CHARACTERISING THE SLEEP-WAKE BEHAVIOUR OF ADOLESCENTS IN A SAMPLE OF SOUTH AFRICAN HIGH SCHOOL STUDENTS IN MAKHANDA, EASTERN CAPE

BY

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Declaration

I, Natasha Luleka Mandondo, hereby declare that this thesis is based on original work (except where referenced otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree at Rhodes University or in any other university.

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Abstract

Introduction: Sleep plays a significant role during adolescence. Overall, sleep is essential for growth and development, cognitive function, memory consolidation, concentration, alertness, mental and physical health, as well as the overall quality of life. During adolescence though, sleep-wake behaviour has been shown to undergo drastic changes, progressing from the early ages of 11-13 years through to late adolescence while attending school. During this period, adolescents experience later bedtimes, earlier waketimes, and less than recommended sleep durations, especially on weekdays during the school term. On weekends, however, adolescents tend to further delay their bed and wake times, resulting in discrepancies between week-and-weekend sleep-wake behavior. These changes are driven by a variety of systemic factors, that include biological, psychosocial, school, and behavioural changes that adolescents experience. The interaction of systematic factors has been described as the "Perfect Storm of insufficient and inappropriately-timed sleep" (Carskadon, 2011a; Crowley *et al*., 2018). While previous research on adolescent sleep has been focused mainly in countries of the Global North, there has been comparatively less research in the Global South, particularly in countries like South Africa, and in out of large city centres like Johannesburg and Cape Town. It is also not known what the impact of certain demographic factors, such as learner sex, boarding/day schooling, and public/private schooling is on sleep-wake habits. Therefore, the purpose of this study was to explore the sleep-wake behaviour of a sample of late adolescents from public and private schools in Makhanda in the Eastern Cape of South Africa and to make comparisons between different groups within. **Method:**This study is comprised of two phases. Phase one adopted a cross-sectional design to characterise Grade 12 learners' (final year students) sleep-wake behaviour across various public and private schools. This was achieved through the administration of an amended version of the School Sleep Habits Survey (SSHS). The SSHS included questions that capture demographic information, academic performance, sleep duration at different times of the week and also incorporated scales to assess daytime sleepiness, sleep-wake behavior problems, depressive mood, and chronotype. Phase two adopted an observational descriptive design. The sleep-wake behaviour of a sample of Grade 11 learners was tracked for 9 days using the Core Consensus Sleep Diary and Actigraphy. Data were not normally distributed and were thus analysed using non-parametric statistics and all data were displayed as the median and interquartile range (no 1-3). **Results:** Analysed surveys totalled 231. All participants were Grade 12s (final year of high school), aged between 17-19, from three private

schools (n=152) and two public schools (n=79). The sample consisted of students identifying as females (n=94) and males (n=137). Participants self-identified as either Black/African (n=73), White (n=125), Colored (n=32) and as Indian (n=1). Over half of the sample lived in boarding houses/hostels (n=130) and slightly less than half (n=95) were day scholars. For Phase One, the median obtained for self-reported sleep duration on weekdays was 07hrs (06hrs-07hrs:18min) and 08hrs (07hrs-09hrs) on the weekend ($p<0.01$; $z=10$). The median for self-reported bedtime on weeknights was 11:00 (10:30-11:30) p.m., while on the weekends, it was an hour later i.e., 12:00 a.m. (11:00 p.m. -12:37 a.m.; $p<0.01$; $z=9.4$). Self-reported waketime on weekdays was 06:20 (06:00-06:30) a.m. and it was one-hour forty minutes later on weekends i.e., 08:00 (07:00-09:00) a.m. ($p<0.01$; $z=13$). With regards to sex differences on school mornings, females reported waking up 14 minutes later than their male counterparts ($p<0.01$; $z=-3.1$). On school mornings, day scholars reported significantly earlier waketimes than boarders ($p<0.01$; $z=8.1$). The opposite was found on weekends with day scholars reporting significantly later waketimes than boarders ($p<0.01$; $z=-4.1$) while day scholars reported going to bed significantly later than boarders during weekends ($p<0.01$; $z=-2.7$). There were noteworthy differences between types of schools with public school learners reporting earlier bed ($p<0.01$; $z=3.9$) and wake times ($p<0.01$; $z=10$) than private school learners on weekdays. On the weekend, however, public school learners reporting later bed ($p=0.01$; $z=-2.7$) and wake times ($p<0.01$; $z=-4.4$) than private school learners. Overall, the Grade 12 learners scored 12 (11-15) on the depressed mood scale indicating a trend towards high self-reported depressive symptoms, and 26 (23-30) on the ME scale, which demonstrated that this sample population reflects a preference for neither evenings nor mornings. The majority (75 %; n=174) of the Grade12 learners perceived themselves as getting too little sleep, 59% (n=134) reported waking up at least once during the night and 92% (n=213) reported experiencing varying degrees of daytime sleepiness. There was a relationship between caffeine consumption and usage of electronic devices (EDs) before bedtime and some sleep parameters. Specifically, the frequency of consumption of coffee/tea and soda had a medium and positive correlation with sleep onset latency as well as to the scale of sleep-wake problems. Academic performance was also positively and significantly correlated with self-reported mean weekday waketime and negatively correlated with mean weekend sleep duration as well as Weekend Waketime Delay (WWD). For Phase Two, the median self-reported sleep duration for 14 female boarders recorded in sleep diaries i.e.,07:32 (07:22-07:55) and the total sleep time (TST) recorded by the actigraphy i.e., 07:06 (06:54-07:35) and was less than the recommended sleep duration of 8-10 hours for adolescents and not

