .05).

To investigate the association between sleep and both childcare and screen use, multiple regression analyses were run using screen time, childcare duration and childcare finishing times as predictor variables. The same actigraphic sleep variables were examined that were used in the correlation tests. Two separate sets of analyses were run, using screen time and childcare duration, and screen time and childcare finishing times, as multicollinearity was apparent in the data when both childcare duration and finishing times were used in the same model. Whilst the majority of variables did not show significant associations (p > .05), a relationship was found between sleep onset latency on school nights and the duration of screen use and childcares (Table 3.24).

Table 3.24
Associations between Screen Use and Childcare Duration and Children's Sleep Onset Latency on School Nights (Multiple Regression)

	B	*SE B*	*β*
Step 1			
Constant	28.47	2.05	
Screen time duration	-.06	.03	-.17*
Step 2			
Constant	30.06	2.09	
Screen time duration	-.06	.02	-.18*
Childcare duration	-.09	.03	-.19*

Note. R^2 = .03 for Step 1; ΔR^2 = .04 for Step 2. Non-constant variance, but *ps* < .025. **p* < .05.

3.7.6 Younger Siblings

Sleep of participants with (*n* = 22) and without (*n* = 29) younger children in the household was analysed using Mann-Whitney U tests (Table 3.25). Sleep quantity and quality were not found to differ significantly between children who lived with at least one child that was younger than themselves, and those who did not. However, differences were apparent in sleep timing. Those with younger family members woke up earlier on school mornings and there was a trend towards earlier sleep start times on school nights. On non-school nights they went to bed, and fell asleep, earlier than the children who did not live with a child younger than themselves.

3.8 Relationship between Daily Activity and Sleep

Mann-Whitney U test results (Appendix G16) showed no significant differences in the duration and quality of sleep, of children who participated in an organised activity during the day and those who did not (*p* > .05). However, modes of transport to school did appear to be associated with differences in children's sleep. Findings from Mann-Whitney U analyses (Appendix G17) indicate that children who used passive transport (car or bus) to travel to school, obtained more sleep (total sleep time: *Mdn* = 8.68 hours) than those who walked, biked or scootered to school (total sleep time: *Mdn* = 8.40 hours). They also had shorter sleep onset latencies (*Mdn* = 16.0 minutes) compared with children who actively went to school (*Mdn* = 23.0 minutes). Effect sizes for findings were small, however. There were no significant differences associated with transport used to travel home from school.

Table 3.25

Comparison of Children Living with at Least One Younger Child and those with No Younger Children at Home (Mann-Whitney U test, N = 50)

Variable	Younger Child at Home: Median (Range)	No Younger Children: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
School Night:						
Sleep duration (hours)	9.91 (8.74 – 11.03)	9.91 (8.98 – 10.70)	297.50	-0.21	.842	-.03
Total sleep time (hours)	8.70 (7.81 – 9.78)	8.60 (7.73 – 9.40)	277.00	-0.61	.554	-.09
Sleep onset latency (minutes)	21.1 (0.0 – 65.6)	21.5 (9.0 – 57.0)	289.50	-0.36	.724	-.05
Sleep efficiency (% sleep)	88.47 (81.87 – 93.24)	87.77 (79.38 – 91.23)	258.00	-0.98	.334	-.14
Sleep fragmentation	31.49 (16.70 – 47.28)	32.98 (16.64 – 49.08)	272.00	-0.70	.491	-.10
Rest start time	20:08 (19:01 – 21:19)	20:24 (19:20 – 21:47)	224.00	-1.64	.102	-.23
Sleep start time	20:33 (19:24 – 21:44)	20:51 (19:33 – 22:06)	213.00	-1.86	.064	-.26
Rest end time	07:00 (06:09 – 07:45)	07:09 (06:10 – 07:54)	224.00	-1.64	.102	-.23
Sleep end time	06:18 (05:17 – 07:24)	06:51 (05:54 – 07:37)	193.00	-2.25	.024	-.32
Non-School Night:						
Sleep duration (hours)	9.55 (8.31 – 11.35)	9.47 (8.39 – 10.66)	280.00	-0.55	.842	-.08
Total sleep time (hours)	8.52 (7.42 – 9.64)	8.12 (7.27 – 9.27)	252.00	-1.10	.278	-.16
Sleep onset latency (minutes)	22.3 (5.8 – 96.5)	23.3 (0.0 – 122.0)	296.50)	-0.23	.827	-.03
Sleep efficiency (% sleep)	88.53 (81.74 – 93.03)	87.93 (79.46 – 92.09)	282.00	-0.51	.621	-.07
Sleep fragmentation	32.53 (17.91 – 51.68)	32.85 (12.84 – 49.00)	285.00	-0.45	.663	-.06
Rest start time	20:13 (19:18 – 22:15)	20:49 (19:40 – 23:06)	163.50	-2.82	.004	-.40
Sleep start time	20:46 (19:40 – 22:27)	21:23 (20:14 – 23:21)	201.00	-2.09	.036	-.30
Rest end time	06:56 (06:21 – 08:39)	07:23 (05:56 – 08:28)	223.00	-1.66	.098	-.23
Sleep end time	06:33 (05:06 – 08:00)	06:56 (05:19 – 08:20)	233.50	-1.46	.148	-.21
CSHQ total score	36.5 (23 – 48)	38 (6 – 60)	307.00	-0.02	.988	-.002

Children's objectively measured daily activity was explored using Spearman's rank correlations of actigraphy data, shown in Table 3.26. Significant relationships were found between children's daytime activity and sleep efficiency. No associations were apparent between activity and sleep onset latency, or sleep duration.

Linear regression of significantly correlated activity variables, found that an increase in actigraphically measured total AC on school days was significantly associated with a decrease in children's sleep efficiency (β = -.17, $t(201) = -2.48$, R^2 = .03, $F(1,201) = 6.13$, $p < .05$). An increase in average AC per minute, on both school and non-school days, also significantly predicted a decrease in sleep efficiency (school day: β = -.18, $t(201) = -2.54$, R^2 = .03, $F(1,201) = 6.46$, $p < .05$; non-school day: (β = -.28, $t(87) = -2.73$, R^2 = .08, $F(1,87) = 7.46$, $p < .01$).

Table 3.26

Association between Objective Daily Activity and Sleep (Spearman's Rank Correlation)

Activity Variable	Sleep Onset Latency	Sleep Efficiency	Sleep Duration
School Day:			
Total AC	-.08	-.23**	-.07
Average AC/minute	.04	-.27**	.03
Non-School Day:			
Total AC	-.01	-.18	-.17
Average AC/minute	.003	-.22*	-.01

*$p < .05$ **$p < .01$

3.9 Parental Feedback on Study Participation

Forty one parents (79%) completed and returned the feedback form (Appendix E3). Results indicate that 83% of families heard about the study via the flyer sent home from school. An additional 7% found out about the study at the shopping mall information day, 5% from a friend, 2% saw the flyer on a community notice board and one parent (2%) could not remember.

All parents indicated that they were provided with enough information prior to taking part. No one reported not having enough support throughout the process, with 37% of respondents answering 'yes' regarding adequate support provision. The remaining 63% answered that they did not have any questions or concerns, with comments added such as *"I knew where and who to ask"* and *"but I feel I could phone or email if needed"*.

As indicated in Table 3.27, the majority of families found the data collection tools to be OK or easy to use. One parent reported finding the diary difficult.

Table 3.27

Parental Report of Difficulty Level of using Data Collection Tools (N = 41)

	Easy	OK	Difficult
Actigraph	32 (78%)	8 (20%)	0
Diary	31 (76%)	9 (22%)	1 (2%)
Questionnaire	34 (83%)	7 (17%)	0

Six (15%) parents commented on the use of the Actiwatch™. One was confused about whether or not the actigraph was on and another felt unsure about what time of the day to start. Another parent suggested using Velcro straps, as their daughter had to have the watch strap on the first hole, resulting in a large length of loose strap. The remaining comments related to use of the event marker, with one parent reporting their child would have preferred not to have to push the button, one finding it difficult to remember to do so and one feeling confused about when to push the button.

Eight (20%) comments were made regarding the diary. These included needing more space to write on the diary and finding it difficult to use the 24 hour clock on the timeline. The remaining comments indicated that parents found it difficult to assess their children's level and duration of daily activity. There was confusion around whether or not to account for activity whilst at school, as well as finding it hard to track activity on weekends when there was less structure to the day.

One parent suggested that the questionnaire needed a 'never' option as well as 'rarely' in the CSHQ section. Another recommended providing children with a chart to put on the wall so they knew what was happening across the week.

Space provided at the end of the form for additional comments was used by 16 (39%) parents. All comments were of a positive nature. Families and children enjoyed the process, for example *"my daughter really enjoyed participating and would happily do it again"*, and found it to be straight forward and well planned *"from our perspective* *the study was well run, the material provided was clear and our son enjoyed being involved."* Families appreciated getting feedback and support, *"we really loved being sent our son's sleep information", "very interesting – liked looking at the activity graph", "email asking how it was going was supportive"* as well as their children being sent something for taking part *"the certificate and stickers were a lovely touch."*

4. Discussion

4.1 Overview

This study aimed to collect normative data on the sleep of 6 – 8-year-old New Zealand children across school and non-school nights, identify modifiable factors that impact on children's sleep, explore the relationship between children's sleep and BMI, and pilot methods for potential future research. These aims were met, with (usable) objective sleep/wake data being successfully collected across the week, and analysed, for a total of 51 children. Subjective information was also gathered, using parental report of 52 children's sleep/wake behaviour and environmental factors within the family.

The combination of these approaches resulted in the first set, as far as the researcher is aware, of normative objective data across both school and non-school nights for New Zealand children, using a within-subjects design. This enabled the analysis of differences in children's sleep and waking behaviour in relation to school attendance, with the main findings replicating a number of studies (Epstein, et al., 1998; Gulliford, et al., 1990; National Sleep Foundation, 2004). In particular, school night sleep duration was found to be, on average, longer than non-school night sleep. Overall, stable objectively measured sleep patterns were seen in New Zealand children in the pilot study, consistent with findings reported by Nixon et al. (2008). Additionally, comparisons of objectively and subjectively measured sleep indicated a tendency for parents to over-estimate their children's sleep duration, which has also been found previously (Goodwin, et al., 2007; Gruber, et al., 1997).

No differences were apparent in the sleep of girls and boys in the study. Modifiable factors of technology and caffeine use were associated with differences in children's sleep. Familial aspects such as shiftworking adults living in the home, childcare duration and finishing times, as well as younger children in the household, were also associated with sleep differences. No children in the sample were identified as being obese, however unlike findings previously reported (Duncan, et al., 2008; Marshall, et al., 2008a; Nixon, et al., 2008; Patel & Hu, 2008), those considered to be overweight (Ministry of Health, 2008) did not appear to sleep significantly differently from the children who were thin, or of normal body size. Results should be interpreted with caution, however, due to the small number of overweight children in the sample. A variety of other factors could not be examined due to limited numbers of children in some categories, highlighting one of the difficulties associated with data from a small pilot sample.

Notably, whilst analyses successfully identified factors within the family environment that were associated with differences in children's sleep, causality was not able to be identified from the current research methods. A number of additional elements may have contributed to children's sleep differences, which were not explored. An evaluation of the pilot study design is summarised and recommendations are made for future study methods that could be used to further investigate 'normal' sleep in New Zealand children.

4.2 Sample Characteristics

The children in the sample were all aged 6 – 8-years and in Year 3 at school. There was also a reasonable balance of boys (42%) and girls (58%). However, the sample was limited in size (N = 52) and demography, which needs to be considered when interpreting results. As noted in Section 3.1.1, there was not an equal proportion of children recruited from high and low decile schools. With the majority of children in the sample living in communities with high SES, differences in sleep that may occur in families from communities with low SES were unable to be investigated.

Notably, the ethnicity of the study sample was not representative of either the New Zealand or Wellington region populations. Census (2006) figures indicate that 67.6% of people in New Zealand belong to the New Zealand European ethnic group and 14.6% to the Māori ethnic group. Similarly, in the Wellington region, 69.8% and 12.8% of people identify as belonging to the New Zealand European and Māori ethnic groups respectively (Statistics New Zealand, 2002). In comparison, 86.3% of the children who participated in the study identified with the New Zealand European ethnic group and 5.8% with the Māori ethnic group. Similarly, 82.4% of mothers and 73.1% of fathers belonged to the New Zealand European ethnic group, and 5.8% of mothers and 3.8% of fathers belonged to the Māori ethnic group. Māori were therefore under-represented, and New Zealand Europeans were over-represented, in the sample. A study with a larger sample, that targeted 50% Māori and 50% non-Māori participants, would be beneficial. This would enable data to be stratified by ethnicity for analyses, with equal statistical power for both groups.

No children were identified as having any form of diagnosed developmental disorder, although developmental stage was not formally assessed. A future study could incorporate an evaluation of children's development, such as Tanner's stages (Rico, et al., 1993), to enable the relationship between children's development and sleep/wake behaviour to be investigated. Concerns were also raised by one parent about their child's sleep, which warranted follow up from the paediatric consultant. This highlighted the value of having adequate clinical support, and of building a diagnostic pathway into subsequent studies, to ensure appropriate follow up could be provided to participants as necessary.

Compared with the New Zealand population (Statistics New Zealand, 2002), the sample over-represented two parent families (86.5% versus 70.8% of families in New Zealand with dependent children), and those with two dependent children (71.2% of the sample versus 40.4% of the population with two dependent children). Conversely, the proportion of families in the study with one child (11.5%) was less than the 34.4% of the New Zealand population with a single dependent child.

Employment patterns were also not comparable to the New Zealand population. Whilst two (3.8%) families in the study had no adults in paid work, recent figures indicate that 7.3% of adults in the country are unemployed (Statistics New Zealand, 2010).

4.3 Objectively Measured Normal Sleep

Children in the pilot study had a school night average sleep duration of 9.9 hours (*SD* = 0.5). This was similar to the mean sleep duration of 10.1 hours (*SD* = 0.8) identified by Nixon et al. (2008), in a sample of 7-year-old New Zealand children (*N* = 519), using 24-hours of actigraphy. Participants' non-school night average sleep duration of 9.5 hours (*SD* = 0.7) appeared comparable to Nixon and colleagues' findings of children's sleep duration being 26.9 minutes less on weekend nights. Findings were also similar to results reported in overseas studies of children using actigraphy (Gruber, et al., 1997; Werner, et al., 2009; Werner, et al., 2008).

Average school night bedtimes (rest start times) of 20:19 (*SD* = 00:39), and rest end times of 07:01 (*SD* = 00:24), were close to those found by Nixon et al. (2008) of

20:11 and 07:08 respectively. Non-school night mean rest start times (*M* = 20:42, *SD* = 00:52), and rest end times (*M* = 07:11, *SD* = 00:39), were also similar to Nixon and colleagues' (2008) findings of weekend bedtimes (*M* = 20:42), and rise times (*M* = 07:17). Children in the pilot study had an average sleep start time of 20:43 (*SD* = 00:39) on school nights, and 21:10 (*SD* = 00:53) on non-school nights, compared with 20:43 on weeknights, and 21:08 on weekends, identified by Nixon et al. (2008). Median sleep onset latencies of participants were found to be 21.4 minutes (0.0 – 65.6) on school nights, and 22.5 minutes (0.0 – 122.0) on non-school nights. In comparison, Nixon et al. (2008) reported median sleep onset latencies of 26 minutes (interquartile range 13 – 42).

The similarities of findings between the two studies suggest that the sleep of New Zealand children in this age group is very stable. The homogeneity of the samples should be noted, however, as both groups consisted of predominantly New Zealand European families. This highlights the need for investigation of children from a broader demographic group in the future, to identify the sleep patterns of different ethnic and socio-economic groups.

Notably, 6 – 8-year-olds in the pilot study did not nap on a regular basis, with one child having a nap on one occasion. This finding is consistent with reports of napping cessation at the age of 5-years by Beine (2007), and Weissbluth (1995). However not all studies concur, including the 2% of 6-year-olds who napped daily in the *Sleep in America* poll (2004). As cultural norms have been reported to influence napping in children (Worthman & Brown, 2007), a larger sample with a broader range of ethnicities would be useful to further examine napping patterns in New Zealand children.

In summary, the data collected in the pilot study supports, and adds to, the objective normative data on sleep timing and duration of normal, healthy children in New Zealand. These may be used by parents and professionals to inform and guide expectations of sleep behaviour.

4.4 Subjectively Measured Normal Sleep

Parental reports of children's usual sleep on school nights (*M* = 10.48 hours, *SD* = 0.11), and non-school nights (*Mdn* = 10.50 hours, range = 8.25 – 11.25), were similar to those of subjectively measured children's sleep in a number of international studies.

For example, Iglowstein and colleagues (2003) found 7-year-olds to sleep, on average, 10.6 hours (*SD* = 0.7), and Owens et al. (2000) reported mean sleep durations of 10.2 hours (*SD* = 0.7) for 4 – 11 year olds (Appendix A3).

However, compared with New Zealand subjective sleep data, the present figures are lower than those previously reported. Landhuis and colleagues (2008) found 7-year-olds to be sleeping an average of 11.4 hours (*SD* = 0.8) per night, although as previously highlighted, this was based on parental reports of children's sleep the night before and therefore may not have represented typical sleep patterns. Duncan et al. (2008) reported 48.1% of a sample of 5 – 11-year-olds (*N* = 1229) to be sleeping 11 – 11.9 hours on week nights, and 36.8% sleeping 11 – 11.9 hours on weekend nights (Appendix A3). These figures were based on parents' responses when asked what time their child usually went to bed and got up, on weekdays and weekends. It is difficult to compare results from these studies, due to different data collection methods and sample sizes used. This highlights one of the challenges with interpreting normative data, and illustrates the value of incorporating both objective and subjective measures of children's sleep within the study design.

Subjective sleep behaviour was also captured using the CSHQ. Results were comparable to those of the community sample (*N* = 469) in Owens and colleagues' (2000) study that evaluated the psychometric properties of the CSHQ. Those children had total CSHQ scores ranging from 6 – 83, compared with 6 – 60 in the present sample. As the subscales of the CSHQ were designed to identify areas requiring further evaluation, as opposed to the diagnosis of sleep disorders, values are not set regarding subscale score cut-offs. Median values for each subscale in the current study, however, appear similar to averages reported by Owens et al. (2000). Rounded scores for each subscale were the same across both studies for Sleep Onset Delay, Sleep Duration, Parasomnias, Sleep Disordered Breathing, and Daytime Sleepiness. Scores differed by one point for the remaining subscales. Notably, medians were reported in the present study as data were skewed, compared with means presented by Owens and colleagues (2000).

Findings indicate similarities in children's sleep behaviour between the sample and those in the study by Owens et al. (2000). The CSHQ appeared to be an effective measure of children's sleep behaviour and sleep disturbance in the pilot study. It is recommended that this be used with a larger, more diverse, group of children in the future, to assist with the gathering of normative data on New Zealand children's sleep.

4.5 Significant Findings

4.5.1 Hypothesis 1: School and Non-School Night Sleep

It was hypothesised that children's sleep on school nights would be longer than on non-school nights. Results support this, with children's objectively measured sleep differing significantly between school and non-school nights. Similar to other studies of this age group (e.g. Epstein, et al., 1998; Gulliford, et al., 1990), on average, children slept for shorter periods of time on non-school nights. They went to bed later, fell asleep later, woke at the same time and got up only slightly later when there was no school.

Comparable differences in objectively measured school and non-school night sleep were found in New Zealand children by Nixon et al. (2008) using 24-hours of actigraphy, as discussed in Section 4.3. Notably, these were between-subjects data, as opposed to within-subjects data of the pilot study. Additionally, using parental report of children's sleep, Duncan et al. (2008) also reported shorter sleep durations on weekends versus weeknights in a sample of 1,229 New Zealand children (42.8% sleeping ≤ 10.9 hours on weeknights, versus 49.1% sleeping ≤ 10.9 hours on weekends).

On average, no differences were found in sleep efficiency and sleep fragmentation on school and non-school nights. This may be interpreted that whilst changes in routine across the week affected sleep quantity, they did not impact on sleep quality. The limitations of actigraphy in accurately measuring sleep quality must be kept in mind, however, when interpreting these results (Ancoli-Israel, et al., 2003; Signal, et al., 2005).