significantly different (p=0.18; z=1.3). However, median sleep duration on the weekend was significantly longer on both actigraphs (08:16; 07:22-08:40) and sleep diaries (08:24; 07:59-08:51) and not significantly different (p=0.3; z=1.1). Overall, bedtimes, waketimes, and sleep onset latency, for both weekdays and weekends, did not differ significantly between the sleep diary responses and actigraph recordings. **Discussion:** Adolescents in this cohort, like many around the world report weekday sleep durations that are shorter than the recommended 8-10 hours. This may probably partly be explained by later bedtimes influenced by academic obligations, bedtime autonomy, and screen time as well as early waketimes influenced by school start times as indicated in the reasons given for bedtimes. Insufficient sleep during school nights, in this cohort, likely resulted in an accumulated sleep debt which may explain the extended sleep duration and later waketimes on weekends. Weekday waketimes were probably determined by commuting and school-related demands, specifically, school start times as indicated in the reasons given for waketimes. Thus, the results of this study do, in part, align with the factors outlined in the Perfect Storm model of poorly timed and insufficient sleep in adolescents proposed by Carskadon (2011a). Personal characteristics or contextual factors, such as being a boarder or a day scholar, attending a public or private school as well sex differences, accompanied by lifestyle factors such as the consumption of caffeine and usage of electrical devices may have interacted and influenced bed and wake times, resulting in what has been termed "a Perfect Storm of insufficient and inappropriately-timed sleep" in this cohort. **Conclusion:** The current study provided new insight into the sleep-wake behaviour of late adolescents in Makhanda, Eastern Cape of South Africa. More research is encouraged in the South African context. This knowledge can be used to implement contextually appropriate sleep hygiene education programs in the school curriculum and on an individual level. Furthermore, the results point to the fact that early school start times, in concert with other lifestyle and personal factors may be contributing to insufficient sleep in this group. These results, therefore, highlight the need for schools in this context to consider interventions such as delaying school start times to possibly improve sleep in this context.

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CHAPTER I

INTRODUCTION

1.1 Background to the study

Adolescence, as defined by the World Health Organization (2001) is the age range between 10-19 and is known to be the most rapid developmental phase in humans (Dahl, 2004; Curtis, 2015) during which adolescents experience a range of physical and neurodevelopmental changes, which is accompanied by an expansion of their social networks and autonomy (Collins, 1997; Dahl and Lewin, 2002). Adolescence is characterized by rapid physical growth; changes in sexual behaviour; newly activated drives and motivations; as well as experimentation (Collins, 2003; Dahl, 2004; Curtis, 2015). In addition to the alterations in social roles, the period of adolescence typically also involves a trend towards increased responsibilities, which is related to a greater need for prioritization of things such as career choices, academics, and personal identity (Curtis, 2015). The many changes that occur during this period of pubertal development are accompanied by various biological and psychosocial changes that affect a range of processes and behaviours in adolescents, one of which is their sleep-wake behaviour (Dahl and Lewin, 2002).

Given that adolescence is a critical developmental stage characterized by maturing physiological, cognitive, and psychological processes (Brand and Kirov, 2011) obtaining optimal sleep in this population group is critical, given that sleep plays an important role in growth and restoration, cognition, and learning and general health and wellbeing (Assefa, Diaz-Abad, Wickwire, and Scharf, 2015; Maquet, 2001; Wagner, Gais, Haider, Verleger, and Born, 2004; Assefa *et al*., 2015). Thus, optimal sleep is important for maintaining physical and mental health as sleep serves many functions aimed at maintaining a normal brain and body homeostasis (Léger, Scheuermaier,Philip, Paillard, and Guilleminault, 2001; Katz and McHorney, 2002; Léger, Massuel, Metlaine, and SISYPHE Study Group, 2006; Roth, Jaeger, Jin, Kalsekar, Stang, and Kessler, 2006; Brand and Kirov, 2011). Adequate sleep length, therefore, is important for learning and problem solving (Wagner *et al*., 2004), while extended sleep has been shown to substantially improve daytime alertness and attention (Oginska and Pokorski, 2006), all of which are important for adolescents