One explanation regarding changes in sleep patterns that were seen across the week, may be that family routines on school nights were more structured. In comparison, on weekends children appear to have had more flexibility, going to bed later and getting up later, although waking at approximately the same time as on school mornings. Activity levels during the day also varied between school and non-school days, which is discussed in Section 4.5.8. These findings illustrate the impact that psychosocial factors, such as school schedules, can have on sleep/wake patterns.

Parental awareness of the tendency for 6 – 8-year-old children to wake at the same time and get up only slightly later on weekends, following generally later bedtimes on non-school nights, may assist families to develop strategies to support children to get enough sleep. An important aspect of this is for parents to be aware of signs and symptoms of daytime sleepiness in children which, as outlined in Section 1.6.1, may present as hyperactivity, inattention, disturbed mood and poor impulse control, in contrast to the classic signs of sleepiness observed in adults (Mindell & Owens, 2003). Therefore, education for parents and children on sleep, and signs of sleepiness, would be a useful strategy when considering the sleep of children within the family context.

4.5.2 Hypothesis 2: Gender Differences in Sleep

The second hypothesis predicted that girls would have earlier bedtimes and longer sleep durations than boys, similar to findings of Russo et al. (2007), and Spruyt et al. (2005). This hypothesis was not supported, as no significant differences were found between actigraphic sleep timing and duration variables of boys and girls. As outlined in Section 1.5.1, the literature varies in relation to gender and sleep in middle childhood, with differences found in some studies and not others.

In regards to New Zealand children, the current findings are in line with Nixon et al. (2008) who found no difference in sleep duration by gender, whereas Landhuis and colleagues (2008) found small differences between boys' and girls' sleep times, although it is unclear in which direction. In comparison, Borlase (2001) found that female teenagers in New Zealand reported sleeping less, both during the week and on weekends, than males. This raises the question of when gender differences in sleep become apparent in the course of children's development, and warrants further investigation within the New Zealand population.

The failure to find differences between boys' and girls' sleep at 6 – 8-years of age is significant in itself. Results may indicate that children in the sample were not yet affected by developmental changes that have been associated with altered sleep patterns, such as later sleep onset times, as children approach puberty (Ohayon, et al., 2004). A future study with a larger sample, and equal proportions of boys and girls, would enable further investigation of potential sleep variation by gender. A longitudinal study design would allow differences between boys' and girls' sleep to be evaluated across time. Subsequent information could be useful to parents and teachers, to recognise the developmental changes and gender differences in children's sleep.

4.5.3 Hypothesis 3: Subjective versus Objective Sleep

It was hypothesised that parents' estimation of children's sleep duration would be longer than objectively measured sleep. Results supported this as, similar to previous studies (Goodwin, et al., 2007; Gruber, et al., 1997; Gulliford, et al., 1990; Werner, et al., 2009), parental report of children's usual amount of sleep on school and weekend nights over-estimated sleep duration when compared with actigraphically measured sleep. On school nights, parents over-estimated sleep by an average of 37 minutes, and on non-school nights by an average of 58 minutes, when compared with objective sleep duration.

Parental estimates were similar to rest times, with school night parental report being, on average, 13 minutes shorter than actigraphic rest duration. On non-school nights, parental report was found to not differ significantly from rest duration ($z = -1.77$, $p = .076$). This illustrates the difficulties of interpreting and comparing results when parental report has been used, versus objective measures such as actigraphy. As New Zealand data are limited on children's sleep in this age group, it is important to be aware that parental estimations in studies by Landhuis and colleagues (2008), and Duncan et al. (2008), may represent time in bed, rather than sleep duration. These findings support the idea that parents may be less aware of when children in this age group are actually sleeping, due to independence at bedtime and rise time, and with resettling during the night (Acebo, et al., 2005; Aronen, et al., 2000; Nixon, et al., 2009; Owens, Spirito, McGuinn, et al., 2000).

4.5.4 Hypothesis 4: Body Size and Sleep

The fourth hypothesis, that children with BMI scores indicating they were overweight or obese would have shorter sleep durations than those in the normal BMI range, was not supported. Findings were not in line with New Zealand studies of Nixon et al. (2008), and Duncan et al. (2008), who both identified associations between shorter sleep in children and increased body size.

It is possible that pilot study results were affected by limited statistical power of the small numbers involved. None of the children in the sample were categorised as being obese, compared with 8.4% of boys and 8.0% of girls in the general New Zealand population who were identified as obese in the 2006/07 New Zealand Health Survey (Ministry of Health, 2008). Six (14%) of the children who participated were overweight. The prevalence of being overweight or obese in the parental sample was also lower than that of the New Zealand population, as Ministry of Health (2008) figures indicate that 36.2% of adults are overweight and 26.5% obese.

Additionally, although the sample was reasonably homogeneous, BMI cut-off values did not take ethnicity into account. Adjusted cut-off points developed by Duncan, Duncan, and Schofield (2010) include Māori, Pacific Island, East Asian and South Asian adjusted values. These may have provided a more accurate identification of body size, although it is unlikely that more children would have been categorised as being overweight or obese in the present sample.

It is also important to keep in mind the longitudinal relationship, previously reported, between short sleep duration in childhood, and adult obesity (Landhuis et al., 2008). It may therefore be that children in the sample who slept less, may be at a higher risk of developing obesity as adults, even though their current body size is normal. A future study with a larger sample, would increase the ability to analyse children's sleep duration in relation to BMI. Ideally this would be of a longitudinal design, to track changes in sleep/wake activity as well as body size over time.

4.5.5 Hypothesis 5: Normal and Problem Sleepers

It was initially hypothesised that children who were considered by their parents to have a sleep problem would sleep less, and have poorer quality sleep, than those not considered to have a problem. Five categories of problem sleep were piloted, resulting in differing outcomes depending on criteria. Using subjective measures, 37% of children had CSHQ total scores > 41, whereas 27% of parents considered their child to have a small or very serious problem with sleep. Whilst these figures varied from each other, they were comparable with previously published prevalence data, indicating parentally reported sleep problems in children to range from approximately 20 – 40% (e.g. Blunden, et al., 2004; Davis, Mindell, & Meltzer, 2008; Liu, Ma, et al., 2005; Mindell, 1993).

Objectively measured school night total sleep time was, on average, 21 minutes less for children who scored > 41 in the CSHQ. Similarly, those children whose parents indicated they had a small or very serious problem with sleep obtained, on average, 17 minutes less total sleep time on school nights compared to children who were not reported to have a problem. Parental report of sleep problems, as well as CSHQ total score cut-off criteria, were found to be effective ways of identifying children in the sample who had less sleep than their counterparts, although actigraphic sleep quality variables were not shown to differ. This highlights the value of combining subjective and objective measures of children's sleep, and involving parents in the data collection process.

Results of problem sleep, using actigraphic sleep duration criteria of < 9 hours and < 10 hours, indicated that whilst shorter sleepers had less sleep, they appeared to have better quality sleep, according to sleep efficiency and sleep fragmentation actigraphic variables. Similar patterns were noted by Signal (2002) in shorter sleeping adults. However, it appears that rather than children experiencing better quality sleep, results may be due to the limited ability of actigraphy to accurately measure elements of sleep quality. Signal, Gale, and Gander (2005) showed actigraphic sleep efficiency estimates to have moderate to poor correlation with PSG values, when investigating the sleep of adults. This illustrates the limitations of actigraphy, and indicates the potential for a future study to incorporate the use of PSG with at least a sub-sample of children to further investigate this phenomenon. Similarly, children who slept less than 9 hours, on average, had longer sleep onset latencies on non-school nights. Signal et al. (2005) also reported a moderate to poor correlation between actigraphic sleep latency and PSG, therefore these results should be interpreted with caution.

Children in the shorter sleep duration categories also tended to go to bed, and fall asleep, later than the rest of the sample, when there was no school the next day. This information would be useful for parents of children who sleep for shorter periods and show signs of daytime sleepiness. A strategy of bringing bedtimes forward on non-school nights, for example, could assist by providing children with longer sleep opportunities.

The last category of problem sleep that was examined, involved the comparison of sleep duration of children who went to bed after 21:00 with those who went to bed on or before 21:00. On both school and non-school nights, no significant difference in sleep duration was found. Conversely, Nixon et al. (2008) found that the New Zealand children in their sample who went to bed after 21:00 had shorter sleep durations (-41.1 minutes, $p < .001$) than those with earlier bedtimes. It is unclear as to why these differences in findings occurred between the two studies, particularly given the similarities identified in the other sleep duration and timing variables. One explanation is that the limited number of children in the pilot study with bedtimes after 21:00 on school nights (n = 12), and non-school nights (n = 16), may have affected the statistical power of analyses and subsequent results. Therefore, it would be beneficial to replicate analyses of bedtimes before and after 21:00 in a future study with a larger sample.

4.5.6 Hypotheses 6 and 7: Psychosocial, Behavioural and Environmental Factors

A number of factors within the family environment, some of which were modifiable, were predicted to be associated with children's sleep quantity and quality. Whilst bed sharing, crowded housing, and children skipping breakfast could not be analysed due to minimal occurrence, the main findings for data that were able to be examined are discussed below.

Caffeine

Approximately one third (29%) of children in the sample consumed caffeinated beverages sometimes or often, but the majority (98%) never drank energy drinks. The sample under-represented children who drank caffeinated drinks, when compared with Ministry of Health (2003) data that reported 43% of New Zealand children (aged 5 – 14 years) consumed cola drinks weekly, and 9% drank Mountain Dew. Similarly, the sample's caffeinated drink consumption appeared less than the 41% of school-aged children reported in the *Sleep in America* poll to consume at least one caffeinated drink per day (Mindell, et al., 2009).

Children in the study who drank caffeinated drinks went to bed later on school nights, and went to sleep and woke up later across the week. They also got up later on non-school mornings, compared with children who did not drink caffeinated drinks. No differences were found in sleep duration, however on non-school nights sleep quality variables of sleep efficiency and sleep fragmentation indicated better quality sleep among caffeine drinkers. As already discussed, however, actigraphic sleep quality variables should be interpreted with caution.

The differences in sleep timing are interesting. Potentially, children who consumed caffeinated drinks may have had more difficulty going to sleep earlier in the evening due to the effect of the caffeine. These results are difficult to interpret, however, as the timing and regularity of caffeine consumption was not captured on a daily basis. In the future, this could be added to the diary in order to gauge how much caffeine was consumed via drinks and at what time of the day, particularly in relation to how close to bedtime drinks were consumed. As caffeinated drink consumption is a potentially modifiable factor associated with sleep, further exploration is recommended.

Shiftworking Adults

Whilst the predominant (81%) work pattern for families was *daytime with no shifts (fulltime),* 28% of children lived with at least one adult shiftworker. Shorter sleep onset latencies were found across the week for children from shiftworking households. There was a trend towards later bedtimes on school nights, and children obtained more sleep on non-school nights, compared with the rest of the sample. One interpretation of these findings may be that in shiftworking households, adults' work patterns had more impact on sleep routines than school, which altered the school and non-school night sleep patterns seen in other families.

Firm conclusions cannot be drawn from the limited data in the present study, however future research could incorporate questions on daily work hours of adults in the home to more accurately analyse the relationship between children's sleep and household employment patterns. Whilst shiftwork is not necessarily a modifiable factor, it would be beneficial for parents to be aware of the potential association between children's sleep patterns and adult work routines.

Bed and Bedroom Sharing

The majority (96%) of children in the sample slept in their own bed. The 4% who regularly shared a bed was comparable with the 5% of Italian children (aged 6 – 12) reported by Cortesi et al. (2004) to regularly co-sleep, and significantly less than the 55.8% of Chinese seven year olds reported by Liu and colleagues (2003) to regularly share parents' beds. The third (33%) of children who shared a bedroom were not found to have significantly different objectively measured sleep, compared with the rest of the sample. The exception was shorter sleep onset latencies on non-school nights, however as already discussed, actigraphic estimates of sleep latency are not reliable. Results do not replicate those of the National Sleep Foundation (2004), which reported that children who shared a bedroom had more parentally reported sleep problems and less sleep. The small size and homogeneity of the pilot sample must be kept in mind when interpreting these data, however they do provide an initial snapshot of children's sleeping environments in New Zealand.

Technology

Just under half of the sample (44.2%) had some form of technology in their bedrooms. The sleep efficiency of children with technology in rooms was found to be lower, and there was a trend towards higher total CSHQ scores, compared with the rest of the sample. Whilst keeping limitations of actigraphy (see Section 4.5.5) in mind, CSHQ total score trends also point towards more potentially disturbed sleep in children with technology in their bedrooms. Although not conclusive, these results highlight an area for further investigation.

Approximately 12% of children had screen technology in their bedrooms and 10% of children had a television in their rooms. This was a smaller proportion compared with other studies, such as 43% of children in the *Sleep in America* poll (National Sleep Foundation, 2004) who were reported to have a television in their room. Differences were found in the school night sleep of children with screens in their rooms, compared to those without screens. On average, those with screens in their bedrooms went to bed and to sleep later, and obtained less sleep, than their counterparts. Children with screens also had, on average, higher total CSHQ scores, which may indicate more disturbed sleep.

Having a television in the bedroom has been associated with sleep problems (Li, et al., 2007) and less sleep (National Sleep Foundation, 2004) in previous studies. Current results appear to indicate a similar pattern. One explanation may be that children were using screens prior to bedtime or whilst in bed, resulting in later sleep onset, less sleep opportunity due to having to get up for school the next day, and more disturbed sleep. This is speculative, however, as the timing of screen use was not measured in the pilot study. Incorporating a timeline of technology use into future diary design, particularly in the two hour window prior to bedtime, is recommended.

In regards to duration of screen use, children spent approximately one hour on school days and two hours on non-school days using screens. This is within the Ministry of Education (2007) guidelines for screen time, although duration of viewing had a broad range. This was seen particularly on non-school days, with children spending up to six hours using screens. Significant correlations were identified between increased screen time and later bedtimes and sleep start times on school nights. Using linear regression, increased screen time duration was also found to predict later bedtimes on school nights.

These results indicate an association between the amount of screen time during the day, and sleep timing on school nights. However, they do not provide evidence of causality and do not take into account the multifactorial nature of children's sleep. As significant associations were found between technology use and children's sleep, and as this is a potentially modifiable factor within the family home, further investigation appears warranted.

Childcare

The majority (80%) of children who participated in the study were not in childcare. Of those who were, only one had regular care in the mornings. It is difficult to know if the prevalence and pattern of childcare seen in the sample was typical of New Zealand children, due to limited sample size and demographics. However, data do provide an initial set of normative information regarding childcare and sleep in New Zealand which, as far as the researcher is aware, has not been done before.

Compared with children who had no childcare, those in care for at least part of the week had shorter actigraphically measured sleep onset latencies on school nights. They went to sleep earlier on non-school nights and woke up, and got up, earlier on weekends. Additionally, an increase in the duration of childcare was associated with shorter sleep onset latencies. Later finishing times of care were associated with less sleep time and lower sleep efficiencies.

One explanation may be that during the week, children had less opportunity for sleep when childcare finished later in the day. To compensate for this, a strategy may have been for children to go to bed earlier on non-school nights. Results must be interpreted with caution, however. Childcare details were recorded in the questionnaire and it was assumed that children attended childcare on the regular days and times identified by parents. Potentially, this may not have occurred. To clarify this in the future, childcare could be recorded on a daily basis using a diary. A number of other factors may have also contributed to children's sleep patterns that were not analysed alongside childcare.

Lastly, the combination of childcare and screen use was examined in relation to children's sleep. A significant negative relationship was found between the length of both childcare and screen time, and sleep onset latencies on school nights. However, shorter sleep onset latencies may potentially be explained by later bedtimes that were associated with screen use and screens in bedrooms.

Whilst these findings require further investigation, there does appear to be a potential link between childcare duration and timing, and children's sleep. Although childcare is not necessarily a modifiable factor for families, further exploration of the relationship between childcare and children's sleep could be beneficial. An increased awareness of these associations may enable families to develop strategies around bedtime routines and sleep hygiene, to support children to get adequate sleep quantity and quality.

4.5.7 Hypothesis 8: Younger Siblings and Sleep

The hypothesis that children living with younger siblings would have longer sleep durations and earlier sleep start times was partially supported. Unlike Nixon et al. (2008), who found that children living with younger siblings slept longer than those without younger children at home, sleep quantity did not differ significantly between children in the study with and without younger siblings. Differences were identified in sleep timing however, with a trend towards earlier sleep start times on school nights and significantly earlier waking times on school mornings in the group of children with a younger child at home. Earlier bedtimes and sleep start times were also apparent on non-school nights.

This may be an indication of children's bedtime routines being affected by the age of other family members, as well as children potentially being woken by younger siblings during the week. Specific questions were not asked regarding these assumptions, however, so results need to be interpreted with caution. Having a younger child in the family is not a modifiable factor, but it may be useful for parents to be aware of the potential association between sleep timing and the age of family members. This could assist with bedtime routines being tailored to individual children's needs.

4.5.8 Hypothesis 9: Daily Activity and Sleep

The final hypothesis, that children's level of daytime activity would be positively associated with sleep duration and negatively associated with sleep onset latency, was not supported. Unlike findings reported by Nixon et al. (2009) who found higher mean daytime activity counts to be associated with decreased sleep latency in

New Zealand children, no significant relationship was identified between sleep onset latency and objective levels of daily activity.

Children who travelled to school using passive transport had longer total sleep times, and shorter sleep onset latencies, than those who actively went to school. This is the opposite of what would be predicted, based on lower activity among passive travellers, and suggests possible confounding by other uncontrolled factors. It would therefore be beneficial to gather data on transport to and from school in a larger sample, and to examine interactions with additional psychosocial factors, in relation to sleep.

Parents reported a number of events, such as family outings and celebrations, that resulted in days being identified as atypical. These highlight the potential impact that social factors have on children's sleep/wake activity and provide a snapshot of the normal variation that occurs in the daily activity of 6 – 8-year-olds in New Zealand. Atypical events were not analysed in relation to sleep, due to limited numbers, however there is potential for examination of these factors in a larger sample.

Although no significant difference was found between average activity duration on school and non-school days, objectively measured levels of activity (total AC and average AC/minute) were lower on non-school days. Conversely, the time spent using screens, for example watching television, approximately doubled on non-school days. No significant difference was seen in participation in organised activities on school and non-school days. These findings suggest less structure in the weekends resulted in children engaging in more sedentary activities of choice, such as watching television or playing computer games.

Significant negative relationships were found between sleep efficiency and objectively measured levels of activity. These results were unexpected, and it is difficult to ascertain why increased activity would be associated with less efficient sleep. Keeping limitations of actigraphy (see Section 4.5.5) in mind, the timing of activity may have been a relevant factor, as sleep hygiene recommendations include the cessation of vigorous activity close to bedtime (Mindell & Owens, 2003; Sheldon, 2005a). The timing, and varying intensity levels, of activity were not investigated in the pilot study, which would be beneficial to include in future study design.

4.6 Pilot Study Design: Strengths and Limitations

Methods were piloted, with a view to identifying study design requirements for future research on New Zealand children's sleep. A brief evaluation of the strengths and limitations of recruitment procedures and measures is outlined.

4.6.1 Recruitment

Information about the pilot study was primarily distributed via printed flyers that were sent home with children from school. Using schools as the predominant recruitment sites enabled the targeting of children in Year 3, thereby minimising developmental differences in the sample. Schools with specific decile ratings were also able to be targeted. However, the aim of recruiting half of the sample from low decile schools was not met. This may have been due, at least in part, to the reliance on parents reading the flyers and having to contact the researcher by phone or email. Language may have been a barrier for families with English as a second language, some families may not have had phones or email access, and others may not have felt comfortable contacting a researcher they had not previously met.

Forty six schools agreed to flyer distribution, resulting in 83% of the sample being recruited. In comparison, one day at the shopping mall providing face-to-face and take home printed information, resulted in 7% of the sample participating. This indicates that a more personal approach may improve recruitment rates in the future. This could include contact with families via community groups, marae, churches, sports clubs, markets and local events. A replication of the shopping mall information day is recommended, as well as making contact with families via schools, but using a more personal approach. Speaking to children at assemblies and in class time may provide children with a better idea about the study. Being available to speak to parents at school fairs and parent/teacher evenings may also improve recruitment rates of a more diverse group of families.

4.6.2 Measures

Actigraphy

Feedback received from parents indicated that the actigraph was not difficult to use. The actigraphs were lightweight and able to be worn by all participants without any known adverse affects. One family recommended the use of Velcro straps in the future, to enable a better fit on children's wrists. An alternative may be sourcing paediatric wrist bands for the AW-2™s.

Some confusion was apparent regarding use of the event marker, therefore clearer written and verbal instructions should be provided in the future. The advantage of using the actigraphs was that children could manage them independently, including pushing the event marker and taking the Actiwatch™ off as required, such as when swimming. The limitation of this was demonstrated when two actigraphs were temporarily misplaced (but relocated).

Four families were asked to repeat one week of recording. One was due to the wristband buckle breaking and having to be replaced, and the others due to technical problems with delayed recording not commencing. It is therefore recommended that watches be activated immediately prior to distribution to families in the future, to minimise the chance of having to repeat data collection.

Compared with Acebo et al. (1999) who reported that up to 28% of actigraphic recordings may be unusable, 92.9% of night time data were retained and 80.8% of daytime data were usable. This indicates that the protocols for data collection, screening and scoring were effective. However, Acebo and colleagues (1999) found that data aggregated over one or two nights showed poor reliability for sleep measures. As it is important to measure children's sleep on school and non-school nights in order to identify differences across the week, it is recommended that a future study incorporates at least 10 consecutive days and nights of recording to provide two weekends of data. A standardised approach to the starting day and time of recording may also be beneficial, to minimise confusion for families as well as to have more consistent periods of data (for example recording from 08:00 Friday for 10 consecutive days and nights).

Actigraphy data were analysed using a 'medium' sensitivity threshold. This may have resulted in conservative estimates of sleep, as Hyde et al. (2007) concluded that using the 'low' and 'auto' sensitivity thresholds were best at predicting sleep in children and 'high' and 'medium' settings were better for predicting waking. Notably, their study sample consisted of 45 children, who were being seen for potential sleep disordered breathing, and therefore may not have been representative of the normal population.

Guidelines for manually screening the actigraphy data were used by two independent researchers, who both scored a sample of 11 files (21.2%). An overall agreement of 93.9% indicated that the rules for identifying rest and excluded intervals enabled consistent processing of data. It is recommended that a minimum of 20% of files be double scored in future study protocols.

Due to the limitations of actigraphy outlined in Section 4.5.5, results of sleep quality, and sleep latency, analyses must be interpreted with caution. The potential incorporation of home-based PSG with a sub-sample of children in the future could therefore provide useful comparative data. It is recommended that this take place over three nights, to incorporate one adaptation night, one school night, and one non-school night.

Child's Sleep/Wake Diary

Diary data were double entered into SPSS 16.0 databases by two researchers, with overall agreement of 98.4%. It is recommended that a future study protocol incorporates this process prior to analyses, to ensure accurate data entry. The majority (76%) of parents found the diary easy to use and one (2%) found it difficult. As per parental feedback, it is recommended that the timeline be amended so that it does not use the 24 hour clock, and that more space is provided for comments. Adding childcare and parental work patterns to the diary would enable more accurate estimates of family routines and their association with children's sleep. Caffeine consumption, technology use, and exercise, particularly within two hours of bedtime, would also be beneficial to incorporate into the diary.

Notably, parents reported confusion regarding the diary questions on children's 'quiet', 'moderate' and 'physical' play. As this raised concerns about how accurate parental estimations were, the decision was made to not use parentally reported activity levels and duration data for further analyses. It is therefore recommended that a different method of gathering subjective waking activity data be explored. One alternative is the multimedia activity recall (MARCA). This is a computerised time use diary, which has been found to be a valid self-report measure of activity in 9 – 16 year olds (Olds, Ridley, Dollman, & Maher, 2010).

Child/Family Questionnaire

All families who provided feedback found the questionnaire to be 'easy' or 'OK' to use. Questionnaires were double entered into SPSS 16.0 databases, with overall agreement of 94.2%. It is recommended that questionnaire data be double entered in future studies to ensure accuracy of data entry. As already discussed, childcare timing and duration would be more accurately captured in the diary, as opposed to the questionnaire, therefore this section should be removed from the current questionnaire format. Analysis of children's developmental level may be added in future versions, following paediatric consultation regarding appropriate measures. Factors to consider including in the future include children's mood, behaviour (such as hyperactivity), emotional lability, and academic performance, as well as parental sleep patterns, mood, and parenting style. However, it is important to balance the amount of information being gathered against the burden placed on participating families, and the impact on compliance and data accuracy.

Children's Sleep Habits Questionnaire (CSHQ)

As outlined in Section 4.4, CSHQ scores in the current sample were comparable to those reported by Owens et al. (2000). The cut-off total score of 41 provided a useful measure of parentally reported sleep problems. Amendments made to the CSHQ for the pilot study enabled subjective reports of school and non-school sleep/wake behaviour, as well as parental perception of problem sleep, to be measured. It is recommended that these adaptations be retained for future studies. As per parental feedback, it is also recommended that a column labelled 'never' be added as an option to questions on sleep behaviours. Revalidation of the amended format would therefore need to be carried out. In general, the CSHQ was an effective tool for subjectively measuring the sleep/wake behaviour of children in the sample, and was completed by parents with no apparent difficulty.

4.6.3 Procedures

Parental feedback indicated that, on the whole, adequate information was provided before, during and after participation in the pilot study. The exception was information about the use of the event marker, as already discussed.

Limitations were apparent in the screening process. Although each family was asked verbally whether their child was in Year 3 at school, as well as printed information including this, two children's data could not be used as they were in Year 2 and Year 4. One factor that may have contributed to this was that the initial flyer did not include the wording *"and in Year 3 at school"*. This was amended in the early stage of the pilot. Secondly, although schools were asked to distribute flyers only to Year 3 pupils, one school sent flyers home to all children in a composite Year 2/3 class.

Parents were asked to delay actigraph and diary use if children were sick, however one set of actigraphic data could not be used in analyses due to the child being sick and taking medication on all seven days of recording. This needs to be clarified in the written information provided to parents, as well as reiterated verbally in the future.

Feedback from parents was positive regarding the follow up procedures in the protocol. It is recommended that a mid-week phone call or email to parents be retained in future study design. Prompt provision of children's actograms was also appreciated by parents, as was the certificate, pen and stickers sent to children. It is important, therefore, to incorporate feedback and acknowledgement in future protocols. Overall, few problems were encountered and compliance levels of families were high, indicating an effective study protocol.

4.7 Recommendations for Future Research

Guided by the evaluation of the pilot study, and feedback received from families, two potential study design options have been identified to further explore normative sleep of children in New Zealand. Implementation would be dependent on factors such as funding, time and equipment availability.

1. Using a similar format to the pilot, a medium scale study could be implemented using 10 consecutive days and nights of actigraphic recording, and amended questionnaires and diaries (Section 4.6.2). A targeted community-based recruitment approach, for example through marae, would be used. The aim would be to recruit a total of 100 children, with the sample consisting of 50% Māori and 50% non-Māori children. Additionally, home-based PSG would be used to measure the sleep of a sub-group of ten children, in order to compare actigraphy with PSG and collect more accurate sleep onset latency and sleep efficiency data.

2. A longitudinal cohort study of children, starting at five years of age, would involve yearly follow up including 10 consecutive days and nights of actigraphy along with amended questionnaires and diaries, as already outlined. Such an approach would enable changes in sleep associated with children's age and development to be accurately identified, as well as differences between boys' and girls' sleep changes to be analysed. It would also provide data on changing social and environmental factors associated with differences in children's sleep over time. Whilst a study of this type would be ideal, realistic limitations of funding, recruitment and resources are acknowledged.

4.8 Summary and Conclusion

This pilot study successfully measured the objective sleep/wake activity of 6 – 8-year-old New Zealand children, across school and non-school days and nights. It also measured parentally reported subjective sleep, and gathered data on a number of demographic, psychosocial, and environmental factors associated with children's sleep.

As far as the researcher is aware, this is the first study in New Zealand to provide normative actigraphic sleep/wake data using a within-subjects design on children, across both school and non-school days and nights. It also provided unique New Zealand data on the relationship between children's sleep and caffeine consumption, childcare and shiftworking households, as well as describing bed and bedroom sharing practices.

Stable sleep patterns were identified, that were consistent with existing objective New Zealand data on children's sleep. Children aged 6 – 8-years were found to sleep less on non-school nights compared with school nights, and to sleep for an average of approximately 9.9 hours on school nights and 9.5 hours on non-school nights. Modifiable factors associated with differences in children's sleep were technology in bedrooms, screens in bedrooms, screen time and caffeine use. Factors not necessarily modifiable, but that may be beneficial for parents to be aware of, were the duration and finishing time of childcare, living with a shiftworking adult, and living with a younger child.

It is important, therefore, to consider the sleep of children within the wider family context. Strategies, such as removing televisions from bedrooms and minimising caffeine consumption, could be a simple, cost-effective way of supporting children to sleep well. Parental awareness of non-modifiable factors within the family, and their association with children's sleep, could also enable strategies to be developed to meet children's individual sleep needs. Normative values for children's sleep duration and timing may guide parents, teachers, and health professionals to assist children with establishing good sleep hygiene habits.

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Appendix A

Literature on Normal Children's Sleep

Table A1

Polysomnographic Values from Paediatric Normative Literature

	Coble et al (1984)	Goodwin et al (2007)	Marcus et al (1992)	Montgomery-Downs et al (2006)	Quan et al (2003)[e]
Country	USA	USA	USA	USA	USA
Age range (years)	6.0 – 15.9	6 - 11	1.1 – 17.4	3.2 – 8.6	6 - 11
N	87	480	50	542	42
Method	lab-based PSG	home-based PSG	lab-based PSG	lab-based PSG	home-based PSG
Subgroup data	6 – 7yrs (*n* = 9) 8 – 9yrs (*n* =14)	6 – 8yrs (*n* = 245)	-	6 – 8yrs (*n* = 369)	6 – 7yrs (*n*=10) 8 – 9yrs (*n*=19)
Type of Night	weeknights	weeknights & weekends	-	not specified	not specified
Number of nights measured	3[a]	1	1	1	1
Time in bed (hours)	9.7 (1.1) & 9.1 (0.8)	-	-	-	10.1 (0.2) & 9.7 (0.2)
Total sleep time (hours)	9.1 (0.9) & 8.9 (0.6)	8.1 (1.7)	6.0 (1.6)	7.9 (0.7)	9.3 (0.2) & 8.8 (0.2)
Bedtime/lights out	-	-	-	21:31 (23.0)	-
Rise time/lights on	-	-	-	06:20 (26.0)	-
Sleep onset latency (min)	18.4(9.0) & 24.6(15.6)[b]	10.0	-	23.0[c]	12 (4) & 16 (3)
Sleep efficiency (%)	94.5 (2.9) & 94.7 (2.5)	-	-	89.3	92 & 91
Wake after sleep onset (min)	8.2 (9.0) & 4.3 (3.0)	-	-	-	-

Note. Values reported as means and SD except Quan et al study where SE reported. Sleep efficiency variable defined as the ratio of total sleep time to time in bed x 100. [a]Mean variable values are for nights 2 and 3 only to compensate for 'first night effect'. [b]Sleep latency defined as time from beginning of recording to onset of stage 2 sleep for 10 consecutive minutes interrupted by not more than 2 minutes stage 1 or wake. [c]Sleep latency defined as time from lights out to first 3 consecutive epochs of stage 1 sleep.

Table A1 *(Polysomnographic Values)* continued

	Stores et al (1998)	Traeger et al (2005)	Uliel et al (2004)	Wong et al (2004)
Country	UK	USA	Israel	Hong Kong/USA
Age range (years)	5 - 16	2.5 – 9.4	1 - 15	3 - 8
N	60	66	70	16 (normal)
Method	home-based PSG	lab-based PSG	lab-based PSG	lab-based PSG
Subgroup data	5 – 7yrs (*n* = 13) 8 – 9yrs (*n* = 14)	-	-	11 age-matched to children with OSAS
Type of Night	not specified	not specified	not specified	not specified
Number of nights measured	1	1	1	1
Time in bed (hours)	-	-	-	-
Total sleep time (hours)	9.8 (1.4) & 9.4 (0.6)	7.7 (0.9)	6.5 (1.2)	7.0 (0.8)
Bedtime/lights out	-	-	-	-
Rise time/lights on	-	-	-	-
Sleep onset latency (min)	16.9 (9.1) & 16.4 (15.2)	23 (20)	-	-
Sleep efficiency (%)	98.1 (2.2) & 98.2 (1.1)	89 (8)	90.8 (6.5)	89 (7)
Wake after sleep onset (min)	5.1 (10.6) & 5.3 (6.1)	-	-	23 (31)

Note. Values reported as means and SD except. Sleep efficiency variable defined as the ratio of total sleep time to time in bed x 100.

Table A2

Actigraphic Values from Paediatric Normative Literature

	Aronen et al (2001)	Aronen et al (2000)	Corkum et al (2001)	El-Sheikh et al (2008)
Country	Finland	Finland	Canada	USA
Age range (years)	5 - 12	7 - 12	7 - 11	7.2 – 11.0
N	66	49	25	64
Actigraph placement	waist	waist	non-dominant wrist	non-dominant wrist
Sensitivity/algorithm	Sadeh algorithm	Sadeh algorithm	fixed (2-3 Hz)	Sadeh algorithm
Subgroup data	-	-	weekday & weekend	-
Type of day/night	weekdays	weekdays	weekday & weekend	weekday & weekend
Monitoring duration	72 hours	72 hours	7 nights	7 nights
Time in bed (hours)	-	-	-	-
Sleep duration (hours)			9.2 (0.7) & 9.0 (0.9)	-
Actual sleep time (hours)	9.1 (0.6)	9.0 (0.6)		7.0 (1.2)
Bedtime/lights off	-	-	-	-
Sleep start time/sleep onset	-	-	22:08 (40) &22:51 (54)	21:37 (38)
Sleep end time/wake time	-	-	07:13 (45) & 07:42 (46)	05:59 (34)
Sleep onset latency (min)	19 (17.1)	17.9 (17.4)	25.2 (14) & 26.5 (25)	-
Sleep efficiency (%)	93.1 (3.6)	93.2 (3.6)	-	83.8 (9.2)[b]
Wake after sleep onset (min)	-	-	-	79.6 (42.6)
Number of awakenings			16.6 (6.6) & 16.5 (5.7)[a]	

Note. Values reported as means and SD. Sleep duration defined as number of hours from sleep onset to wake onset. Sleep time defined as total time scored as sleep excluding periods of wake during total sleep period. Bedtime defined as time child went to bed. Sleep efficiency defined as the percentage of actual sleep time from total sleep period.

[a]Number of blocks of contiguous wake epochs between time of sleep onset and wake onset. [b]Percentage of minutes scored as sleep during down time interval (time from first significant decrease in activity associated with going to bed and end of sleep period).

Table A2 *(Actigraphic Values)* continued

	Gruber et al (1997)	**Nixon et al (2008; 2009)**	Owens et al (2009)	Paavonen et al (2009)
Country	Israel	**New Zealand**	USA	Finland
Age range (years)	7 - 12	**7**	6 - 14	7.4 - 8.8
N	144	**519**	45	280
Actigraph placement	-	**waist**	wrist	non-dominant wrist
Sensitivity/algorithm	-	**-**	medium	medium
Subgroup data	7 – 8yrs boys & girls	**-**	-	weekday & weekend
Type of day/night	-	**weekday & weekend**	weekday & weekend	weekday & weekend
Monitoring duration	4 nights	**24 hours**	at least 5 days	7 days
Time in bed (hours)	-	**-**	-	-
Sleep duration (hours)	9.3 (0.4) & 9.3 (0.5)	**10.1 (0.8)**	-	-
Actual sleep time (hours)	8.6 (0.6) & 8.7 (0.6)	**-**	8.2 (0.7)	8.4 (0.7) & 8.4 (0.7)[g]
Bedtime/lights off	-	**-**	21:57 (60.3)	-
Sleep start time/sleep onset	-	**-**	-	-
Sleep end time/wake time	-	**-**	07:24 (54.5)	-
Sleep onset latency (min)	21.6 (0.5) & 21.7 (0.6)	**26**[c]	32.9 (17.4)	18 (12)
Sleep efficiency (%)	92.5 (4.3) & 93.8 (3.0)	**-**	86 (4)[d]	84.2 (5.8)
Wake after sleep onset (min)	-	**-**	44.5 (17.9)[e]	-
Number of awakenings	3.2 (1.7) & 3.1 (1.4)	**-**	44.5 (14.4)[f]	-

Note. Values reported as means and SD. Sleep duration defined as number of hours from sleep onset to wake onset. Sleep time defined as total time scored as sleep excluding periods of wake during total sleep period. Bedtime defined as time child went to bed. Sleep efficiency defined as the percentage of actual sleep time from total sleep period. New Zealand data are highlighted.
[c]Median reported. [d]Sleep efficiency defined as actual sleep time divided by total time in bed. [e]Sum in minutes of total number of one minute epochs scored as wake from sleep onset to final morning awakening. [f]Number of time periods scored as wake from sleep onset to final morning waking, ranging from one minute to over an hour provided wake epochs were contiguous. [g]N=276.

Table A2 *(Actigraphic Values)* continued

	Paavonen et al (2002)	Sadeh et al (2000)	Werner et al (2009)	Werner et al (2008)
Country	Finland	Israel	Switzerland	Switzerland
Age range (years)	7.3 – 13.3	7.2 – 12.7	4 - 11	4 - 7
N	20	140	85	50
Actigraph placement	wrist & waist	non-dominant wrist	non-dominant wrist	non-dominant wrist
Sensitivity/algorithm	Sadeh algorithm	ASA	medium	medium
Subgroup data	wrist vs waist results	7.2 – 8.6 (*n* = 50) boys & girls	-	weekdays & weekends
Type of day/night	week day	week nights	scheduled & free days	week & weekend
Monitoring duration	72 hours	5 nights	6 – 14 nights[i]	6 – 8 nights[j]
Time in bed (hours)	-		-	-
Sleep duration (hours)	-	9.2 (0.5) & 9.3 (0.5)	9.8 (0.6) & 9.9 (0.7)	10.1 (0.5) & 10.2 (0.6)
Actual sleep time (hours)	7.9 (0.5) & 8.0 (0.7)	8.6 (0.6) & 8.7 (0.6)	-	8.6 (0.7) & 8.8 (0.7)
Bedtime/lights off	-		20:49(43) & 21:31(57)	-
Sleep start time/sleep onset	-		21:08(42) & 21:51(56)	20:54(42) & 21:24(48)
Sleep end time/wake time	-	06:52 (18)& 06:55(18)	07:00(26) & 07:42(44)	07:00(30) & 07:36(48)
Sleep onset latency (min)	27.2(17.3)&28.1(17.6)	21.6 (0.5) & 21.7 (0.6)	20 (11) & 20 (14)	-
Sleep efficiency (%)	89.5 (5.1) & 89.8 (6.3)	92.5 (4.3) & 93.8 (3.0)	-	-
Wake after sleep onset (min)	-	-	-	90 (29) & 96 (26)
Number of awakenings	-	2.09(1.3) & 2.05 (1.1)[h]	-	-

Note. Values reported as means and SD. Sleep duration defined as number of hours from sleep onset to wake onset. Sleep time defined as total time scored as sleep excluding periods of wake during total sleep period. Bedtime defined as time child went to bed. Sleep efficiency defined as the percentage of actual sleep time from total sleep period.

[h]Number of night waking that lasted 5 minutes or longer and that were preceded and followed by at least 15 minutes of uninterrupted sleep. [i]Median = 8 days/nights. [j]Mean = 7 consecutive days/nights.