given that most spend a significant amount of their time at school, engaged in academic and other extracurricular activities. Recommended sleep hours for late adolescents i.e. persons aged between 15-19 years (Patton, Sawyer, Santelli, Ross, Afifi, Allen, ... and Viner, 2016) average between 8-10 hours for optimal functioning (Mary, Harvey, Duke, Thomas, Iris, and William, 1980; Carskadon and Acebo, 2002; Reid, Maldonado, and Baker, 2002; Yang, Kim, Patel, and Lee, 2005; Wolfson, Spaulding, Dandrow, and Baroni, 2007; Hirshkowitz, Whiton, Albert, Alessi, Bruni, DonCarlos, and Kheirandish-Gozal, 2015; American Academy of Pediatrics., 2016; Fuligni, Bai, Krull, and Gonzales, 2017; Short, Weber, Reynolds, Coussens, and Carskadon, 2018). However, despite this, there is extensive evidence that school-going adolescents are obtaining less than the recommended sleep duration. Studies report specifically that, increases in age and grade level are accompanied by later sleep times and reduced sleep durations (Strauch and Meier, 1988; Andrade, Benedito- Silva, Domenice, Arnhold, and Menna-Barreto, 1993; Gau and Soong, 1995; Carskadon, Wolfson, Acebo, Tzischinsky, and Seifer, 1998a; Laberge, Petit, Simard, Vitaro, Tremblay, and Montplaisir, 2001; Giannotti and Cortesi, 2002; Reid et al., 2002; Iglowstein, Jenni, Molinari, and Largo, 2003; Roenneberg, Kuehnle, Pramstaller, Ricken, Havel, Guth, and Merrow, 2004; Jenni and O'Connor, 2005; Campbell, Higgins, Trinidad, Richardson, and Feinberg, 2007; Crowley, Acebo, and Carskadon, 2007).

These changes in sleep during adolescence are influenced by intrinsic, biological as well as extrinsic psychosocial factors (as discussed in Carskadon, Acebo, and Jenni, 2004; Taylor, Jenni, Acebo, and Carskadon, 2005; Crowley et al., 2007). This is in addition to other societal pressures such as early school start times and school-related commitments (academic, sporting, and cultural commitments) (Crowley et al., 2007; Wolfson et al., 2007). In fact, many high school learners have indicated early school start times as one of the primary reasons for insufficient sleep as grade level increases (Carskadon et al., 1998a; Reid et al., 2002; Wahlstrom, 2002; Yang et al., 2005; Wolfson et al., 2007; Owens et al., 2010; Minges and Redeker, 2016; Wheaton, Chapman, and Croft, 2016; Bowers and Moyer, 2017). Based on this, it appears therefore that the older adolescent population sample may be affected more so than younger adolescents (Wolfson et al., 2007). Changes in sleep during adolescence are also further influenced by using EDs before bedtimes, busy daily schedules inclusive of other social and recreational activities and perhaps neighbourhood or school characteristics (Wolfson et al., 2007; Buxton, Chang, Spilsbury, Bos, Emsellem, and Knutson, 2015). In short, many systemic factors have been found to affect adolescent sleep which is likely

influenced by the specific context in which adolescents live and go to school (Belísio, Louzada, and Azevedo, 2010).

South Africa has a diverse population characterized by demographic differences and economic disparities, which is particularly evident in the schooling systems. Currently, vast differences exist between public schools and private schools and this is largely due to the historic residential segregation implemented by the apartheid regime (Jansen and Amsterdam, 2006). In addition to this, some schools have boarding/hostel facilities where learners work, play, and sleep at school, and therefore may face different experiences and challenges when compared to day scholars, particularly around how this environment influences sleep-wake behaviour (Martin, Papworth, Ginns, and Liem, 2014). In the context of South Africa, there has been limited research that has focused on understanding adolescent sleep. Reid et al. (2002) and Hanson et al. (2019) reported on the sleep behavior of adolescents in Johannesburg, the largest city in South Africa. Reid et al. (2002) concluded that like other adolescents around the world, South African adolescents are getting insufficient sleep on weeknights and that many of them experience daytime sleepiness. Hanson et al. (2019) sought to understand behaviours related to adolescent physical activity, sedentary behavior, and sleep. Findings in that cohort demonstrated that sleep duration did not decline through adolescence, between ages 12 to 17 (Hanson et al., 2019). While much of this research has been conducted in Gauteng, there has been no research performed in other parts of South Africa, such as the Eastern Cape region. Furthermore, much remains unknown with regards to the sleep-wake behaviour of adolescents in South Africa and the influence of factors such as the type of school (boarding vs. day scholars, private vs. public school), sex, race, and other psychosocial factors on sleep-wake behaviour in this context.

Furthermore, research conducted among adolescents in South Africa has been based on self-reported data obtained through the use of cross-sectional surveys. Although surveys are useful to get an across sectional overview, the inclusion of more objective forms of characterising sleep-wake behaviour, such as the use of actigraphy, is important and important to use alongside other qualitative measures.

1.2 Statement of the problem

Sleep plays a vital role during the critical development stage of adolescence. Despite this, adolescents have been identified as a population group that is prone to insufficient and poor-quality sleep, likely due to the interaction between various biological, psychosocial and environmental

factors that are context specific. Despite the extensive research on adolescent sleep-wake behaviour in other countries in the Global North, there has been comparatively little research on the sleep-wake behavior of South African adolescents especially out of large urban cities and in smaller towns in other provinces such as the Eastern Cape. While South African adolescents may face the same academic pressures as other adolescents globally, the South African context presents many unique economic, social, cultural, and racial differences which may influence whether a learner can attend a public or private school and whether they can board at school or live at home, all of which may influence sleep-wake behaviour. It is therefore important to characterize the sleep-wake behaviour of learners in this context and explore the impact of these different demographic factors on learner sleep-wake behaviour. Furthermore, while most of the research in adolescent sleep has been cross-sectional in nature, in South Africa, there has been little research focused on characterising sleep-wake behavior of adolescents over a school week and a weekend through more objective measures such as the use of actigraphy.