Table A3

Subjective Values from Paediatric Normative Literature

	Duncan et al (2008)	Gulliford (1990)	Iglowstein et al (2003)
Country	**New Zealand**	UK	Switzerland
Age range (years)	**5 - 11**	5 - 11	1 month – 16years
N	**1229**	9913	493
Measurement tool	**proxy questionnaire**	National Study of Health & Growth questionnaire	Zurich Longitudinal Studies interview questionnaire
Parent/child report	**parent**	parent	parent
Subgroup data	**weekday & weekend**	weekday & weekend 6, 7 & 8yr boys & girls	6 (*n* = 452), 7 (*n* = 448) & 8yrs (*n* = 439)
Type of day/night	**weekday & weekend**	weekday & weekend	-
Sleep duration (hours)	**weekday:[a]** **≥ 12hr = 9.2%** **11-11.9hr = 48.1%** **10 – 10.9hr = 36.2%** **< 10hr = 6.6%** **weekend:** **≥ 12hr = 14.0%** **11-11.9hr = 36.8%** **10 – 10.9hr = 36.4%** **< 10hr = 12.7%**	weekday boys:[b] 6yr - 11.2 (0.7), 7yr – 10.9 (0.7) 8yr – 10.7 (0.7) weekend boys: 6yr – 10.9 (0.9), 7yr – 10.7 (0.9) 8yr – 10.7 (0.9) weekday girls: 6yr - 11.2 (0.7), 7yr – 11.0 (0.8) 8yr – 10.8 (0.7) weekend girls: 6yr – 11.0 (0.9), 7yr – 10.9 (1.0) 8yr – 10.9 (1.0)	6yrs: 11.0 (0.8)[c] 7yrs: 10.6 (0.7) 8yrs: 10.4 (0.7)

Note. Values reported as means and SD. ‘Weekdays’ used to relate to schooldays. New Zealand data are highlighted.
[a]Sleep question: What time child usually goes to bed & gets up on weekdays and weekends. [b]Sleep questions: At about what time does child usually go to sleep at night a)before a schoolday? b)when there is no school the next day?. At about what time does he or she usually wake up in the morning a)on schooldays? B)on days when there is no school? [c]Sleep questions: When does the child go to bed and wake usually? How long does the child sleep during the daytime?

Table A3 *(Subjective Values)* continued

	Jenni et al (2007)	**Landhuis et al (2008)**	Liu et al (2005)
Country	Switzerland	**New Zealand**	China & USA
Age range (years)	1 - 10	**5 - 11**	4 - 13
N	305	**1012**	1011
Measurement tool	structured face-to-face interview	**Dunedin Multidisciplinary Health & Development Study parent interview**	CSHQ
Parent/child report	parent	**parent**	parent
Subgroup data	6, 7 & 8yrs	**5, 7 & 9yrs**	Chinese 7 – 13yrs (*n* = 517) & US 4 – 11yrs (*n* = 415)
Type of day/night	-	**-**	-
Sleep duration (hours)	6yrs: 11.3 (0.8)[d] 7yrs: 11.1 (0.7) 8yrs: 10.6 (0.6)	**5yrs: 11.8 (0.8)[e] 7 yrs: 11.4 (0.8) 9 yrs: 11.0 (0.8)**	Chinese children: 9.13 (0.74) US children: 10.15 (0.65)
Bedtime	-	-	Chinese children: 21:06 (44.4) US children: 20:27 (30.6)
Waketime	-	-	Chinese children: 06:24 (19.8) US children: 06:55 (25.8)

Note. Values reported as means and SD. 'Weekdays' used to relate to school days. New Zealand data are highlighted.
[d]Sleep questions: When does the child go to bed and wake usually? How long does the child sleep during the daytime? [e]Sleep question: What time did the child go to bed the night before and what time did they wake up on the morning of the assessment day?

Table A3 *(Subjective Values)* continued

	National Sleep Foundation (2004)	Owens et al (2000)	Russo et al (2007)
Country	USA	USA	Italy
Age range (years)	0 - 10	4.8 - 11.0	8 - 14
N	1473	494	1073
Measurement tool	telephone interview	CSHQ	School Sleep Habits Survey (modified version)
Parent/child report	parent	parent	child
Subgroup data	school-age children 6 – 10yrs (*n* = 637)	-	8yrs boys (*n* = 121) & girls (*n* = 108)
Type of day/night	weekdays & weekends	-	weekdays & weekends
Sleep duration (hours)	diurnal: 1.8[f] nocturnal: 9.4 total: 9.5 17% sleep more on weekends 27% sleep less on weekends	10.2 (0.7)	weekdays: boys 9.4 (1.0) girls 9.6 (0.9) weekends: boys 10.1 (1.4) girls 10.5 (1.3)
Bedtime	weekdays: 21:07	20:34 (50)	weekdays: boys 22:00 (53) girls 21:39 (50) weekends: boys 23:02 (64) girls 22:40 (60)
Wake time	weekdays: 07:05	07:19 (45)	weekdays: boys 07:18 (28) girls 07:11 (29) weekends: boys 09:10 (81) girls 09:10 (67)

Note. Values reported as means and SD. 'Weekdays' used to relate to school days.
[f]Parents were asked to report on the usual time their child went to sleep at night/woke in the morning in the past two weeks and napping behaviour.

Table A3 *(Subjective Values)* continued

	Spilsbury et al (2004)	Touchette et al (2008)	Worthman & Brown (2007)
Country	USA	Canada	Egypt
Age range (years)	8 - 11	4 - 6	2 - 60
N	755	1094	16 families
Measurement tool	child-completed 7 day structured sleep journal & parent-completed Child's Health Questionnaire & Children's Sleep and Health Questionnaire	Quebec Longitudinal Study of Child Development self-administered questionnaire	individual sleep history and family activity record (continuous 24hr records for 7 consecutive days)
Parent/child report	child & parent	parent (mother)	parents & study recorders
Subgroup data	8yrs (*n* = 262)	6yrs	2 – 10yrs
Type of day/night	'all days' & weekends	weekdays & weekends	diurnal & nocturnal sleep
Sleep duration (hours)	all days: 9.74 (0.7) weekends: 9.76 (0.9)	weekdays: 10.9[g] weekends: 10.7	diurnal: 2.1 (0.8) nocturnal: 9.8 (1.9) total: 11.0 (3.6)
Bedtime	all days: 10:00 (48)	weekdays: 19:50 (30) weekends: 20:44 (38)	diurnal: 15:11 (78) nocturnal: 23:20 (84)
Wake time	all days: 07:45 (54)	weekdays: 06:42 (27) weekends: 07:26 (46)	diurnal: 17:19 (102) nocturnal: 08:56 (72)

Note. Values reported as means and SD. 'Weekdays' used to relate to school days.
[g]Sleep duration was calculated from bedtime to waketime. Mothers were asked about bedtimes and waketimes during weekdays and weekends: 'In general what time do you put your child to bed for the night?' and 'In general at what time does your child wake up or that you wake up your child in the morning?' Specific sleep durations not reported, but calculated for this table using the sleep duration definition specified in the paper.

Appendix B

Study Pack Documents for Data Collection

Appendix B1

Actigraphy Information Sheet

Massey University

SLEEP~WAKE *research centre*
MOE TIKA~MOE PAI

ACTIWATCH INFORMATION

The Actiwatch contains a small accelerometer and memory chip and records movement. Data from the Actiwatch is analysed in conjunction with what you record in the 'Child's Sleep/Wake Diary' to give us information about the amount and quality of sleep your child obtains. Please note the Actiwatch will be cleaned prior to being delivered to you.

Information about your child wearing the Actiwatch:

1. If you are agreeable, we would like your child to wear the Actiwatch continuously (except when in water) for one week.
2. We cannot tell what your child is doing from the Actiwatch data. We can only tell if they are moving or not.
3. Please ask your child to wear the Actiwatch on their non-dominant wrist (the hand they **don't** write with).
4. It should be attached reasonably firmly so that it does not move about on their wrist. If it does move about, tighten the strap slightly.
5. The Actiwatch is water resistant, not waterproof. This means your child will need to take it off to have a shower/bath or go swimming, but it is important that they then put it back on again.
6. If your child takes the Actiwatch off for any reason (such as having a bath) then please note this in the 'Child's Sleep/Wake Diary (write OFF).
7. If your child forgets to put the Actiwatch back on at any stage then assist them to put it back on as soon as you realise. Please note in the 'Child's Sleep/Wake Diary' when your child has the watch back on (write ON).
8. On the side of the face is a small button, which is an event marker. If you push this, a small mark will appear on the data output. It does not stop or start the watch. The watch will keep going the entire time your child is wearing it.
9. We ask that you assist your child to push the event marker when they are in bed and starting to try to sleep (often for families this is when the light is turned off). We would like the event marker to be pushed again when the child wakes up in the morning i.e. has stopped trying to sleep any more (as close to your child waking up as is practical).
10. If your child has a nap during the day we would like you to assist them to push the event marker when the nap starts and finishes and write NP (when nap starts) and NS (when nap stops) on the diary.
11. We would like the event marker to be pushed when the watch is taken off (for a bath etc) and again when the watch is put back on.

Please do not worry if you sometimes forget to write down the above mentioned information in the diary or to assist your child to push the event marker. Our main request is that your child wears the Actiwatch continuously for one week (except when showering, swimming etc).

Thank you for your assistance with this. Please do not hesitate to contact the researcher if you have any questions or concerns.

Appendix B2

Child's Sleep/Wake Diary

SLEEP~WAKE *research centre*
MOE TIKA~MOE PAI

Child's Sleep/Wake Diary

Thank you for taking the time to complete this diary of your child's sleep and waking activities.

Instructions:

- Please complete the diary as accurately as you can **every day for 1 week (1 page per day)**.
- It should take about 5 to10 minutes to complete each day.
- It does not matter which day of the week you start, as long as you complete the same 7 consecutive days that your child wears the Actiwatch.

For each day, please mark the following times on that page's timeline:

- When your child woke up **(WK)** and when they started trying to go to sleep **(SL)** (including any waking during the night that you are aware of)**.**
  *Please note, if your child goes to bed to read etc we do **not** need to know this. We are interested in when they **begin trying to go to sleep,** for example when the light is turned off.*
- If they had a nap, mark the start time of the nap **(NP)** and finish time of the nap **(NS)**.
- Times when the Actiwatch was removed, for example when swimming, **(OFF)** and when put back on **(ON)**.

For each day please answer the questions in the box below the timeline.

- Please see the example on the next page.

Remember, everything you record in the diary is confidential to the team at the Sleep/Wake Research Centre. No information that could lead to identification of individuals will be provided in the study outputs.

If you have any questions please contact the Sleep/Wake Research Centre on free phone 0508 328 448, telephone 04 380 0638 or email D.P.Muller@massey.ac.nz.

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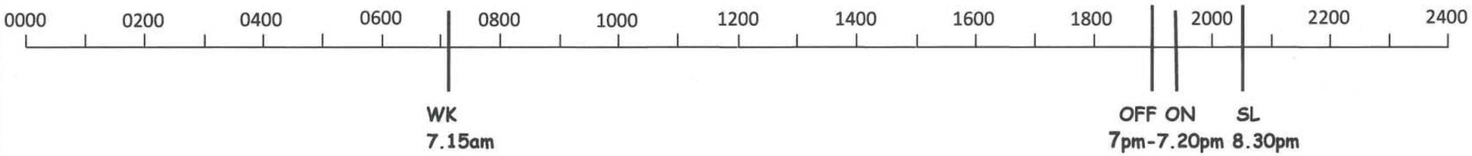
Appendix B2 *(Child's Sleep/Wake Diary)* continued

***Example Diary*:**

Scenario: *A child woke up at 7.15am, had breakfast & walked to school. They had lunch at school, were driven home and had soccer practice for 45 minutes. They watched TV for an hour before having dinner at 6.10pm. They took their Actiwatch off for a bath between 7pm and 7.20pm and read for 30 minutes before going to bed at 8.30pm.*

Day 1: Day (circle) Monday (Tuesday) Wednesday Thursday Friday Saturday Sunday **Date:** 24 /03 /09

This line represents one day (24 hours, from midnight to midnight).



Please complete the following questions about what your child did today:
Circle answers as appropriate and fill in blanks where requested

1. **Went to school.** (Yes) / No → If 'No' go straight to question 4.
2. **Travelled to school by:** car / rode bike or scooter / (walked) / other → if 'other' please specify ______
3. **Travelled from school by:** (car) / rode bike or scooter / walked / other → if 'other' please specify ______
4. **Watched TV/played video games/used computer.** (Yes) / No → If 'Yes' for how long? 1 hour
5. **Went to an organised activity (e.g. sport, music).** (Yes) / No → If 'Yes' please specify soccer
6. **Did some 'physical' play (lots of running/fast moving).** (Yes) / No → If 'Yes' for how long? 45 minutes
7. **Did some 'moderate' play (some running/moving).** Yes / (No) → If 'Yes' for how long? ______
8. **Did some 'quiet' play (mostly sitting/small amount of moving)** (Yes) / No → If 'Yes' for how long? 30 minutes
9. **Meals** (circle which of these meals your child had today) (Breakfast) / (Lunch) / (Dinner)
10. **Today was a typical day.** (Yes) / No → if 'No' please specify (e.g. child sick, special event) ______

2

Appendix B2 *(Child's Sleep/Wake Diary)* continued

Day 1: **Day** (circle) Monday Tuesday Wednesday Thursday Friday Saturday Sunday **Date:** ____/____/____

This line represents one day (24 hours, from midnight to midnight).

0000 0200 0400 0600 0800 1000 1200 1400 1600 1800 2000 2200 2400

On the line above, mark the times your child:
- Woke up **(WK)** & started trying to go to sleep **(SL)**.
- Started a nap **(NP)** & finished a nap **(NS)**.
- When Actiwatch was removed **(OFF)** & put back on **(ON)**.

Please complete the following questions about what your child did today:
Circle answers as appropriate and fill in blanks where requested

1. **Went to school.** Yes / No → If 'No' go straight to question 4.
2. **Travelled to school by:** car / rode bike or scooter / walked / other →If 'other' please specify ____________________
3. **Travelled from school by:** car / rode bike or scooter / walked / other →If 'other' please specify ____________________
4. **Watched TV/played video games/used computer.** Yes / No → If 'Yes' for how long? ____________________
5. **Went to an organised activity (e.g. sport, music).** Yes / No →If 'Yes' please specify ____________________
6. **Did some 'physical' play (lots of running/fast moving).** Yes / No → If 'Yes' for how long? ____________________
7. **Did some 'moderate' play (some running/moving).** Yes / No → If 'Yes' for how long? ____________________
8. **Did some 'quiet' play (mostly sitting/small amount of moving).** Yes / No → If 'Yes' for how long? ____________________
9. **Meals** (circle which of these meals your child had today) Breakfast / Lunch / Dinner
10. **Today was a typical day.** Yes / No → If 'No' please specify (e.g. child sick, special event) ____________________

3

Appendix B3

Child/Family Questionnaire

Massey University

SLEEP~WAKE *research centre*
MOE TIKA~MOE PAI

Sleep Patterns and Factors Affecting Sleep Duration in New Zealand: A Pilot Study

Child/Family Questionnaire

If you have any questions please call 0508 328 448

Instructions for Questionnaire Completion:

Most questions require you to TICK your answer in a box. If you make a mistake put a cross in the box and tick the correct answer. Only tick one option unless otherwise instructed.
Examples of how to mark the questionnaire:

To answer "no" ☐ Yes
☑ No

To answer "yes" ☑ Yes
☐ No

Please note you have the right to decline to answer any question in this questionnaire.

This information is confidential and will only be accessed by members of the Sleep/Wake Research Centre team. ***No information that could lead to identification of individuals will be provided in the study outputs.***

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 09/19. If you have any concerns about the conduct of this research, please contact Professor Julie Boddy, Chair, Massey University Human Ethics Committee: Southern A, telephone 06 350 5799 xt 2541, email humanethicsoutha@massey.ac.nz

Office Use Only ☐☐☐

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Appendix B3 *(Child/Family Questionnaire)* continued

Today's Date: _____/_____/_____
Day Month Year

Parent and Child's Details:

Name of parent: First Name ________________ Surname __________________

Name of child: First Name ________________ Surname __________________

Child's date of birth: _____/_____/_____
Day Month Year

Child's gender: Male ☐
Female ☐

Name of school your child attends: ________________________

Which Year is your child in at school? (e.g. Year 3) ______________

Phone numbers: Home _____________________________

Work ______________________________

Cell phone ___________________________

Email: ____

2

Appendix B3 *(Child/Family Questionnaire)* continued

Ethnicity:

1. (a) Ethnicity of child:

Which ethnic group does your child belong to? *Tick the box or boxes which apply to your child.*
a☐ NZ European b☐ Maori c☐ Samoan d☐ Cook Island Maori
e☐ Tongan f☐ Niuean g☐ Chinese h☐ Indian
i☐ Other (such as Dutch, Japanese, Tokelauan). Please state ________________________

1. (b) Ethnicity of mother:

Which ethnic group do you belong to? *Tick the box or boxes which apply to you.*
a☐ NZ European b☐ Maori c☐ Samoan d☐ Cook Island Maori
e☐ Tongan f☐ Niuean g☐ Chinese h☐ Indian
i☐ Other (such as Dutch, Japanese, Tokelauan). Please state ________________________

1. (c) Ethnicity of father:

Which ethnic group do you belong to? *Tick the box or boxes which apply to you.*
a☐ NZ European b☐ Maori c☐ Samoan d☐ Cook Island Maori
e☐ Tongan f☐ Niuean g☐ Chinese h☐ Indian
i☐ Other (such as Dutch, Japanese, Tokelauan). Please state ________________________

Height and Weight Details:
(Researcher to complete if meeting arranged)

2. (a) What is the child's current height (centimetres) and weight (kilograms)?
Height ________________cm
Weight ________________kg

2. (b) What is the mother's current height (centimetres) and weight (kilograms)?
Height ________________cm
Weight ________________kg

2. (c) What is the father's current height (centimetres) and weight (kilograms)?
Height ________________cm
Weight ________________kg

3

Appendix B3 *(Child/Family Questionnaire)* continued

Health:

3. Has your child been diagnosed with any form of developmental disorder?

☐ Yes → Please specify ____________________

☐ No

4. Does your child have any ongoing health problem/s that you think may affect their sleep?

☐ Yes → Please specify ____________________

☐ No

Drinks:

5. How often does your child drink caffeinated tea, coffee, Coke, Pepsi, Mountain Dew or other drinks that have caffeine in them (do **not** include energy drinks like V or Red Bull)?

☐ Never

☐ Sometimes – once or twice a week at most

☐ One or two cups or cans a day

☐ Often – more than three cups or cans a day

6. How often does your child drink energy or smart drinks like V, Red Bull or something similar?

☐ Never

☐ Sometimes – once or twice a week at most

☐ One or two cups or cans a day

☐ Often – more than three cups or cans a day

Family Home:

7. How many people live in your house?

__________ adults (18 years & older)

__________ children & teenagers (0 to 17 years)

→How many of these children are **younger** than your child in this study? ________

Your Child's Room:

8. Does your child share the room he/she sleeps in with:

(a) Other children? ☐ Yes → How many other children share this room? ________

☐ No

(b) Any adults? ☐ Yes → How many adults share this room? ________

☐ No

9. Where does your child sleep?

Own bed ☐

Parent(s) bed ☐→ How many share the bed? ______

Sibling(s) bed ☐→ How many share the bed? ______

Other ☐→ Please specify ______________

4

Appendix B3 *(Child/Family Questionnaire)* continued

10. Does your child have any of the following things in their bedroom?
(Please tick all the items they have)

- ☐ TV
- ☐ Stereo or similar (e.g. iPod)
- ☐ Phone (landline)
- ☐ Cell phone they use in their bedroom (talking and/or texting)
- ☐ Computer
- ☐ Play Station/Xbox/Wii that they use in their bedroom
- ☐ None of the above are in or are used in your child's bedroom

Childcare:

11. (a) Does your child spend any time in After School Care or Childcare?

- ☐ Yes
- ☐ No

11. (b) If 'Yes' please tick which days and write down the time in childcare next to those days.
(e.g. Monday ☑ 3pm to 6pm)

Monday ☐ ______________________ (time in childcare)
Tuesday ☐ ______________________ (time in childcare)
Wednesday ☐ ______________________ (time in childcare)
Thursday ☐ ______________________ (time in childcare)
Friday ☐ ______________________ (time in childcare)
Saturday ☐ ______________________ (time in childcare)
Sunday ☐ ______________________ (time in childcare)

Employment:

12. (a) Are any adults in your home currently employed for pay, profit, or income, or in a family business, or farm?

Yes ☐→How many adults are employed? __________
No ☐

12. (b) If 'Yes' what types of work patterns are adults in your home engaged in?
(please tick the boxes that best describe the work patterns of adults in your home)

- ☐ Daytime with no shifts (full-time)
- ☐ Daytime with no shifts (part-time)
- ☐ Rotating shifts with nights (full-time)
- ☐ Rotating shifts with nights (part-time)
- ☐ Rotating shifts without nights (full-time)
- ☐ Rotating shifts without nights (part-time)
- ☐ Permanent nights (full-time)
- ☐ Permanent nights (part-time)
- ☐ Irregular or variable hours
- ☐ Other work patterns ___________________________ (please specify)

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Appendix B3 *(Child/Family Questionnaire)* continued

13. Your Child's Sleep:

The following statements are about your child's sleep habits. Think about the **past week** in your child's life when answering the questions. **If last week was unusual** for a specific reason (such as your child had an ear infection and did not sleep well or the TV set was broken), choose the **most recent typical week**.

Bedtime:	**Usually (4-5 nights)**	**Sometimes (2-3 nights)**	**Rarely (0-1 night)**
Child goes to bed at the same time on **school nights** *(Sunday night to Thursday night)*	☐	☐	☐

	Usually (2 nights)	**Sometimes (1-2 nights)**	**Rarely (0-1 night)**
Child goes to bed at the same time on **weekend nights** *(Friday & Saturday nights. Think of the last month to answer this question)*	☐	☐	☐

	Usually (5-7nights)	**Sometimes (2-4 nights)**	**Rarely (0-1 night)**
Child falls asleep within 20 minutes after going to bed	☐	☐	☐
Child falls asleep alone in own bed	☐	☐	☐
Child falls asleep in parent's or sibling's bed	☐	☐	☐
Child needs parent in the room to fall asleep	☐	☐	☐
Child struggles at bedtime (e.g. cries, refuses to stay in bed)	☐	☐	☐
Child is afraid of sleeping in the dark	☐	☐	☐
Child is afraid of sleeping alone	☐	☐	☐

Sleep Behaviour:

Child's usual amount of sleep each **school night**: ________ hours and ____________ minutes.
(Sunday night to Thursday night)

Child's usual amount of sleep each **weekend night**: _______ hours and ___________minutes.
(Friday & Saturday nights)

	Usually (5-7nights)	**Sometimes (2-4 nights)**	**Rarely (0-1 night)**
Child sleeps too little	☐	☐	☐
Child sleeps the right amount	☐	☐	☐
Child sleeps about the same amount each day	☐	☐	☐
Child wets the bed at night	☐	☐	☐
Child talks during sleep	☐	☐	☐
Child is restless and moves a lot during sleep	☐	☐	☐
Child sleepwalks during the night	☐	☐	☐
Child moves to someone else's bed during the night	☐	☐	☐
Child grinds teeth during sleep	☐	☐	☐
Child snores loudly	☐	☐	☐
Child seems to stop breathing during sleep	☐	☐	☐

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Appendix B3 *(Child/Family Questionnaire)* continued

	Usually (5-7nights)	Sometimes (2-4 nights)	Rarely (0-1 night)
Child snorts and/or gasps during sleep	☐	☐	☐
Child has trouble sleeping away from home *(visiting relatives, going on holiday etc)*	☐	☐	☐
Child awakens during night screaming, sweating and inconsolable	☐	☐	☐
Child awakens alarmed by a frightening dream	☐	☐	☐
Waking During the Night:			
Child awakes once during the night	☐	☐	☐
Child awakes more than once during the night	☐	☐	☐
Child returns to sleep without help after waking	☐	☐	☐

Morning Waking:	Usually (4-5 mornings)	Sometimes (2-3 mornings)	Rarely (0-1 morning)
Child gets up at the same time on **school mornings** *(Monday morning to Friday morning)*	☐	☐	☐

	Usually (2 mornings)	Sometimes (1- 2 mornings)	Rarely (0-1 morning)
Child gets up at the same time on **weekend mornings** *(Saturday & Sunday mornings. Think of the last month to answer this question)*	☐	☐	☐

	Usually (5-7 mornings)	Sometimes (2-4 mornings)	Rarely (0-1 morning)
Child wakes up by him/herself	☐	☐	☐
Child wakes up in a negative mood	☐	☐	☐
Adults or siblings wake up child	☐	☐	☐
Child has difficulty getting out of bed in the morning	☐	☐	☐
Child takes a long time to become alert in the morning	☐	☐	☐
Daytime Sleepiness:			
Child seems tired	☐	☐	☐

During the past week your child has appeared very sleepy or fallen asleep during the following:

(please tick any that apply)	Not Sleepy	Very Sleepy	Falls Asleep
Playing alone	☐	☐	☐
Watching TV	☐	☐	☐
Riding in the car	☐	☐	☐
Eating meals	☐	☐	☐

General Sleep:

In general do you consider your child's sleep a problem?

- A very serious problem ☐
- A small problem ☐
- Not a problem at all ☐

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Appendix B3 *(Child/Family Questionnaire)* continued

14. If there is anything else you feel is important regarding the sleep of your child that has not been included in this questionnaire please comment.

Thank you very much for your help with this questionnaire. Please return your completed questionnaire, 'Child's Sleep/Wake Diary' and Actiwatch, using the self-addressed postage paid envelope provided, to:

D. Muller
Sleep/Wake Research Centre
Massey University
Private Box 756
Wellington

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Appendix B4

Instruction Sheet for Returning Study Material

Instructions for Returning Paperwork and Actiwatch

- If you would like me to collect the Actiwatch and completed paperwork please telephone 380 0638 or 0508 328 448 to arrange a time that is convenient for you.
- Alternatively, please place the Actiwatch (in its plastic storage container), Diary and Questionnaire in the courier bag provided. You can drop this into a Post Office (you will need to hand it over at the counter) or phone 0800 268 7437 to arrange NZ Post to pick it up from your house. Please **do not post the courier bag in a mail box**.

Please do not hesitate to contact me if you have any questions.

Kind regards

Dee Muller
Ph: 380 0638
Freephone: 0508 328 448
Email: D.P.Muller@massey.ac.nz

Appendix C

Ethics and Recruitment

Appendix C1

Ethics Committee Approval Letter

Massey University

OFFICE OF THE ASSISTANT
TO THE VICE-CHANCELLOR
(Research Ethics)
Private Bag 11 222
Palmerston North 4442
New Zealand
T 64 6 350 5573/350 5575
F 64 6 350 5622
humanethics@massey.ac.nz
animalethics@massey.ac.nz
gtc@massey.ac.nz
www.massey.ac.nz

23 April 2009

Diane Muller
Sleep/Wake Research Centre
WELLINGTON

Dear Diane

Re: HEC: Southern A Application – 09/19
Sleep patterns and factors affecting sleep duration in New Zealand children: A pilot study

Thank you for the above application that was considered by the Massey University Human Ethics Committee: Southern A at their meeting held on Tuesday 7 April 2009.

On behalf of the Massey University Human Ethics Committee: Southern A, I am pleased to advise you that the ethics of your application are approved.

Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

JMBoddy

Professor Julie Boddy, Chair
Massey University Human Ethics Committee: Southern A

cc Prof Philippa Gander & Dr Leigh Signal
Sleep/Wake Research Centre
WELLINGTON

Massey University Human Ethics Committee
Accredited by the Health Research Council

Te Kunenga ki Pūrehuroa

Appendix C2

Ethics Committee Approval of Amendments

Massey University

OFFICE OF THE ASSISTANT
TO THE VICE-CHANCELLOR
(RESEARCH ETHICS)
Private Bag 11 222
Palmerston North 4442
New Zealand
T 64 6 350 5573
64 6 350 5575
F 64 6 350 5622
humanethics@massey.ac.nz
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gtc@massey.ac.nz
www.massey.ac.nz

17 July 2009

Diane Muller
Sleep/Wake Research Centre
WELLINGTON

Dear Diane

Re: HEC: Southern A Application – 09/19
Sleep patterns and factors affecting sleep duration in New Zealand children: A pilot study

Thank you for your letter dated 7 July 2009 outlining the changes you wish to make to the above application.

The changes have been approved and noted as follows:

- Minor amendment to the information sheet (removal of statements regarding measuring and weighing family members);
- Inclusion of communication details and child's DOB on the consent form to facilitate contact and setting of the Actiwatch;
- An additional advertising flyer noting the school year (Year 3) in which children must be for participation in the study;
- The inclusion of feedback forms to families who have completed the study.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee. If over time, more than one request to change the application is received, the Chair may request a new application.

Yours sincerely

Associate Professor Hugh Morton, Acting Chair
Massey University Human Ethics Committee: Southern A

cc Prof Philippa Gander & Dr Leigh Signal
Sleep/Wake Research Centre
WELLINGTON

Massey University Human Ethics Committee
Accredited by the Health Research Council

Te Kunenga ki Pūrehuroa

Appendix C3 *Study Flyer*

Children's Sleep Study

Is your child 6 – 8 & in Year 3 at school?

Are you interested in how they sleep?

- It is widely accepted that sleep is an important part of children's health, but limited information exists on the 'normal' sleep patterns of primary school aged children in New Zealand.
- Some research suggests a link between sleep duration (how long a child sleeps for) and mood, school performance and obesity, but many of these studies have not included objective measures of sleep.
- This pilot study aims to look at how children are typically sleeping, how long they are sleeping for (using objective and subjective measures) and what modifiable factors affect children's sleep.
- We are seeking 50 families with healthy children aged 6 – 8, living in the Wellington region, to take part. The study involves:
  - Children wearing an activity monitor on their wrist for 1 week to monitor sleep.
  - Parents completing a questionnaire and filling out a diary for 1 week on their children's sleep and waking activities.
- The findings will help us design a future large-scale study and provide you with some information on children's sleep.

If you are interested in finding out more about this study please contact Dee Muller on:
Toll-free 0508 328 448
(04) 380 0638
D.P.Muller@massey.ac.nz

Massey University

SLEEP~WAKE research centre
MOE TIKA~MOE PAI

Appendix C4

Board of Trustees Letter

Massey University

SLEEP~WAKE *research centre*
MOE TIKA~MOE PAI

<Date>

<Name>
Chairperson
<name of school> Board of Trustees
<Address line 1>
<Address line 2>
<Address line 3>

Sleep Patterns and Factors Affecting Sleep Duration in New Zealand Children: A Pilot Study

Dear <insert name>

My name is Diane (Dee) Muller. I am conducting a pilot study, with the Sleep/Wake Research Centre, looking at children's sleep patterns and duration within the family context. Findings from this study will contribute to my Master of Public Health thesis.

My supervisors are:

- Professor Philippa Gander, Director of the Sleep/Wake Research Centre, Massey University, Wellington Campus.
- Dr Leigh Signal, Associate Director of the Sleep/Wake Research Centre, Massey University, Wellington Campus.

I have discussed this project with Principal *<insert name>* and would like to request your permission to distribute a printed advertisement (copy enclosed) about this study via *<insert school's name>*. If the Board of Trustees is agreeable, I would like to send an advertisement home with each of your Year Three pupils.

The advertisement invites parents to contact me if they are interested in finding out more about the study. Those who do will be given verbal information and a printed study pack containing a letter of invitation, information sheets for parents and children and written consent forms (copies enclosed).

Please note my request is for advertisement distribution only. Actual data collection will take place in children's homes. Parents who agree to take part will be requested to complete a questionnaire and diary at home. Children will be asked to wear an activity monitor, the size of a small watch, on their wrist for a week.

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 09/19. If you have any concerns about the conduct of this research, please contact Professor Julie Boddy, Chair, Massey University Human Ethics Committee: Southern A, telephone 06 350 5799 ext 2541, email humanethicsoutha@massey.ac.nz.

Thank you very much for your consideration of this request. Please do not hesitate to contact me if you have any questions.

Regards

Diane (Dee) Muller
Massey Masterate Scholar
Sleep/Wake Research Centre
D.P.Muller@massey.ac.nz
Telephone: 04 380 0638
Toll Free: 0508 328 448

Appendix D

Information Pack Documents

Appendix D1

Letter of Invitation

Massey University

SLEEP~WAKE *research centre*
MOE TIKA~MOE PAI

<Date>

Sleep Patterns and Factors Affecting Sleep Duration in New Zealand Children: A Pilot Study

Dear Parent

We are inviting you and your child to take part in a study concerning sleep in children. This project is being run by the Sleep/Wake Research Centre at Massey University, Wellington. Findings from this study will contribute to the Master of Public Health thesis research of Diane Muller.

Limited information exists on normal sleep patterns of children and how sleep impacts on their health and wellbeing. Some research suggests a link between sleep duration and accidents, mood, difficulties at school and obesity. However in many of these studies, data gathering methods have been limited in regards to capturing both subjective and objective information.

This is a pilot study for a potentially larger project in the future studying the sleep of children across New Zealand. For the current study we are recruiting 50 families in the Wellington region with children aged from 6 to 8 years of age.

Participation in this study would involve completing a diary on your child's sleep and waking activities for a week while your child wore an activity monitor (the size of a small wristwatch) on their wrist to monitor sleep patterns. Completion of the diary would take approximately 5 to 10 minutes of your time per day. You would also be asked to complete a questionnaire about your child's sleep and some general questions about your family which would take approximately 10 to 15 minutes.

If you wish to take part in this project please carefully read through the enclosed information sheet, complete the consent form and post it to us in the prepaid envelope provided. This should take about 5 – 10 minutes of your time.

All of the information you provide is confidential and we will not publish anything that could identify you or your family. The results of this study will be used for a Master of Public Health thesis as well as potential scientific journal publication.

If you decide to participate you can choose to have an annotated copy of your child's sleep recording and to discuss it with the research team. We will also send a summary of the study findings to everyone who takes part and some general information about children's sleep.

Appendix D1 *(Letter of Invitation)* continued

Please note you have the right to:

- Decline to participate
- Refuse to answer any particular questions
- Withdraw from the study at any time

Please contact us at the Sleep/Wake Research Centre if you have any questions or concerns about the study. Thank you very much for your time.

Yours sincerely

Diane (Dee) Muller
Master of Public Health student
Massey Masterate Scholar
Sleep/Wake Research Centre

D.P.Muller@massey.ac.nz
Telephone: 04 380 0638
Toll Free: 0508 328 448

Supervisors:
Professor Philippa Gander
P.H.Gander@massey.ac.nz
Telephone: 04 801 5799 ext 6033

Dr Leigh Signal
T.L.Signal@massey.ac.nz
Telephone: 40 801 5799 ext 6034

Appendix D2

Information Sheet for Parents

Massey University

SLEEP~WAKE *research centre*
MOE TIKA~MOE PAI

Sleep Patterns and Factors Affecting Sleep Duration in New Zealand Children: A Pilot Study

INFORMATION SHEET FOR PARENTS

This project is being run by the Sleep/Wake Research Centre at Massey University, Wellington. We are asking you to consider taking part, and to allow your child to take part, in a pilot study looking at children's sleep patterns and duration within the family context. Findings from this study will contribute to the Master of Public Health thesis research of Diane Muller.

The research team:

- Researcher – Diane (Dee) Muller, Master of Public Health student, Massey Masterate Scholar, Sleep/Wake Research Centre, Massey University, Wellington Campus.
- Supervisor – Professor Philippa Gander, Director of the Sleep/Wake Research Centre, Massey University, Wellington Campus.
- Supervisor – Dr Leigh Signal, Associate Director of the Sleep/Wake Research Centre, Massey University, Wellington Campus.
- Dr Dawn Elder, Department of Paediatrics, School of Medicine and Health Sciences, University of Otago, Wellington.

What is this Study About?

It is widely accepted that sleep is an important part of children's health, but limited information exists on the 'normal' sleep patterns of primary school aged children in New Zealand. Some research suggests a link between sleep duration (how long a child sleeps) and accidents, mood, difficulties at school and obesity. Many of these studies (particularly those looking at obesity) have relied on parents reporting the time their children usually go to bed and get up in the morning, without any objective measurement of sleep. Therefore, existing sleep duration data may be inaccurate.

This study aims to gather information on how children are typically sleeping, accurately record how long they are sleeping for (using both subjective and objective measures) and identify factors within the family context that affect their sleep duration. This small study will be used to test and refine the methods of gathering and analysing data, with the view to a much larger study potentially being carried out in the future.

We are inviting you and your child to consider joining this pilot study that will monitor the sleep of 50 children, aged between 6 and 8, in the Wellington region for one week.

1

Appendix D2 *(Information Sheet for Parents)* continued

Who Will be Involved?
This study will involve 50 children, aged 6 to 8 years of age, and their families living in the Wellington region. We are very interested in sleep for all children, however for this small pilot study we will be looking at the sleep of children who do not have any known developmental problems. If a future large-scale study is conducted we would look at a larger, more diverse population including children with developmental issues. If this applies to your child and you are interested in being contacted about future research, please complete the enclosed Future Research Consent Form and return it in the postage paid envelope. Please note, responding 'yes' to being contacted about future research does **not** commit you to participation in future research, only to be contacted about it.

What is Involved?
If you choose to participate in this project, you will be asked to fill in a diary on your child's sleep and waking activities for a week which will take approximately 5 to 10 minutes of your time per day. This will involve reporting on when your child goes to bed, gets up, eats meals, how they get to and from school and what kind of playing they do.

If you agree to your child participating in this study they will be given an activity monitor the size of a small watch, called an Actiwatch, to wear on their wrist for one week. The Actiwatch contains a small accelerometer and memory chip and continuously monitors movement, from which we can identify periods of sleep and activity. We cannot tell what your child is doing from the Actiwatch data, only whether or not they are moving. We would ask that your child wears the Actiwatch continuously except for when in water such as showering or swimming. The Actiwatch is a widely used tool in sleep research and is non-invasive. Actiwatches will be cleaned between participants and you will not be held liable if the Actiwatch is damaged or lost.

Example of an Actiwatch

If you choose to take part you will also be asked to complete a questionnaire which will take approximately 10 to 15 minutes of your time. It includes questions about your child's typical sleep behaviour, activities, environment and family such as how many people live in your child's home, childcare and employment. If you are agreeable we would like to record your child's height and weight and parent/s height and weight as part of this process.

2

Appendix D2 *(Information Sheet for Parents)* continued

The questions on your child's sleep in the questionnaire are based on a sleep screening tool called the Children's Sleep Habits Questionnaire which has been used in a number of studies internationally. In the highly unlikely event that your answers to these, or any other questions in the study, raises concerns about your child you would be offered the opportunity to discuss this in greater depth with Dr Dawn Elder, a very experienced Paediatrician on the research team, at no cost.

If you choose to participate, the researcher will arrange a time for you to receive the diary, questionnaire and activity monitor. Instructions will be provided on how to complete the diary and questionnaire and how to use the Actiwatch. A free phone number will be available for you to ask questions before, during and after the research.

Our preference is to visit you at home to give you the questionnaire, diary and Actiwatch. This allows us to offer you maximum information and support concerning the study, as well as being able to measure height and weight using standardised equipment. However if you prefer, you have the option of having paperwork and equipment couriered to you. You can take your own measurements of height and weight and write them in the questionnaire.

What will Happen to the Data?
The data will be analysed and presented as a Master of Public Health thesis and with the aim of being published as a scientific paper. They will also help us to decide whether we need to undertake a larger scale study of the sleep of children in New Zealand and, if so, what amendments we need to make to the methodology.

Participants will only be identified to research team members from the Sleep/Wake Research Centre. All study data will be identified only by study ID numbers, only grouped data will be reported on and no information that could lead to identification of individuals will be provided in the study outputs.

You will have the option to receive an annotated printout of your child's sleep/wake patterns as recorded by the Actiwatch and diary and have the opportunity to discuss it if you wish. In addition, all participating families will receive a short brochure describing the study findings and some general information on children's sleep.

Your Rights
You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- Decline to answer any particular question;
- Withdraw from the study at any time;
- Ask any questions about the study at any time during participation;
- Provide information on the understanding that your name will not be used unless you give permission to the researcher;
- Be given access to a summary of the project findings when it is concluded.

If your child is reluctant to be involved in this study they have the right to decline to participate. We do **not** expect children to do anything in this study that they are not agreeable to.

3

Appendix D2 *(Information Sheet for Parents)* continued

Project Contacts
Please feel free to contact the researcher or supervisors (details below) if you have any questions concerning this research.

Researcher:
Diane (Dee) Muller
D.P.Muller@massey.ac.nz
Telephone: 04 380 0638
Toll free: 0508 328 448

Supervisors:
Professor Philippa Gander
P.H.Gander@massey.ac.nz
Telephone: 04 801 5799 xt6033

Dr Leigh Signal
T.L.Signal@massey.ac.nz
Telephone: 04 801 5799 xt6034

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 09/19. If you have any concerns about the conduct of this research, please contact Professor Julie Boddy, Chair, Massey University Human Ethics Committee: Southern A, telephone 06 350 5799 xt 2541, email humanethicsoutha@massey.ac.nz.

Thank you for your time and consideration of this project.