1.3 Study aims and objectives

In light of the above, this study aimed to provide a detailed overview of the sleep-wake behaviour of a sample of late adolescents from public and private schools in Makhanda, South Africa, achieved in two distinct phases. The aim of Phase one was to describe the sleep-wake habits or patterns of a sample of Grade 12 (last year of school) adolescents from local private and public high schools based on the School Sleep Habits Survey (SSHS). Therefore, the objectives of phase 1 of this study were as follows:

- To characterise the sleep-wake behaviour of Grade 12 learners in this context and then to report on and make comparisons between weekdays and weekend sleep-wake behaviour
- To explore the impact of certain demographic factors (such as learner sex, whether they attended public or private schools, and whether they were boarders or day scholars) on sleep-wake behaviour.
- To report on the associations between sleep-wake behaviour and daytime sleepiness, chronotype, as well as depressed moods, and sleep-wake problems.
- To determine behavioral or lifestyle factors that may influence these sleep-wake patterns e.g., physical activity, caffeine intake, and use of EDs before bedtime, in this cohort of adolescents.

The aim of Phase two was to characterize sleep-wake behavior in a sample of Grade11 female boarders using actigraphy and sleep diaries. Therefore, the objectives of phase 1 of this study were as follows:

- To characterise the sleep-wake behaviour of Grade 11 learners in this context and then to report on and make comparisons between weekdays and weekend sleep-wake behaviour as recorded on sleep diaries and measured by actigraphs.

1.4 Research Question

What are the sleep-wake habits of late adolescents in South Africa and what context-specific factors influence sleep-wake behaviour?

CHAPTER II

REVIEW OF LITERATURE

This chapter presents literature related to late adolescents' sleep patterns. It defines sleep and elaborates on its' structure. It characterizes adolescents and highlights the importance of sleep, processes that regulate sleep, and the implications for poor sleep patterns. It also describes how various systematic factors interact to create the Perfect Storm of insufficient and ill-timed sleep. Then lastly, highlights some ways to track sleep in adolescents.

2.1 Defining and understanding the structure of sleep

To understand the importance of sleep in adolescents, it is important to gain a general understanding of sleep, how it works and the role it plays in adolescents' health, wellbeing, function, development, and performance. Sleep is a neurochemical and physiological process that is organized by centers that promote sleepand arousal in the brain (Zisapel, 2007). It is defined as a state of being unresponsive to sensory stimuli and the environment (Dijk and von Schantz, 2005). The sleep state is also described as being active, repetitive, and reversible (Dewald, Meijer, Oort, Kerkhof, and Bögels, 2010).Furthermore, sleep is cyclical (Carskadon and Dement, 2011) with these cycles occurring roughlyevery 90 minutes to 2 hours. Thus, one entire sleep period is characterized by several cycles (Carskadon and Dement, 2011) which are comprised of different stages of sleep. The two broad stages are Rapid Eye Movement (REM) sleep and non-Rapid Eye Movement (non-REM) sleep (which is comprised of three stages) (Dahl and Lewin, 2002; Carskadon and Dement, 2011). Stage1 of the non-REM phase is characterized by light sleep and lasts for several minutes or less as the sleeper progresses to deeper sleep stages (Hobson, 2005; Zisapel, 2007). Sleep then progresses to stage 2, which is a more subdued state, and it occurs before individuals enter into a deep sleep (Dahl and Lewin, 2002; Carskadon and Dement, 2011; Hobson, 2005). Following this is stage 3 of the non-REM phase, also referred to as slow-wave sleep (SWS), delta sleep, or deep sleep during which heart rate and breathing are markedly reduced and muscles are relaxed (Carskadon and Dement, 2011). From this, generally individuals' transition to REM sleep which is characterized by neurological and physiological responses that are similar to what a person may experience during wakefulness such as eye movements, increased heart rate, irregular

breathing as well as mixed frequency brain wave activity and dreaming (Carskadon and Dement, 2011). During REM sleep, muscles are also temporarily "paralyzed", in this way, the body prevents people from acting out their dreams which occur in the REM period of sleep (Dahl and Lewis, 2002; Hobson, 2005). It is also worth noting that the length of this deep sleep differs depending on how long the person has been awake for as well as an individuals' previous sleep-wake behaviour (Carskadon and Dement, 2011). Sleep-wake cycles are also associated with changes in many physiological and endocrine functions and processes such as body temperature, heart rate, cortisol, melatonin, and growth hormone, many of which change in rhythmic behaviour (Dijk and von Schantz, 2005). These rhythms, discussed below, in conjunction with other processes, may contribute to the changes in sleep-wake propensity and more generally in sleep-wake regulation (Dijk and von Schantz, 2005).

2.1.1 Sleep Regulation

Sleep is regulated by two processes; the circadian process and the sleep homeostatic process, captured in the two-process model of sleep regulation (Borbély, 1982; Borbély and Achermann, 1999, see Figure 1 below).