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Appendix D3

Information Sheet for Children

Massey University

SLEEP~WAKE *research centre*
MOE TIKA~MOE PAI

CHILDREN'S INFORMATION SHEET

Hi. My name is Diane (but most people call me Dee) and I work at a place called the Sleep/Wake Research Centre. At the moment I am doing a project on children's sleep. I am interested in the sleep of children who are aged 6, 7 or 8.

I have asked your mum, dad or person who normally looks after you to think about helping me with my project.

If they agree, I will ask them to write some stuff down so I can find out:

- what kind of things you do when you go to sleep
- how long you sleep for
- what makes a difference to your sleep

If you are happy to help, I will ask you to wear a special watch for one week. Instead of telling the time, this watch can tell when you are moving. This will help me to work out when you are awake and when you are asleep.

It is **really important** that you and your family know **you don't have to** help me with my project. If you take part **you don't have to** do anything that you don't want to do.

If you have any questions your family can contact me and I will happily answer them.

Thank you very much.

Diane (Dee) Muller

Appendix D4

Participant Consent Form

Massey University

SLEEP~WAKE *research centre*
MOE TIKA~MOE PAI

Sleep Patterns and Factors Affecting Sleep Duration in New Zealand Children:

A Pilot Study

PARTICIPANT CONSENT FORM

This consent form will be held for a period of ten (10) years

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction and I understand that I may ask further questions at any time.

I agree to participate in this study under the conditions set out in the Information Sheet.

I agree to my child participating in this study under the conditions set out in the Information Sheet.

Signature of parent: ______________________ **Date:** __________

Full name of parent - printed: ______________________________

Relationship to child (e.g. mother) ___________________________

Full name of child - printed: ________________________________

Please tick one box for each of the following questions:

- I **would** like the researcher to visit me at home to deliver the research materials and instructions on how to use them.
  ☐ Yes
  ☐ No
- I **would** like to be provided with an annotated copy of my child's sleep/wake recording.
  ☐ Yes
  ☐ No

Phone number: ____________________

Address: ____

Email: ____

Child's date of birth: _____________________________________

Appendix D5

Future Research Consent Form

Massey University

SLEEP~WAKE *research centre*
MOE TIKA~MOE PAI

Sleep Patterns and Factors Affecting Sleep Duration in New Zealand Children:

A Pilot Study

FUTURE RESEARCH CONSENT FORM

We are hoping to conduct a future large-scale study on children's sleep, using a more diverse population of children, once pilot data have been analysed.

Would you like to be **contacted** about any future research? ☐ Yes

Name - printed: ______________________________

Signature: ______________________________

Contact details (phone or email): ______________________________

There is no need to return this form if you do not wish to be contacted about future research.

If you are interested in being contacted about future research, please complete this form and return it in the enclosed postage paid envelope.

Responding 'yes' does not commit you or your child to participation in future research, only to be contacted about it.

Thank you for your consideration of this.

Appendix E

Follow-up and Feedback Documents

Appendix E1

Family Feedback Letter and Actogram

Massey University

SLEEP~WAKE research centre
MOE TIKA~MOE PAI

14 August 2009

Dear Katherine and Jane

Thank you very much for taking part in the children's sleep study. I really appreciate the time and effort you put in to help with our project.

Enclosed is the printout of Jane's Actiwatch recording. The Actogram runs from midday to midday and the black vertical lines indicate when Jane was moving. The height of each line represents how much movement was recorded per one minute interval.

The blue triangles show when the event marker was pushed on the Actiwatch. The red lines are periods that the software has calculated as activity/wakefulness. Areas without red lines are deemed to be sleep time or may be periods when the watch was removed.

Jane appears to have a consistent sleep pattern throughout the week, with limited variability between school nights and non-school nights. Movement during sleep is normal and expected and Jane's Actogram shows small periods of movement/wakefulness throughout each night (these may have been as short as one minute and information used by the software is based on movement only).

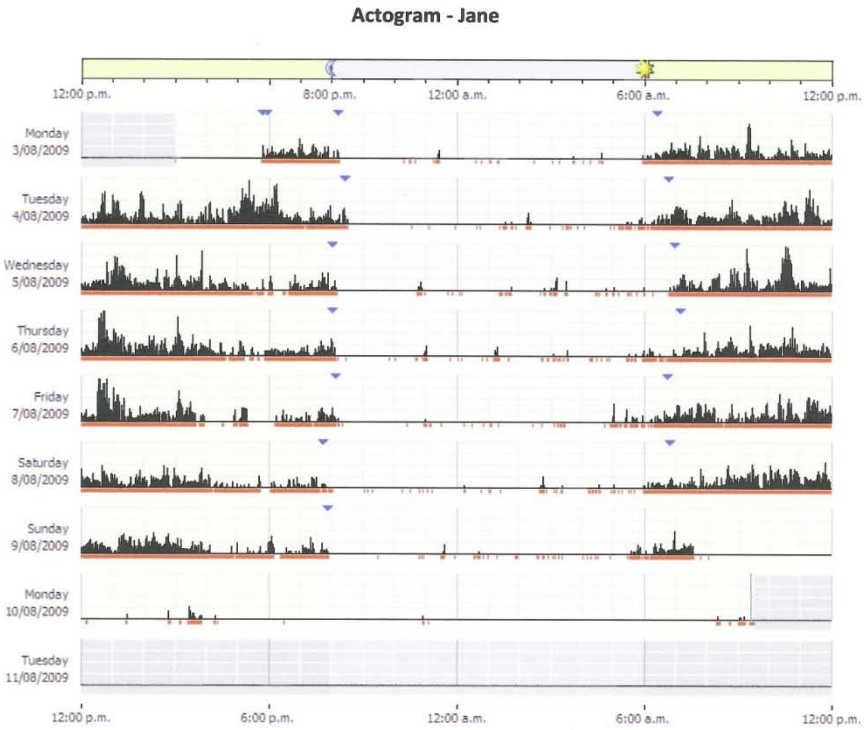
A variety of statistical analyses will be conducted using the actigraphy data in conjunction with information from the sleep diaries. These will be used in my thesis and potentially in scientific paper publication once the study has been completed.

A summary of study results will be sent to you at the end of the project, however if you would like more detailed information about Jane's records please do not hesitate to contact me on 380 0638 or D.P.Muller@massey.ac.nz.

Kind regards

Diane (Dee) Muller
Master of Public Health student
Sleep/Wake Research Centre

Appendix E1 *(Family Feedback Letter and Actogram)* continued



Appendix E2

Example of a Child's Certificate

Certificate of Appreciation

Awarded to

Jane

For taking part in our sleep study

Thank You, You Were Great!

Appendix E3

Parental Feedback Request Letter

Massey University

SLEEP~WAKE *research centre*
MOE TIKA~MOE PAI

Dear Parent

Thank you to you and your family for the time and effort you have put into participating in the children's sleep study. I would value your honest feedback on the experience, which will be used to assist with the redesign of a potential future study. Feedback received will be anonymous, so please do not hesitate to be critical.

If you decide to complete the attached form, please return it to me using the enclosed prepaid envelope. Thank you again for all of your help.

Kind regards

Diane (Dee) Muller
Master of Public Health student
Sleep/Wake Research Centre

Appendix E3 *(Parental Feedback Request Letter)* continued

Sleep Patterns and Factors Affecting Sleep Duration in New Zealand Children: A Pilot Study

Feedback Form

1. How did you hear about the study?
   - ☐ Flyer sent home from school
   - ☐ Community notice board
   - ☐ Other (please specify) ____________________
2. Did the information given to you prior to taking part give you a clear idea of what was involved?
   - ☐ Yes
   - ☐ No → If no, what else should you have been told about?

     ____
3. Was there enough support available during the study if you had any questions or concerns?
   - ☐ I didn't have any questions or concerns
   - ☐ Yes
   - ☐ No → If no, what other support would have been useful?

     ____
4. How did you find using the Actiwatch?
   - ☐ Easy
   - ☐ OK
   - ☐ Difficult
5. How did you find completing the sleep diary?
   - ☐ Easy
   - ☐ OK
   - ☐ Difficult
6. How did you find completing the questionnaire?
   - ☐ Easy
   - ☐ OK
   - ☐ Difficult
7. Were the estimates accurate of how much time the study would take?
   - ☐ Yes
   - ☐ No → If no, how much time did the study take?

     Questionnaire: ____________________

     Diary: ____________________
8. Any other comments you would like to make:

Thank you.

Appendix F

Scoring Guidelines

Appendix F1

CSHQ Scoring Instructions

(source: http://www.kidzzzsleep.org/pdfs/CSHQCover5_08.pdf)

May 2008

Dear Colleague:

Thank you for expressing interest in the Children's Sleep Habits Questionnaire (CSHQ). The CSHQ was designed by clinical researchers at Brown University for children aged 4 through 12 years, to screen for the most common sleep problems in that age group. The CSHQ is not intended to be used to diagnose specific sleep disorders, but rather to identify sleep problems and the possible need for further evaluation.

Reliability and validity data has been collected on a sample of 495 elementary school children and on a clinical sample from a pediatric sleep clinic. The manuscript detailing the psychometric properties of the CSHQ was published in the December 2000 issue of the journal SLEEP (Owens J, Nobile C, McGuinn M, Spirito A. The Children's Sleep Habits Questionnaire: Construction and validation of a sleep survey for school-aged children. Sleep, 2000;23(8):1043-51) and data on a large sample of school-aged children appears in JDBP (Owens J, Spirito A, McGuinn M, Nobile C. Sleep habits and sleep disturbance in school-aged children. Journal of Developmental and Behavioral Pediatrics, 2000; 21(1):27-36); further information about the journal SLEEP may be found on the American Academy of Sleep Medicine web site, aasmnet.org.

We are happy to share the instrument with you, and there are no copyright issues regarding its use. The "abbreviated" version of the scale contains only those items that are included in scoring the survey; these are the 35 individual items which comprise the CSHQ subscales (note: 2 of the 35 items are found in 2 subscales and are thus there are only 33 separate items in the total CSHQ score). The "longer" version also contains items which, although not utilized in either the subscale or total scores, may yield clinically relevant information. There is also a self-report version for children aged 7 years and above, which we would be happy to provide on request.

The coding and scoring of the CSHQ are included on the attached. **Please note:** There has been some confusion regarding the scoring for the CSHQ. **A higher score is indicative of *more* sleep problems.** The first column `of responses are scored: Usually=3, Sometimes=2, Rarely=1 for the entire questionnaire (except for the R=reversed items, which are considered to be "desirable" sleep behaviors, and thus scored in the opposite direction). On the current research version, the sleepiness items (at the end) are scored 1 for "not sleepy", 2 for "very sleepy", 3 for "falls asleep" for each item. The second column of responses ("Problem?") may be scored Yes=1, No=0; alternatively, this scale may be used to determine what percentage of the sample has at least one item in each subscale that is identified as a "problem" or to assess the effect of an intervention (e.g., percent of items that change from "problem" to "not problem"

Appendix F1 (*CSHQ Scoring Instructions)* continued

status pre to post-intervention). If you are using the modified version of the CSHQ (for which there is no second "problem" column) simply skip this column.

The total and subscale scores listed in the SLEEP paper are based on the 1-3 scoring system described above, except that sleepiness items 32 and 33 were scored as: default (not checked) = 0, "very sleepy"= 1 and "falls asleep"= 2. Although an ROC curve analysis described in this paper suggested a cut-off score of 41 yielded the best diagnostic confidence (correctly identified 80% of the clinical sample in the study), it should be emphasized that there are no established "norms" for the total and subscale scores. Thus, we have found the instrument most useful in comparing samples or in assessing sleep pre and post-intervention.

We would appreciate receiving feedback from you if you utilize the CSHQ and/or self-report version in your research. We are maintaining a bibliography of published studies utilizing the CSHQ, so we are asking that you please forward a copy of any publications you generate from your research that incorporate CSHQ data. You are also welcome to translate the instrument into other languages; it would also be most helpful if you could forward a copy of any translations, so we can make these available to other researchers. Please feel free to contact me (owensleep@gmail.com) with any questions regarding use of the CSHQ. Good luck!

Sincerely,
Judith A. Owens, MD, MPH
Associate Professor of Pediatrics
Brown University School of Medicine
Division of Ambulatory Pediatrics
Potter Building, Suite 200
Rhode Island Hospital
593 Eddy Street
Providence, RI 02903
(401) 444-8280
(401) 444-6218 fax
owensleep@gmail.com

Appendix F1 (*CSHQ Scoring Instructions)* continued

Child's Sleep Habits
(Preschool and School-Aged)

____
Coding

The following statements are about your child's sleep habits and possible difficulties with sleep. Think about the past week in your child's life when answering the questions. If last week was unusual for a specific reason (such as your child had an ear infection and did not sleep well or the TV set was broken), choose the most recent typical week. Answer USUALLY if something occurs **5 or more times** in a week; answer SOMETIMES if it occurs **2-4 times** in a week; answer RARELY if something occurs **never or 1 time** during a week. Also, please indicate whether or not the sleep habit is a problem by circling "Yes," "No," or "Not applicable (N/A).

Bedtime

Write in child's bedtime: ________________

	3 Usually (5-7)	2 Sometimes (2-4)	1 Rarely (0-1)	Problem?
Child goes to bed at the same time at night **(R) (1)**	☐	☐	☐	Yes No N/A
Child falls asleep within 20 minutes after going to bed **(R) (2)**	☐	☐	☐	Yes No N/A
Child falls asleep alone in own bed **(R) (3)**	☐	☐	☐	Yes No N/A
Child falls asleep in parent's or sibling's bed **(4)**	☐	☐	☐	Yes No N/A
Child falls asleep with rocking or rhythmic movements	☐	☐	☐	Yes No N/A
Child needs special object to fall asleep (doll, special blanket, etc.)	☐	☐	☐	Yes No N/A
Child needs parent in the room to fall asleep **(5)**	☐	☐	☐	Yes No N/A
Child is ready to go to bed at bedtime	☐	☐	☐	Yes No N/A
Child resists going to bed at bedtime	☐	☐	☐	Yes No N/A
Child struggles at bedtime (cries, refuses to stay in bed, etc.) **(6)**	☐	☐	☐	Yes No N/A
Child is afraid of sleeping in the dark **(7)**	☐	☐	☐	Yes No N/A
Child is afraid of sleep alone **(8)**	☐	☐	☐	Yes No N/A

Sleep Behavior

Child's usual amount of sleep each day: __________ hours and __________ minutes
(combining nighttime sleep and naps)

	3 Usually (5-7)	2 Sometimes (2-4)	1 Rarely (0-1)	Problem?
Child sleeps too little **(9)**	☐	☐	☐	Yes No N/A
Child sleeps too much	☐	☐	☐	Yes No N/A
Child sleeps the right amount **(R) (10)**	☐	☐	☐	Yes No N/A
Child sleeps about the same amount each day **(R) (11)**	☐	☐	☐	Yes No N/A
Child wets the bed at night **(12)**	☐	☐	☐	Yes No N/A
Child talks during sleep **(13)**	☐	☐	☐	Yes No N/A
Child is restless and moves a lot during sleep **(14)**	☐	☐	☐	Yes No N/A
Child sleepwalks during the night **(15)**	☐	☐	☐	Yes No N/A
Child moves to someone else's bed during the night (parent, brother, sister, etc.) **(16)**	☐	☐	☐	Yes No N/A

CSHQ with coding-rev 3/31/09

Appendix F1 (*CSHQ Scoring Instructions)* continued

Coding

Sleep Behavior (continued)

	3 Usually (5-7)	2 Sometimes (2-4)	1 Rarely (0-1)	Problem?
Child reports body pains during sleep. If so, where? ______________________	☐	☐	☐	Yes No N/A
Child grinds teeth during sleep (your dentist may have told you this) **(17)**	☐	☐	☐	Yes No N/A
Child snores loudly **(18)**	☐	☐	☐	Yes No N/A
Child seems to stop breathing during sleep **(19)**	☐	☐	☐	Yes No N/A
Child snorts and/or gasps during sleep **(20)**	☐	☐	☐	Yes No N/A
Child has trouble sleeping away from home (visiting relatives, vacation) **(21)**	☐	☐	☐	Yes No N/A
Child complains about problems sleeping	☐	☐	☐	Yes No N/A
Child awakens during night screaming, sweating, and inconsolable **(22)**	☐	☐	☐	Yes No N/A
Child awakens alarmed by a frightening dream **(23)**	☐	☐	☐	Yes No N/A

Waking During the Night

	3 Usually (5-7)	2 Sometimes (2-4)	1 Rarely (0-1)	Problem?
Child awakes once during the night **(24)**	☐	☐	☐	Yes No N/A
Child awakes more than once during the night **(25)**	☐	☐	☐	Yes No N/A
Child returns to sleep without help after waking	☐	☐	☐	Yes No N/A

Write the number of minutes a night waking usually lasts: ________________

Morning Waking

Write in the time of day child usually wakes in the morning: ______________

	3 Usually (5-7)	2 Sometimes (2-4)	1 Rarely (0-1)	Problem?
Child wakes up by him/herself **(26) (R)**	☐	☐	☐	Yes No N/A
Child wakes up with alarm clock	☐	☐	☐	Yes No N/A
Child wakes up in negative mood **(27)**	☐	☐	☐	Yes No N/A
Adults or siblings wake up child **(28)**	☐	☐	☐	Yes No N/A
Child has difficulty getting out of bed in the morning **(29)**	☐	☐	☐	Yes No N/A
Child takes a long time to become alert in the morning **(30)**	☐	☐	☐	Yes No N/A
Child wakes up very early in the morning	☐	☐	☐	Yes No N/A
Child has a good appetite in the morning	☐	☐	☐	Yes No N/A

2 CSHQ with coding-rev 3/31/09

Appendix F1 (*CSHQ Scoring Instructions)* continued

Coding

Daytime Sleepiness

	3 Usually (5-7)	2 Sometimes (2-4)	1 Rarely (0-1)	Problem?
Child naps during the day	☐	☐	☐	Yes No N/A
Child suddenly falls asleep in the middle of active behavior	☐	☐	☐	Yes No N/A
Child seems tired **(31)**	☐	☐	☐	Yes No N/A

During the past week, your child has appeared very sleepy or fallen asleep during the following (check all that apply):

	1 Not Sleepy	2 Very Sleepy	3 Falls Asleep
Play alone	☐	☐	☐
Watching TV **(32)**	☐	☐	☐
Riding in car **(33)**	☐	☐	☐
Eating meals	☐	☐	☐

3 CSHQ with coding-rev 3/31/09

Appendix F1 (*CSHQ Scoring Instructions)* continued

Subscale Items
Children's Sleep Habits Questionnaire (CSHQ)

Numbers in parentheses refer to CSHQ item number

1. Bedtime Resistance (6 items) [A]
Goes to bed at same time **(1) (R)**
Falls asleep in own bed **(3) (R)**
Falls asleep in other's bed **(4)**
Needs parent in room to sleep **(5)**
Struggles at bedtime **(6)**
Afraid of sleeping alone **(8)**

2. Sleep Onset Delay (1 item)
Falls asleep in 20 minutes **(2) (R)**

3. Sleep Duration (3 items)
Sleeps too little **(9)**
Sleeps the right amount **(10) (R)**
Sleeps same amount each day **(11) (R)**

4. Sleep Anxiety (4 items)
Needs parent in room to sleep **(5)**
Afraid of sleeping in the dark **(7)**
Afraid of sleeping alone **(8)**
Trouble sleeping away **(21)**

5. Night Wakings (3 items)
Moves to other's bed in night **(16)**
Awakes once during night **(24)**
Awakes more than once **(25)**

6. Parasomnias (7 items)
Wets the bed at night **(12)**
Talks during sleep **(13)**
Restless and moves a lot **(14)**
Sleepwalks **(15)**
Grinds teeth during sleep **(17)**
Awakens screaming, sweating **(22)**
Alarmed by scary dream **(23)**

7. Sleep Disordered Breathing (3 items)
Snores loudly **(18)**
Stops breathing **(19)**
Snorts and gasps **(20)**

8. Daytime Sleepiness (8 items)
Wakes by himself **(26) (R)**
Wakes up in negative mood **(27)**
Others wake child **(28)**
Hard time getting out of bed **(29)**
Takes long time to be alert **(30)**
Seems tired **(31)**
Watching TV **(32)**
Riding in car **(33)**

Total Sleep Disturbance Score (33 items) [B]

Scoring: Usually = 3 Sometimes = 2 Never/Rarely = 1

[A] Note: Some items (*R*) should be reversed in scoring, so that a higher score reflects more disturbed sleep behavior.