2.1.1.1 The circadian process

The circadian process functions as a clock-like mechanism. In short, it is an internal 24-hour clock that primarily regulates sleep timing (and uses sleepiness and alerting signals to enforce this) (Hershner and Chervin, 2014; Kabrita, Hajjar- Muça, and Duffy, 2014). The circadian process is not dependent on prior sleep and waking but determines the alternation of periods with high and low sleep propensity (Jenni, Achermann, and Carskadon, 2005; Hershner and Chervin, 2014; Kabrita et al., 2014), while also regulating meal timing and changes in body temperature, the timing of hormone release and sleep-wake cycles (Swaab, Hofman, Mirmiran, Ravid, and van Leeuwen, 1992; Dahl and Lewin, 2002). These circadian rhythms are self-sustained and oscillate roughly every 24 hours (Crowley et al., 2007). The rhythms are generated by a pacemaker, the suprachiasmatic nucleus (SCN) (Moore, 1997; Dijk and von Schantz, 2005) which is a group of cells located near the hypothalamus in the brain. This circadian pacemaker is synchronized to or entrained by light, which is received through the retinohypothalamic tract (Moore, 2013) and other time givers or 'zeitgebers' (such as meal timing and physical activity) which in turn, influence the

signals sent to peripheral clocks around the body (Dijk and von Schantz, 2005). These signals and the associated physiological responses drive certain behaviors that are synchronized to the changes in light and dark cycles under entrained conditions (Dijk and von Schantz, 2005; Moore, 2013).

2.1.1.2 The homeostatic sleep-wake process

The homeostatic sleep-wake system operates much like a pressure system, where sleep pressure increases during wakefulness and decreases with the occurrence of sleep (Crowley et al., 2007). Sleep pressure can be measured through slow-wave sleep (SWS, NREM stage 3) and electroencephalographic (EEG) slow-wave activity (SWA) (Crowley et al., 2007). At the beginning of the sleep episode, SWA is high and that is when sleep pressure is at its peak. During successive non-rapid eye movement (non-REM) episodes (Borbély Baumann, Brandeis, Strauch, and Lehmann, 1981; Borbély, 1982), SWA begins to decline exponentially (Crowley et al., 2007). Additionally, the longer a person is awake, SWA is increased in subsequent sleep activity (Borbély et al., 1981; Dijk, Brunner, Beersma, and Borbély, 1990). Thus, sleep pressure is only dissipated through sleep.

2.1.1.3 The two-process model

Intrinsic sleep-wake regulation is described using models that rely on the circadian timing mechanism and the sleep homeostatic process (Carskadon and Acebo, 2002). This model was first proposed and described by Borbély (1982) who labelled the circadian process, Process C, and the homeostatic process, Process S (Carskadon and Acebo, 2002). This model is known as the two-process model and is illustrated in Figure 1 below. In this model, the homeostatic process dynamically interacts with the sleep-wake independent clock-like circadian process, which counteracts the increasing sleep propensity of the homeostatic process (Carskadon, Acebo, and Seifer, 1998b; Borbély and Achermann, 1999; Hershner and Chervin, 2014; Kabrita et al., 2014). These two systems, therefore, have opposing effects and an equal contribution to sleep-wake propensity (Hershner and Chervin, 2014).

Daily fluctuations in alertness are regulated by the circadian clock, which partially accounts for why humans are usually alert in the morning, late afternoon, and early evening hours but are often less alert just after lunch (in the post-prandial dip) and during the night (Hershner and Chervin, 2014; Kabrita et al., 2014). The circadian process maintains wakefulness and counteracts the

effects of homeostatic sleep drive which also increases throughout the day (Goel, Basner, Rao and Dinges, 2013). Because of this, the amount of sleep a person gets, together with the quality and the time elapsed from the last episode of sleep is reflected by the build-up of sleep pressure (Borbély and Achermann; 1999; Sadeh, Gruber, and Raviv, 2003).

In the evening, the circadian clock, through its interaction with the pineal gland, regulates the release of melatonin (Carskadon et al., 1998b; Dahl and Lewin, 2002; Crowley et al., 2007), which plays an important role in preparing the body for sleep. Combined with heightened sleep pressure, physiological downregulation, and the onset of darkness, sleep onset occurs, and sleep pressure dissipates exponentially (Dahl and Lewin, 2002; Crowley et al., 2007). During the nighttime, melatonin levels rise consistently and reach a peak around the midpoints of sleep, and thereafter begin to decline (Crowley et al., 2007; Goel et al., 2013). Following this, the circadian process initiates the gradual release of cortisol which plays an important role in preparing for wakefulness (Dahl and Lewin, 2002). Eventually, awakening happens when the circadian drive for arousal overcomes the homeostatic sleep drive, which tends to coincide with dawn in entrained situations (Dahl and Lewin, 2002; Crowley et al., 2007).

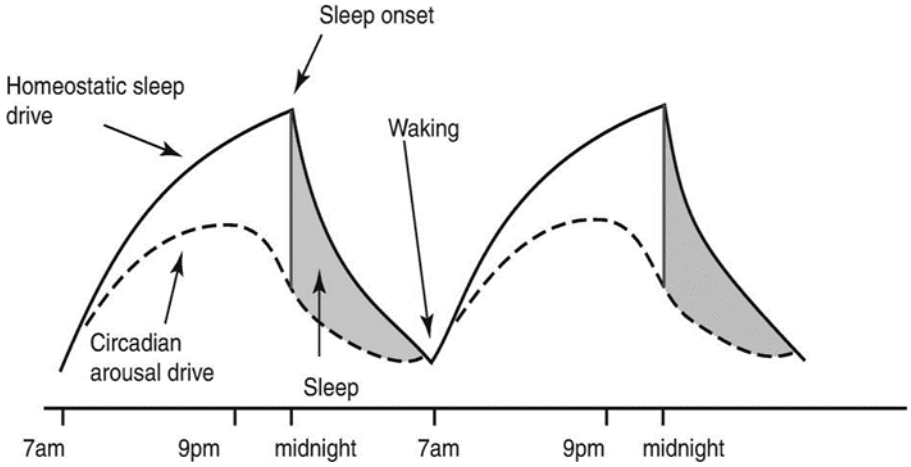


Figure 1. The two-process model for the regulation of sleep. Process C is the circadian arousal drive and Process S is the homeostatic sleep drive (taken from Borbély and Achermann, 1999).

2.1.2 Recommended sleep hours

Sleep need changes across the lifespan. The National Sleep Foundation recommends that children (6-13-year-olds) should obtain 9 to 11 hours of sleep, while adolescents/adolescents (14-17year olds) should be getting 8 to 10 hours of sleep. More recently, a category of young adults (18-25-year-olds) has been included and their recommended sleep hours are 7 to 9, while adults (26-64-year-olds), should be getting 7 to 9 hours of sleep on average (see: b et al., 2015; American Academy of Pediatrics, 2016; Fuligni et al., 2017; Chaput, Dutil, and Sampasa-Kanyinga, 2018; Short et al., 2018). These recommended sleep hours are vital for optimal health and daytime functioning. It is, however, worth noting that, inter alia, genetics, lifestyle behaviors, medical history, and the environmental context, are factors that can influence individual variability in sleep-wake behavior (American Academy of Pediatrics, 2016; Chaput et al., 2018), and this is particularly evident during adolescence.

2.1.3 The importance of sleep in adolescents

The focus on sleep among adolescents is worth noting because sleep has a significant role during this critical stage of development (Brand and Kirov, 2011). Sleep contributes to growth, development, immune system function, energy conservation, synaptic homeostasis, neuronal recuperation, emotional regulation/processing and it has shown to be beneficial for coping strategies in response to stress (Lewin and Dahl, 1999; Siegel, 2009; Brand and Kirov, 2011). Furthermore, sleep has been implicated in brain plasticity (Siegel, 2009). Therefore, sleep is necessary for effective cognitive performance and in turn executive functioning, including abstract reasoning, goal-directed behavior, and creative processing (Zisapel, 2007; Dewald et al., 2010).

Hofman and Steenhof (1997) surveyed 600 European high school students and found that good school performance was associated with longer sleep durations, good sleep quality, shortened sleep delay (i.e., the difference between weekday and weekend bed and wake times), and reduced substance use (e.g., alcohol, caffeine, nicotine). In the same vein, Wolfson and Carskadon (1998) surveyed 3120 Rhode Island, USA adolescents and found that those students with longer sleep durations and earlier bedtimes on school nights performed better academically. Adolescents who got less than 6hours:45 minutes of sleep duration, on the other hand, reported higher levels of daytime sleepiness, more depressed mood, and performed poorly academically (Wolfson and Carskadon, 1998). Overall, enough restorative sleep is important for maintaining physical and

mental health (Le´ger et al., 2001; Katz and McHorney, 2002; Le´ger et al., 2006; Roth et al., 2006). It has therefore been established that sufficient sleep not only plays a vital role in adolescent development but is also associated with many other processes (Brand and Kirov, 2011; Buxton et al., 2015). Much like a good diet and physical exercise, adolescents need sleep to stay healthy, for overall optimal functioning and alertness, which would be essential in achieving academic goals and other daily activities (Buxton et al., 2015).

2.2 Characterizing adolescents

Adolescence has been defined as the time of progression from childhood to adulthood (Dahl, 2004; Konrad, Firk, and Uhlhaas, 2013). During adolescence, the brain undergoes many rapid and significant changes (Konrad et al., 2013). Some neuronal systems undergo maturation, which includes significant changes that are observed in the limbic system which is responsible for the reward system and the prefrontal cortex, also known as the regulatory system (Konrad et al., 2013; Giedd, 2015). More specifically, the limbic system influences how adolescents determine rewards and punishments (Romeo, 2013). The limbic system also plays a role in how they process their emotions and make judgements (Dahl, 2004). During adolescents, the levels of the neurotransmitter dopamine in the limbic system and prefrontal cortex are increased (Romeo, 2013). As dopamine is associated with pleasurable rewards and cognition, its increase impacts adolescent emotions and their responses to rewards and stress (Romeo, 2013).