[B] Note: The Total Sleep Disturbance Score: Consists of all 33 subscale items instead of 35 (although items 5 and 8 are on both the Bedtime Resistance and Sleep Anxiety scales, they should be included only once in the total score)

Appendix F2
Actigraphy Manual Screening Guidelines

Guidelines for Actigraphy Screening

Rest Intervals:
In order to determine Bed Time and Get Up Time, consider three pieces of information:

- Changes in actigraphy data (reduction or increase in movement)
- Event marker
- Sleep/Wake Diary
  NB: Bed Time is the time the child is in bed and starting to try to sleep. Get Up Time is when they have finished trying to sleep.

- When two of the information sources match but the third does not, then be guided by the two that match. Therefore:
  - If the event marker and change in actigraphy data match (reduction or increase in movement at the time the event marker is pushed) but the Sleep/Wake Diary time does not match or is missing, use the event marker and change in actigraphy data to determine Bed Time/Get Up Time. This may be due to parents thinking children have started trying to sleep or have woken up, when in fact they haven't.
  - If the sleep diary and actigraphy data match (reduction or increase in movement at the time recorded in the sleep diary) but the event marker is not present or does not match, then use the Sleep/Wake Diary and actigraphy to determine Bed Time/Get Up Time. This may be due to the child forgetting to press the event button, pressing it in error at a different time of the day, pressing it early such as when still getting ready for bed or pressing it in the morning then going back to sleep.
  - If the event marker and Sleep/Wake Diary match but there is no clear change in the actigraphy data, use the event marker and Sleep/Wake Diary time to determine Bed Time/Get Up Time. This may be due to the child moving around whilst trying to go to sleep, restless sleep or having woken but lying still in bed.
- When all three information sources do not match or event marker and Sleep/Wake Diary times are not present, use the change in actigraphy data (reduction or increase in movement) to determine Bed Time/Get Up Time. When changes in actigraphy data are not apparent, use the event marker. In this case if there is no event marked use the time recorded in the Sleep/Wake Diary. In general, if all three information sources do not match then rely most heavily on activity, then the event marker, then the Sleep/Wake Diary in order of priority (particularly as parents are completing the diary and may not be aware of what their child is actually doing whilst in bed).

Exclusion Intervals:

- Exclude the initial period between the set up and monitor being put on, as well as the time between the monitor being removed and data being downloaded.
- Exclude intervals recorded in the Sleep/Wake Diary as when the monitor was removed, for example at bath time. Be guided by changes in actigraphy data, event marker and diary entry for exact timing of exclusion interval. If there is no diary entry, but a clear cessation of activity during the day plus event marker present, then exclude. If there is no event marker, but a clear cessation of activity during the day plus a diary entry, then exclude.
- If there is a clear cessation in activity during the day for longer than one hour but no diary entry or event marker, then exclude.

Appendix G

Additional Tables and Figures

Table G1

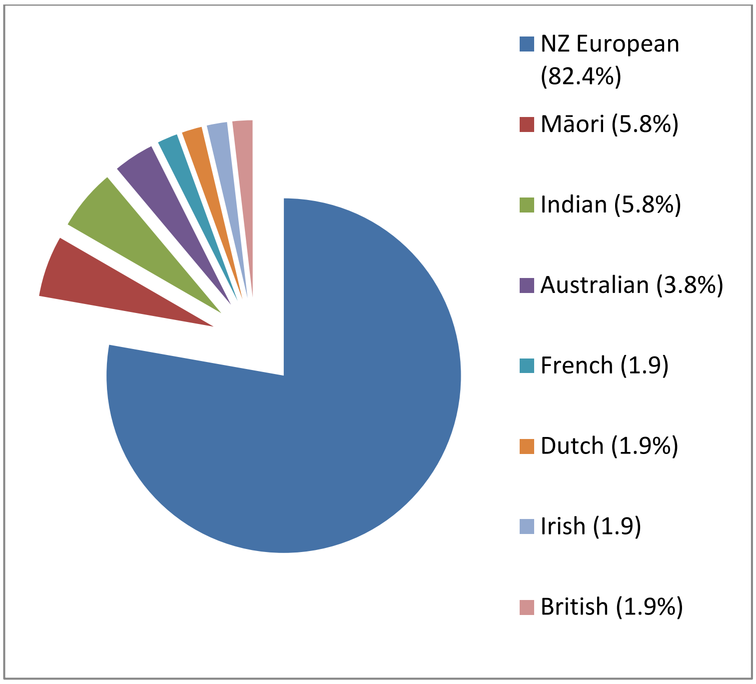
Shapiro-Wilk Test of Normality Results for Questionnaire Data

Variable	*W*	*df*	*p*
Age	.972	52	.253
Number of adults living in house	.427	52	< .001
Number of children living in house	.727	52	< .001
Number of younger children living in house	.719	51	< .001
Bedroom sharing – number of other children	.592	52	< .001
Bedroom sharing – number of adults	.193	52	< .001
Bed sharing – number of other children	.122	52	< .001
Bed sharing – number of adults	.189	52	< .001
Time in childcare per week	.467	52	< .001
Number of adults in paid employment	.689	52	< .001
BMI (all children)	.954	42	.087
BMI (all boys)	.932	20	.170
BMI (all girls)	.943	22	.226
BMI (boys 7yrs)	.732	4	.026
BMI (boys 7.5yrs)	.979	12	.981
BMI (boys 8yrs)	.890	4	.384
BMI (girls 7yrs)	.972	3	.680
BMI (girls 7.5yrs)	.905	12	.186
BMI (girls 8yrs)	.909	6	.429
BMI (girls 8.5yrs)[a]			
Mother's BMI	.896	47	.001
Father's BMI	.918	40	.007

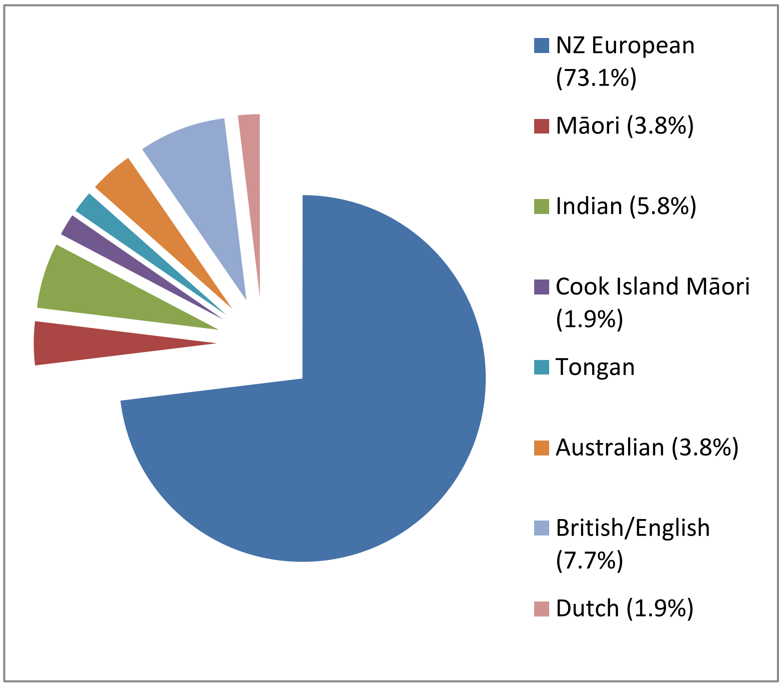
[a]No values reported as 1 participant met criteria for Girl 8.5yr age group.

Appendix G2

Ethnicity of mothers and fathers in the sample



Ethnic identification of mothers in the sample (questionnaire data, *n* = 51).



Ethnic identification of fathers in the sample (questionnaire data, *n* = 51).

Figure G2. Ethnicity of mothers and fathers who completed the ethnicity question in the Child/Family Questionnaire.

Table G3

Descriptive Statistics for BMI (Questionnaire Data)

	Mean	Standard Deviation	Range	*n*
All Children				
Height (m)	1.27	0.06	1.18 – 1.43	44
Weight (kg)	26.00[a]		20.70 – 37.00	46
BMI (kg/m^2)	16.22	1.56	13.91 – 20.40	42
Boys				
Height (m)	1.28	0.05	1.18 – 1.40	20
Weight (kg)	27.18	4.10	21.00 – 37.00	21
BMI (kg/m^2)	16.37	1.52	13.99 – 18.94	20
Girls				
Height (m)	1.25[a]		1.18 – 1.43	24
Weight (kg)	25.70	3.82	20.70 – 35.00	25
BMI (kg/m^2)	16.09	1.62	13.91 – 20.40	22
Boys 7yrs				
Height (m)	1.26	0.07	1.18 – 1.32	4
Weight (kg)	25.50	5.45	21.00 – 33.00	4
BMI (kg/m^2)	15.00[a]		14.54 – 18.94	4
Boys 7.5yrs				
Height (m)	1.27	0.03	1.21 – 1.32	12
Weight (kg)	26.67	2.65	21.90 – 31.50	13
BMI (kg/m^2)	16.26	1.21	13.99 – 18.64	12
Boys 8yrs				
Height (m)	1.33	0.06	1.26 – 1.40	4
Weight (kg)	30.50	5.92	25.00 – 37.00	4
BMI (kg/m^2)	17.18	1.95	14.79 – 18.88	4
Girls 7yrs				
Height (m)	1.23	0.05	1.18 – 1.27	3
Weight (kg)	22.00[a]		22.00 – 27.00	3
BMI (kg/m^2)	15.54	1.35	14.08 – 16.74	3
Girls 7.5yrs				
Height (m)	1.26	0.05	1.20 – 1.33	13
Weight (kg)	25.45	4.31	20.70 – 35.00	12
BMI (kg/m^2)	16.21	1.89	13.91 – 20.40	12
Girls 8yrs				
Height (m)	1.27	0.08	1.20 – 1.43	7
Weight (kg)	26.69	3.68	22.00 – 33.00	9
BMI (kg/m^2)	16.25	1.44	14.31 – 18.75	6
Girls 8.5yrs[b]				
Mother's BMI	22.86[a]		18.00 – 35.16	47
Father's BMI	25.07[a]		20.18 – 39.08	40

[a]Median reported as data not normally distributed. [b]One participant met the criteria for 'Girls 8.5yrs' category, with Height=1.30m, Weight=26.00kg & BMI=15.38kg/m^2.

Table G4

Distribution of CSHQ Responses (Questionnaire Data)

	Frequency	%
Bedtime:		
Same time on school nights (Sun-Thurs)		
Usually (5 – 7 nights)	50	96.2
Sometimes (2 – 4 nights)	2	3.8
Total	52	100.0
Same time on weekend nights (Fri & Sat)		
Usually (5 – 7 nights)	35	67.3
Sometimes (2 – 4 nights)	15	28.8
Rarely (0 – 1 night)	1	1.9
Total	51	98.1
Falls asleep within 20mins of going to bed		
Usually (5 – 7 nights)	32	61.5
Sometimes (2 – 4 nights)	14	26.9
Rarely (0 – 1 night)	6	11.5
Total	52	100.0
Falls asleep alone in own bed		
Usually (5 – 7 nights)	47	90.4
Sometimes (2 – 4 nights)	1	1.9
Rarely (0 – 1 night)	3	5.8
Total	51	98.1
Falls asleep in parent's or sibling's bed		
Usually (5 – 7 nights)	2	3.8
Sometimes (2 – 4 nights)	2	3.8
Rarely (0 – 1 night)	38	73.1
Total	42	80.8
Needs parent in room to fall asleep		
Usually (5 – 7 nights)	2	3.8
Sometimes (2 – 4 nights)	3	5.8
Rarely (0 – 1 night)	36	69.2
Total	41	78.8
Struggles at bedtime (e.g. cries, refuses to stay in bed)		
Usually (5 – 7 nights)	3	5.8
Sometimes (2 – 4 nights)	4	7.7
Rarely (0 – 1 night)	35	67.3
Total	42	80.8
Afraid of sleeping in the dark		
Usually (5 – 7 nights)	11	21.2
Sometimes (2 – 4 nights)	6	11.5
Rarely (0 – 1 night)	25	48.1
Total	42	80.8
Afraid of sleeping alone		
Usually (5 – 7 nights)	5	9.6
Rarely (0 – 1 night)	37	71.2
Total	42	80.8

Table G4 *(CSHQ Responses)* continued

	Frequency	%
Sleep Behaviour:		
Usual amount of sleep each school night (Sun-Thurs)hrs		
9.00	1	1.9
9.50	8	15.4
9.75	1	1.9
10.00	8	15.4
10.25	2	3.8
10.50	12	23.1
11.00	9	17.3
11.25	2	3.8
11.50	5	9.6
12.00	1	1.9
12.42	1	1.9
Total	50	96.2
Usual amount of sleep each weekend night (Fri & Sat) hrs		
8.25	1	1.9
8.50	2	3.8
9.50	5	9.6
9.75	1	1.9
10.00	12	23.1
10.25	2	3.8
10.50	12	23.1
10.67	1	1.9
11.00	13	25.0
11.25	1	1.9
Total	50	96.2
Sleeps too little		
Usually (5 – 7 nights)	4	7.7
Sometimes (2 – 4 nights)	8	15.4
Rarely (0 – 1 night)	35	67.3
Total	47	90.4
Sleeps the right amount		
Usually (5 – 7 nights)	42	80.8
Sometimes (2 – 4 nights)	3	5.8
Rarely (0 – 1 night)	4	7.7
Total	49	94.2
Sleeps about the same amount each day		
Usually (5 – 7 nights)	46	88.5
Sometimes (2 – 4 nights)	4	7.7
Rarely (0 – 1 night)	1	1.9
Total	51	98.1
Wets the bed at night		
Usually (5 – 7 nights)	5	9.6
Sometimes (2 – 4 nights)	1	1.9
Rarely (0 – 1 night)	41	78.8
Total	47	90.4

Table G4 *(CSHQ Responses)* continued

	Frequency	%
Talks during sleep		
Usually (5 – 7 nights)	6	11.5
Sometimes (2 – 4 nights)	11	21.2
Rarely (0 – 1 night)	33	63.5
Total	50	96.2
Restless and moves a lot during sleep		
Usually (5 – 7 nights)	9	17.3
Sometimes (2 – 4 nights)	16	30.8
Rarely (0 – 1 night)	24	46.2
Total	49	94.2
Sleepwalks during the night		
Sometimes (2 – 4 nights)	3	5.8
Rarely (0 – 1 night)	45	86.5
Total	48	92.3
Moves to someone else's bed during the night		
Usually (5 – 7 nights)	2	3.8
Sometimes (2 – 4 nights)	5	9.6
Rarely (0 – 1 night)	43	82.7
Total	50	96.2
Grinds teeth during sleep		
Usually (5 – 7 nights)	3	5.8
Sometimes (2 – 4 nights)	5	9.6
Rarely (0 – 1 night)	39	75.0
Total	47	90.4
Snores loudly		
Usually (5 – 7 nights)	2	3.8
Sometimes (2 – 4 nights)	8	15.4
Rarely (0 – 1 night)	37	71.2
Total	47	90.4
Seems to stop breathing during sleep		
Rarely (0 – 1 night)	47	90.4
Total	47	90.4
Snorts and/or gasps during sleep		
Sometimes (2 – 4 nights)	3	5.8
Rarely (0 – 1 night)	46	88.5
Total	49	94.2
Has trouble sleeping away from home		
Usually (5 – 7 nights)	2	3.8
Sometimes (2 – 4 nights)	5	9.6
Rarely (0 – 1 night)	43	82.7
Total	50	96.2
Awakens screaming, sweating & inconsolable		
Usually (5 – 7 nights)	1	1.9
Rarely (0 – 1 night)	49	94.2
Total	50	96.2

Table G4 *(CSHQ Responses)* continued

	Frequency	%
Awakens alarmed by frightening dream		
Usually (5 – 7 nights)	1	1.9
Sometimes (2 – 4 nights)	11	21.2
Rarely (0 – 1 night)	38	73.1
Total	50	96.2
Waking During the Night:		
Awakes once during the night		
Usually (5 – 7 nights)	6	11.5
Sometimes (2 – 4 nights)	12	23.1
Rarely (0 – 1 night)	32	61.5
Total	50	96.2
Awakes more than once during the night		
Usually (5 – 7 nights)	1	1.9
Sometimes (2 – 4 nights)	5	9.6
Rarely (0 – 1 night)	43	82.7
Total	49	94.2
Returns to sleep without help after waking		
Usually (5 – 7 nights)	27	51.9
Sometimes (2 – 4 nights)	4	7.7
Rarely (0 – 1 night)	19	36.5
Total	50	96.2
Morning Waking:		
Gets up the same time school mornings (Mon-Fri)		
Usually (5 – 7 nights)	52	100.0
Gets up the same time weekend mornings (Sat & Sun)		
Usually (5 – 7 nights)	42	80.8
Sometimes (2 – 4 nights)	9	17.3
Rarely (0 – 1 night)	1	1.9
Total	52	100.0
Wakes up by him/herself		
Usually (5 – 7 nights)	44	84.6
Sometimes (2 – 4 nights)	6	11.5
Rarely (0 – 1 night)	2	3.8
Total	52	100.0
Wakes up in a negative mood		
Usually (5 – 7 nights)	2	3.8
Sometimes (2 – 4 nights)	19	36.5
Rarely (0 – 1 night)	30	57.7
Total	51	98.1
Adults or siblings wake up child		
Usually (5 – 7 nights)	5	9.6
Sometimes (2 – 4 nights)	14	26.9
Rarely (0 – 1 night)	32	61.5
Total	51	98.1

Table G4 *(CSHQ Responses)* continued

	Frequency	%
Difficulty getting out of bed in the morning		
Sometimes (2 – 4 nights)	14	26.9
Rarely (0 – 1 night)	37	71.2
Total	51	98.1
Takes a long time to become alert in the morning		
Usually (5 – 7 nights)	1	1.9
Sometimes (2 – 4 nights)	7	13.5
Rarely (0 – 1 night)	43	82.7
Total	51	98.1
Daytime Sleepiness:		
Seems tired		
Sometimes (2 – 4 nights)	10	19.2
Rarely (0 – 1 night)	41	78.8
Total	51	98.1
Past Week Appeared very sleepy or fallen asleep while:		
Playing alone		
Not sleepy	49	94.2
Watching TV		
Not sleepy	45	86.5
Very sleepy	4	7.7
Total	49	94.2
Riding in a car		
Not sleepy	41	78.8
Very sleepy	5	9.6
Falls asleep	4	7.7
Total	50	96.2
Eating meals		
Not sleepy	49	94.2
General Sleep:		
Does parent consider their child's sleep a problem?		
A very serious problem	3	5.8
A small problem	11	21.2
Not a problem at all	38	73.1
Total	52	100.0

Table G5

Shapiro-Wilk Test of Normality Results for Children's Sleep Habits Questionnaire Data

Variable	*W*	*df*	*p*
Sleep duration school nights	.961	50	.094
Sleep duration weekend nights	.881	50	< .001
CSHQ total score	.951	52	.032
CSHQ total non-responses	.518	52	< .001
CSHQ Subscales:			
Bedtime resistance	.735	52	< .001
Bedtime resistance non-responses	.512	52	< .001
Sleep onset delay	.693	52	< .001
Sleep onset delay non-responses[a]			
Sleep duration	.734	52	< .001
Sleep duration non-responses	.336	52	< .001
Sleep anxiety	.914	52	.001
Sleep anxiety non-responses	.544	52	< .001
Night waking	.803	52	< .001
Night waking non-responses	.336	52	< .001
Parasomnias	.942	52	.013
Parasomnias non-responses	.366	52	< .001
Sleep disordered breathing	.717	52	< .001
Sleep disordered breathing non-responses	.347	52	< .001
Daytime sleepiness	.898	52	< .001
Daytime sleepiness non-responses	.194	52	< .001

[a]No values reported as all participants responded to sleep onset delay subscale questions.