These developments in brain maturation continue through to the twenties and may influence adolescent judgement and the ability for impulse control (Giedd, 2015; Sawyer, Azzopardi, Wickremarathne, and Patton, 2018). However, these developments are accompanied by new cognitive skills that result in a better ability to think abstractly, solve problems and make plans (Sawyer et al., 2018). Adolescents also develop emotionally, which involves learning how to deal with stress and manage emotions (Giedd, 2015). Furthermore, changes also occur in sleep-wake behavior and regulation. More specifically, during adolescence there is an increased tendency for later bed and wake times, the duration and depth of non-REM (Stage 3) and REM sleep is decreased; REM sleep begins to develop into a more adult-like pattern; daytime sleepiness is increased (Park, Seo, Matsumoto, Shinkoda, 1999; Dahl and Lewin, 2002; National Sleep Foundation, 2006; Hirshkowitz et al., 2015).

In sum, for adolescents, this time is not only characterized by rapid physical growth, changes in sexual behaviour, newly activated drives and motivations, experimentation, changes in social roles but also, by changes in sleep-wake behavior and regulation (Dahl, 2004; Curtis, 2015), all of which are discussed below.

2.2.1 Characterising changes in sleep during adolescence and influencing factors

Overall, research has consistently shown that sleep schedules experience drastic changes with age across adolescence, which may begin as early as the 6th Grade (i.e., ages 11 to 13) (Carskadon, 1990a; Ferber, 1990; Yarcheski, and Mahon, 1994; Giannotti et al., 2002; Reid et al., 2002; Campbell et al., 2007; Wolfson et al., 2007). Young adolescents, from the age of 12 years have been shown to experience restricted sleep, as well as discrepancies between week and weekend sleep schedules. Consequently, they tend to experience sleepiness during the day (Saarenpää-Heikkilä, Laippala, and Koivikko, 2000) and are more likely to take naps than younger children (Wolfson and Carskadon, 1998; Reid et al., 2002; Sadeh, et al., 2003; Wolfson et al., 2003a; Fredriksen, Rhodes, Reddy, and Way, 2004). These changes have been shown to progress and become more extreme as individuals' transition into late adolescents (Carskadon, 1998a; Fukuda and Ishihara, 2001; Liu and Zhou, 2002). Wolfson and Carskadon, (1998) for example found that across the ages of 13-19 years, on weekdays sleep duration was decreased by 40 minutes, from 07hours:42minutes to 07hours:02minutes and on weekends, it was reduced from 09hours:18minutes to 08hours:36minutes.

2.2.2 Adolescent mean sleep durations

The recommended sleep hours for adolescents/teenagers is between 8 and 10 hours (Hirshkowitz et al., 2015; American Academy of Pediatrics., 2016). However, as demonstrated in Table 1, adolescents in many parts of the world adolescents are reporting less than the recommended mean hours. For instance, in America (Wolfson and Carskadon, 1998; Carskadon et al., 1998a), Taiwan (Gau and Soong, 1995; Huang, Wang, and Guilleminault, 2010); China (Liu and Zhou, 2002), Japan (Ohida Osaki, Doi, Tanihata, Minowa, Suzuki, and Kaneita, 2004), Iran (Ghanizadeh, Kianpoor, Rezaei, Rezaei, Moini, Ahmadi, and Moeini, 2008), India (Gupta, Bhatia, Chhabra, Sharma, Dahiya, Semalti and Dua, 2008), Korea (Yang et al., 2005), Greece (Lazaratou, Dikeos, Anagnostopoulos, Sbokou and Soldatos, 2005) and South Africa (Reid et al., 2002), adolescents

have reported weekday mean sleep durations ranging from 04hours:54minutes to 07hours:55minutes. Fewer studies however report sleep durations of 8 hours. Garaulet, Ortega, Ruiz, Rey-Lopez, Beghin, Manios, and Molnár (2011) assessed a sample of 3311 adolescents aged 12.5–17.49 years from 10 European cities and found that mean daily sleep duration was 8 hours, while Gamble, D'Rozario, Bartlett, Williams, Bin, Grunstein, and Marshall, (2014) report a mean weekday sleep duration of 8 hours: 6 min among Australian teenagers. Even fewer studies report sleep durations of more than 8 hours. Finish and Swiss adolescents, for example, have reported averages ranging from 8hours:30 minutes to 9hours (Tynjälä, Kannas, and Välimaa, 1993). In summary, it appears that research from around the world has consistently shown that more often than not, adolescents globally are getting less than the recommended sleep hours, especially on school nights. Table 1 summarizes a mixture of self-report and measured research in the area of adolescents' sleep durations across the different continents.

Table 1. Reports of adolescent sleep durations in different countries based on self-reported and measured sleep variables.

Author(s)	Geographical area	Sample size	Ages (Years)	Overall Sleep Duration (hrs:mins)	Weekday Sleep duration (hrs:mins)	Weekend Sleep Duration (hrs:mins)
Asia						
Gau and Soong, (1995)	Taiwan	930	13-15		07:00	09:06
Liu and Zhou, (2002)	China	1359	12-18	07:36		
Ohida *et al*., (2004)	Japan	106,297	13-18		06:18	08:30
Yang *et al.*, (2005)	Korea	1457	9.4-19		04:54-06:00	08:30-09:06
Chung and Cheung, (2008)	Hong Kong	1629	12-19		07:18	09:30
Ghanizadeh *et al*., (2008)	Iran	1420	15-18	07:42		