Table G6

Shapiro-Wilk Test of Normality Results for Child's Sleep/Wake Diary Data

Variable	*W*	*df*	*p*
School Day			
Aggregated Data:			
Screen time	.939	48	.015
'Physical' activity	.935	46	.013
'Moderate' activity	.861	50	< .001
'Quiet' activity	.905	51	.001
Daily Data:			
Screen time	.883	157	< .001
'Physical' activity	.818	135	< .001
'Moderate' activity	.841	153	< .001
'Quiet' activity	.756	180	< .001
Non-School Day			
Aggregated Data:			
Screen time	.870	47	< .001
'Physical' activity	.643	39	< .001
'Moderate' activity	.842	49	< .001
'Quiet' activity	.826	45	< .001
Daily Data:			
Screen time	.904	88	< .001
'Physical' activity	.709	65	< .001
'Moderate' activity	.798	88	< .001
'Quiet' activity	.788	85	< .001

Table G7

Shapiro-Wilk Test of Normality Results for Averaged Actigraphy Rest and Sleep Data

Variable	*W*	*df*	*p*
School Night			
Rest start time	.985	51	.761
Rest end time	.978	51	.444
Sleep start time	.974	51	.334
Sleep end time	.983	51	.688
Rest duration	.970	51	.214
Sleep duration	.983	51	.670
Total sleep time	.990	51	.940
Sleep efficiency (% sleep)	.970	51	.229
Percentage wake	.970	51	.228
Sleep onset latency	.937	51	.010
Snooze time	.925	51	.003
Wake after sleep onset (WASO)	.953	51	.042
Sleep fragmentation	.981	51	.585
Non-School Night			
Rest start time	.973	51	.294
Rest end time	.958	51	.066
Sleep start time	.990	51	.940
Sleep end time	.979	51	.506
Rest duration	.982	51	.639
Sleep duration	.971	51	.255
Total sleep time	.980	51	.527
Sleep efficiency (% sleep)	.933	51	.006
Percentage wake	.933	51	.006
Sleep onset latency	.818	51	< .001
Snooze time	.869	51	< .001
Wake after sleep onset (WASO)	.893	51	< .001
Sleep fragmentation	.972	51	.276

Table G8

Shapiro-Wilk Test of Normality Results for Averaged Actigraphy Waking Activity Data

Variable	*W*	*df*	*p*
School Day			
Activity start time	.978	51	.462
Activity end time	.987	51	.826
Activity duration (hours)	.892	51	< .001
Average activity counts (AC) per minute	.952	51	.037
Total activity counts (AC)	.953	51	.043
Non-School Day			
Activity start time	.970	51	.273
Activity end time	.942	51	.022
Activity duration (hours)	.786	51	< .001
Average activity counts (AC) per minute	.957	51	.085
Total activity counts (AC)	.968	51	.219

Table G9

Comparison of Girls' and Boys' School and Non-School Night Sleep Duration and Timing (Actigraphy Data, Independent t-test, N = 51)

Variable	Girls: Mean (Std Error)	Boys: Mean (Std Error)	*t*	*df*	*p*	*Effect Size, r*
School Night:						
Rest start time	20:21 (00:06)	20:15 (00:09)	-0.57	49	.572	.08
Sleep start time	20:44 (00:06)	20:41 (00:09)	-0.27	49	.786	.04
Rest end time	07:00 (00:04)	07:01 (00:05)	0.09	49	.927	.01
Sleep end time	06:32 (00:05)	06:38 (00:05)	0.64	49	.525	.09
Rest duration (hours)	10.65 (0.10)	10.77 (0.13)	0.77	49	.446	.11
Sleep duration (hours)	9.80 (0.09)	9.95 (0.12)	0.95	49	.346	.13
Total sleep time (hours)	8.60 (0.08)	8.65 (0.10)	0.36	49	.722	.05
Non-School Night:						
Rest start time	20:43 (00:10)	20:39 (00:08)	-0.28	49	.778	.04
Sleep start time	21:09 (00:10)	21:12 (00:10)	0.18	49	.858	.03
Rest end time	07:14 (00:07)	07:05 (00:07)	-0.75	49	.457	.11
Sleep end time	06:43 (00:09)	06:37 (00:08)	-0.45	49	.657	.06
Rest duration (hours)	10.51 (0.13)	10.44 (0.12)	-0.38	49	.708	.05
Sleep duration (hours)	9.57 (0.14)	9.42 (0.16)	-0.71	49	.480	.10
Total sleep time (hours)	8.38 (0.11)	8.26 (0.12)	-0.72	49	.476	.10

Table G10

Comparison of 'Thin/Normal' and 'Overweight' Groups' Sleep (Independent t-test, n = 41)

Variable	Thin/Normal: Mean (Std Error)	Overweight: Mean (Std Error)	*t*	*df*	*p*	*Effect Size, r*
School Night:						
Sleep duration (hours)	9.89 (0.09)	9.86 (0.28)	0.14	39	.894	.02
Total sleep time (hours)	8.67 (0.07)	8.66 (0.23)	0.01	39	.994	.001
Sleep efficiency (% sleep)	87.67 (0.48)	87.92 (1.20)	-0.193	39	.848	.03
Sleep fragmentation	33.26 (1.22)	30.37 (4.43)	0.838	39	.407	.13
Sleep onset latency (minutes)	23.1 (2.1)	28.2 (8.4)	-0.593	39	.576	.10
Non-School Night:						
Sleep duration (hours)	9.49 (0.11)	9.65 (0.40)	-0.51	39	.614	.08
Total sleep time (hours)	8.31 (0.10)	8.45 (0.25)	-0.52	39	.606	.08
Sleep fragmentation	34.23 (1.50)	28.55 (5.42)	1.35	39	.185	.21

Table G11

Comparison of 'Thin/Normal' and 'Overweight' Groups' Sleep (Mann-Whitney U test, n = 41)

Variable	Thin/Normal: Median (Range)	Overweight: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
Non-School Night:						
Sleep efficiency (% sleep)	88.49 (76.49 – 93.03)	88.94 (81.74 – 89.94)	103.30	-.074	.957	-.01
Sleep onset latency (minutes)	20.0 (0.0 – 80.0)	25.3 (11.5 – 43.0)	88.50	-.609	.552	-.10
CSHQ total score	37.0 (6.0 – 51.0)	38.0 (24.0 – 60.0)	105.00	0.0	1.00	.00
CSHQ SDB score	3.0 (0.0 – 5.0)	3.0 (1.0 – 3.0)	69.00	-1.612	.196	-.25

Table G12

Comparison of Children Who Did or Did Not Live with a Shiftworking Adult (Mann-Whitney U test, N = 51)

Variable	Shiftworking Household: Median (Range)	Non-Shiftworking Household: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
School Night:						
Sleep duration (hours)	9.68 (8.98 – 10.33)	10.04 (8.74 – 11.03)	183.50	-1.59	.114	-.22
Total sleep time (hours)	8.49 (7.90 – 8.98)	8.73 (7.73 – 9.78)	180.00	-1.67	.098	-.23
Sleep onset latency (minutes)	15.9 (0.0 – 51.2)	22.4 (6.0 – 65.6)	146.00	-2.39	.016	-.33
Sleep efficiency (% sleep)	87.19 (82.07 – 93.24)	88.29 (79.38 – 92.55)	222.50	-0.77	.448	-.11
Sleep fragmentation	30.62 (16.64 – 42.97)	33.25 (16.70 – 49.08)	208.00	-1.08	.290	-.15
Rest start time	20:35 (19:50 – 21:47)	20:08 (19:01 – 21:35)	168.50	-1.91	.056	-.27
Sleep start time	20:50 (20:11 – 21:56)	20:39 (19:24 – 22:06)	205.50	-1.13	.264	-.16
Rest end time	07:09 (06:39 – 07:39)	06:59 (06:09 – 07:54)	211.50	-1.00	.323	-.14
Sleep end time	06:28 (06:04 – 07:25)	06:42 (05:17 – 07:37)	257.50	-0.03	.979	-.004
Non-School Night:						
Sleep duration (hours)	9.82 (8.57 – 11.18)	9.45 (8.31 – 11.35)	164.00	-2.01	.046	-.28
Total sleep time (hours)	8.74 (7.43 – 9.64)	8.24 (7.27 – 9.28)	169.50	-1.89	.046	-.26
Sleep onset latency (minutes)	16.9 (5.8 – 47.0)	26.0 (0.0 – 122.0)	177.50	-1.72	.086	-.24
Sleep efficiency (% sleep)	87.12 (79.87 – 91.43)	88.56 (76.49 – 93.03)	228.00	-0.65	.524	-.09
Sleep fragmentation	30.68 (12.84 – 47.08)	33.46 (17.91 – 63.15)	231.00	-0.59	.566	-.08
Rest start time	20:51 (20:04 – 21:43)	20:21 (18:53 – 23:06)	191.50	-1.43	.157	-.20
Sleep start time	21:07 (20:15 – 22:30)	21:14 (19:10 – 23:21)	251.50	-0.16	.879	-.02
Rest end time	07:23 (06:34 – 08:27)	06:57 (05:56 – 08:39)	189.00	-1.48	.142	-.21
Sleep end time	06:53 (06:04 – 08:16)	06:32 (05:06 – 08:20)	173.00	-1.82	.070	-.25
CSHQ total score	38 (24 – 60)	37 (6 – 57)	234.50	-0.52	.306	-.07

Table G13

Comparison of Children Who Did or Did Not Share a Bedroom (Mann-Whitney U test, N = 51)

Variable	Bedroom Share: Median (Range)	Own Bedroom: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
School Night:						
Sleep duration (hours)	9.96 (8.74 – 10.90)	9.93 (8.97 – 11.03)	274.50	-0.11	.916	-.02
Total sleep time (hours)	8.49 (7.81 – 9.51)	8.66 (7.73 – 9.78)	233.00	-0.95	.350	-.13
Sleep onset latency (minutes)	19.7 (9.6 – 43.2)	22.0 (0.0 – 65.6)	246.50	-0.66	.318	-.09
Sleep efficiency (% sleep)	88.02 (79.38 – 92.55)	88.02 (82.07 – 93.24)	251.00	-0.59	.564	-.08
Sleep fragmentation	29.58 (16.70 – 47.28)	32.67 (16.64 – 49.08)	235.00	-0.91	.370	-.13
Rest start time	20:27 (19:01 – 21:35)	20:11 (19:17 – 21:47)	253.50	-0.54	.597	-.08
Sleep start time	20:54 (19:24 – 22:06)	20:42 (19:39 – 21:56)	268.00	-0.24	.813	-.03
Rest end time	07:03 (06:17 – 07:54)	07:03 (06:09 – 07:39)	254.00	-0.53	.605	-.07
Sleep end time	06:30 (05:17 – 07:37)	06:38 (05:44 – 07:25)	277.00	-0.06	.956	-.01
Non-School Night:						
Sleep duration (hours)	9.37 (8.38 – 11.35)	9.56 (8.31 – 11.18)	238.50	-0.84	.406	-.12
Total sleep time (hours)	8.03 (7.43 – 9.28)	8.38 (7.27 – 9.64)	219.50	-1.23	.224	-.17
Sleep onset latency (minutes)	14.4 (0.0 – 46.0)	24.0 (5.8 – 122.0)	179.00	-2.05	.040	-.29
Sleep efficiency (% sleep)	88.12 (79.46 – 93.03)	88.30 (76.49 – 92.10)	256.00	-0.49	.638	-.07
Sleep fragmentation	33.09 (18.41 – 51.68)	33.01 (12.84 – 63.15)	259.00	-0.43	.680	-.06
Rest start time	20:44 (19:18 – 23:06)	20:32 (18:53 – 22:53)	222.50	-1.17	.248	-.16
Sleep start time	21:17 (19:40 – 23:14)	21:12 (19:10 – 23:21)	266.00	-0.28	.783	-.04
Rest end time	06:58 (06:04 – 08:39)	07:05 (05:56 – 08:28)	251.00	-0.59	.563	-.08
Sleep end time	06:36 (05:06 – 08:00)	06:34 (05:27 – 08:20)	271.50	-0.17	.868	-.02
CSHQ total score	40 (28 – 51)	37 (6 – 60)	251.50	-0.58	.285	-.08

Table G14

Comparison of Children With and Without Technology in their Bedroom (Mann-Whitney U test, N = 51)

Variable	Technology in Bedroom: Median (Range)	No Technology in Bedroom: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
School Night:						
Sleep duration (hours)	9.93 (8.97 – 11.03)	9.91 (8.74 – 10.45)	245.00	-1.28	.204	-.18
Total sleep time (hours)	8.65 (7.73 – 9.78)	8.63 (7.81 – 9.51)	319.00	-0.06	.962	-.01
Sleep onset latency (minutes)	21.4 (0.0 – 65.6)	21.3 (2.5 – 57.0)	292.50	-0.56	.382	-.08
Sleep efficiency (% sleep)	86.87 (79.38 – 90.89)	88.36 (81.87 – 93.24)	195.50	-2.40	.016	-.34
Sleep fragmentation	33.86 (19.62 – 47.28)	30.68 (16.64 – 49.08)	260.00	-1.17	.246	-.16
Rest start time	20:10 (19:11 – 21:47)	20:19 (19:01 – 21:35)	279.00	-0.81	.422	-.11
Sleep start time	20:40 (19:24 – 21:56)	20:50 (19:38 – 22:06)	280.50	-0.79	.438	-.11
Rest end time	07:02 (06:09 – 07:54)	07:04 (06:09 – 07:45)	292.00	-0.57	.576	-.08
Sleep end time	06:35 (05:44 – 07:37)	06:37 (05:17 – 07:24)	320.50	-0.03	.981	-.004
Non-School Night:						
Sleep duration (hours)	9.48 (8.39 – 11.35)	9.54 (8.31 – 11.18)	315.00	-0.13	.900	-.02
Total sleep time (hours)	8.20 (7.27 – 9.28)	8.39 (7.42 – 9.64)	283.50	-0.73	.472	-.10
Sleep onset latency (minutes)	18.5 (0.0 – 122.0)	24.3 (3.0 – 73.5)	303.00	-0.36	.724	-.05
Sleep efficiency (% sleep)	86.51 (76.49 – 92.10)	89.23 (79.87 – 93.03)	225.00	-1.84	.068	-.26
Sleep fragmentation	33.46 (17.91 – 63.15)	32.85 (12.84 – 49.00)	317.00	-0.10	.932	-.01
Rest start time	20:22 (18:53 – 23:06)	20:42 (19:18 – 22:15)	283.50	-0.73	.236	-.10
Sleep start time	21:13 (19:10 – 23:21)	21:03 (19:40 – 22:30)	317.00	-0.10	.464	-.01
Rest end time	06:57 (05:56 – 08:28)	07:02 (06:04 – 08:39)	267.50	-1.03	.307	-.14
Sleep end time	06:35 (05:27 – 08:20)	06:35 (05:06 – 08:16)	322.00	0.00	1.00	.00
CSHQ total score	42 (24 – 60)	36 (6 – 49)	237.00	-1.61	.054	-.23

Table G15

Comparison of Children With and Without Childcare during the Week (Mann-Whitney U test, N = 51)

Variable	Childcare: Median (Range)	No Childcare: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
School Night:						
Sleep duration (hours)	9.73 (8.74 – 11.03)	9.94 (8.97 – 10.90)	178.50	-0.63	.538	-.09
Total sleep time (hours)	8.45 (7.81 – 9.78)	8.65 (7.73 – 9.51)	159.00	-1.09	.286	-.15
Sleep onset latency (minutes)	15.8 (0.0 – 27.3)	22.3 (2.5 – 65.6)	105.50	-2.36	.016	-.33
Sleep efficiency (% sleep)	86.68 (82.07 – 90.12)	88.02 (79.38 – 93.24)	162.00	-1.02	.316	-.14
Sleep fragmentation	32.20 (16.70 – 46.51)	32.09 (16.64 – 49.08)	198.00	-0.67	.880	-.09
Rest start time	20:16 (19:20 – 21:47)	20:12 (19:01 – 21:35)	186.00	-0.45	.663	-.06
Sleep start time	20:31 (19:38 – 21:56)	20:50 (19:24 – 22:06)	146.50	-1.39	.169	-.19
Rest end time	06:43 (06:09 – 07:39)	07:03 (06:09 – 07:54)	128.00	-1.83	.068	-.26
Sleep end time	06:13 (05:17 – 07:25)	06:42 (05:44 – 07:37)	130.00	-1.78	.076	-.25
Non-School Night:						
Sleep duration (hours)	9.54 (8.38 – 10.38)	9.53 (8.31 – 11.35)	198.00	-0.17	.874	-.02
Total sleep time (hours)	8.05 (7.43 – 9.28)	8.35 (7.27 – 9.64)	182.00	-0.55	.596	-.08
Sleep onset latency (minutes)	17.9 (3.0 – 33.5)	24.5 (0.0 – 122.0)	153.50	-1.22	.228	-.17
Sleep efficiency (% sleep)	87.47 (83.50 – 91.19)	88.49 (76.49 – 93.03)	181.00	-0.57	.582	-.08
Sleep fragmentation	29.03 (20.64 – 49.00)	33.46 (12.84 – 63.15)	196.00	-0.21	.842	-.03
Rest start time	20:15 (19:38 – 21:43)	20:41 (18:53 – 23:06)	154.00	-1.21	.233	-.17
Sleep start time	20:32 (19:57 – 22:00)	21:19 (19:10 – 23:21)	122.00	-1.97	.049	-.28
Rest end time	06:50 (05:56 – 07:30)	07:09 (06:16 – 08:39)	119.50	-2.03	.042	-.28
Sleep end time	06:06 (05:06 – 07:19)	06:36 (05:27 – 08:20)	116.00	-2.11	.034	-.30
CSHQ total score	40 (34 – 60)	37 (6 – 57)	149.50	-1.32	.096	-.18

Table G16

Comparison of Children who did or did not Engage in an Organised Activity (Mann-Whitney U test, school days n = 197, non-school days n = 88)

Variable	Organised Activity Participation: Median (Range)	No Organised Activity: Median (Range)	*U*	*z*	*p*	*Effect Size, r*
School Night:						
Sleep duration (hours)	9.67 (7.20 – 11.87)	9.80 (7.85 – 11.97)	4266.00	-0.15	.880	-.01
Total sleep time (hours)	8.61 (6.50 – 10.20)	8.55 (6.93 – 10.22)	4173.50	-0.40	.694	-.02
Sleep onset latency (minutes)	19.5 (0.0 – 122.0)	16.0 (0.0 – 126.0)	3935.00	-1.03	.306	-.07
Sleep efficiency (% sleep)	88.12 (77.59 – 93.68)	88.18 (76.61 – 95.50)	4196.50	-0.34	.738	-.02
Non-School Night:						
Sleep duration (hours)	9.87 (7.55 – 11.13)	9.80 (7.58 – 11.73)	774.00	-0.45	.658	-.05
Total sleep time (hours)	8.52 (6.43 – 9.57)	8.62 (6.93 – 10.17)	769.50	-0.49	.628	-.05
Sleep onset latency (minutes)	13.0 (0.0 – 91.0)	14.0 (0.0 – 108.0)	785.00	-0.35	.730	-.04
Sleep efficiency (% sleep)	87.36 (78.0 – 93.0)	88.08 (80.0 – 93.0)	785.00	-0.35	.730	-.04

Table G17

Comparison of Children using Active or Passive Transport To and From School (Mann-Whitney U test, To School n = 200, From School n = 199)

Variable	Passive Transport (car, bus): Median (Range)	Active Transport (walk, scooter, bike): Median (Range)	*U*	*z*	*p*	*Effect Size, r*
To School:						
Sleep duration (hours)	9.93 (7.20 – 11.87)	9.53 (7.85 – 11.68)	4306.50	-1.67	.096	-.12
Total sleep time (hours)	8.68 (6.50 – 10.22)	8.40 (6.93 – 10.12)	4161.50	-2.02	.044	-.14
Sleep onset latency (minutes)	16.0 (0.0 – 122.0)	23.0 (0.0 – 126.0)	4074.00	-2.24	.026	-.16
Sleep efficiency (% sleep)	88.25 (77.59 – 95.50)	88.17 (71.61 – 93.72)	4623.50	-0.89	.374	-.06
From School:						
Sleep duration (hours)	9.88 (7.20 – 11.87)	9.62 (7.85 – 11.68)	4165.50	-1.69	.090	-.12
Total sleep time (hours)	8.64 (6.50 – 10.22)	8.48 (7.07 – 10.12)	4300.50	-1.36	.176	-.10
Sleep onset latency (minutes)	19.0 (0.0 – 126.0)	20.0 (0.0 – 112.0)	4778.00	-0.17	.868	-.01
Sleep efficiency (% sleep)	88.18 (77.59 – 95.50)	88.75 (71.61 – 93.74)	4584.00	-0.65	.318	-.05