Gupta *et al*., (2008)	India	1920	12-18	07:48		
Ouyang *et al*., 2009	China	621	11–20		08:36	09:24
Huang *et al*., (2010)	Taiwan	1939	12-18		07:24	09:24
Shochat *et al*., (2010)	Israel	449	14		07:22	09:53
Tagaya *et al*., (2004)	Japan	3478	15–18	06:20		
North America						
Wolfson and Carskadon, (1998)	USA	3120	13-19		07:24	09:12
Carskadon *et al*., (1998a)	USA	40	14-16.2		06:54	07:54
Knutson and Luderdale, (2009)	USA	3108	15-17		08:00-08:15	10:00-11:00
Matthews *et al*., (2014)	USA	250	15.7		06:00-06:48	07:24-08:42
El-Sheikh *et al*., (2016)	USA	252	15.79	07:00		
Malone *et al*., (2016)	USA	115	15.4-15.5	07:17-07:55	07:04-07:19	08:07-09:23
Park *et al*., (2016)	USA	315	14.5–18.4	07:28		
Europe						
Ohayon *et al*., (2000)	Europe	1125	15-18	07:55		
Lazaratou *et al*., (2005)	Greece	713	16-19		07:30	
Garaulet *et al*., (2011)	Europe (Austria, Belgium, France, Germany, Greece, Hungary,	3311	12.5–17.49	08:00		

	Italy, Spain and Sweden)					
Dewald *et al*., (2014)	Netherlands	175	15.14		06:49	07:43
Tonetti *et al*., (2015)	Italy	36	18.14	06:37		
Australia						
Bei *et al*., (2014)	Australia	146	16.18	07:21		
Gamble *et al*., (2014)	Australia	1184	11-17		08:06	09:30
Africa						
Reid *et al*., (2002)	South Africa	825	14-20		07:30	07:54

Despite the serious implications that insufficient sleep may have on adolescent well-being and functioning, there is relatively little research that has been done in attempts to profile and understand sleep-wake patterns and disturbances on daytime functioning and health issues in adolescents in the South African context. Reid *et al*. (2002) report on the sleep behavior of South African adolescents using 825 high school students. In South Africa, adolescents reported less than the recommended sleep duration on weekdays (07hours:30minutes) and weekends (07hours:54minutes). With regards to sex differences, more females reported spending significantly less time in bed on school nights compared to males (Reid *et al*., 2002). Overall, the reported mean sleep onset latency was 17 minutes during the week. 45% of the students reported sleep onset latencies of less than 10 minutes, and according to the author, this may be an indication of a high sleep drive (Reid *et al*., 2002). Only 6% reported sleep onset latencies of longer than 30 minutes and only 3% reported sleep onset latencies longer than 1 hour (Reid et al., 2002).

Most (77%) of the adolescents reported napping during the day (Reid et al., 2002). 40% of the learners also reported that being sleepy mid-morning did not depend on their night-time sleep quality or duration (Reid et al., 2002). The average bedtime was 10:30 p.m. and waketime was 06:07 a.m. (Reid et al., 2002). Over half reported nocturnal awakenings at least once during the night and this has been assumed to indicate good sleep efficiency in this and other adolescent samples (Reid et al., 2002; Yang et al., 2005). Interestingly, most of the South African adolescents

in this study's sample reported good quality sleep. Reid et al. (2002) concluded that like other adolescents around the world, South African adolescents are getting insufficient sleep for which they try compensating for during the weekend. Given the scarcity of research in South Africa on this issue, more research must be performed in South Africa given its unique contextual characteristics. An important part of understanding how to improve the sleep of adolescents, no matter the context, is to understand the factors that may constrain or influence sleep-wake behaviour in this group.

2.2.3 The influence of various systematic factors on adolescent sleep

Changes in adolescent sleep-wake behaviour are driven by the interaction between internal, biological changes and lifestyle and environmental factors. As they transition from primary to high school and get older, adolescents tend to stay awake later at night due to bioregulatory changes but are required to wake up earlier on weekdays due to school start times (Yang *et al*., 2005; Wolfson *et al*., 2007), increased academic pressures and other commitments such as extracurricular activities which may include early morning sports training or the need to commute (Matsumoto, Kaku, Nakagawa, & Kaneko, 1975; Carskadon, 1990b; Reid *et al*., 2002). This pattern is further influenced by increased independence, less parental supervision over bedtimes (Carskadon, 1990a; Ferber, 1990; Gau and Soong, 1995; National Sleep Foundation, 2006; Short, Gradisar, Wright, Lack, Dohnt, and Carskadon, 2011), increased social activities or expanded social networking (Carskadon and Mancuso, 1988a; Carskadon and Mancuso, 1988b; Carskadon, 1990a; Gau and Soong, 1995; Carskadon *et al*., 1998a; Wolfson and Carskadon, 1998; Saarenpää- Heikkilä *et al*., 2000; Reid *et al*., 2002; Yang *et al*., 2005), electronic device use such as television, video game playing, and the internet to engage in social media activities such as online chatting at night (Van Den Bulck, 2004; Yang *et al*., 2005; National Sleep Foundation, 2006; Wolfson *et al*., 2007; Gamble *et al*., 2014; Kalak, Lemola, Brand, Holsboer–Trachsler, and Grob, 2014). This, in addition to behavioral or lifestyle factors such as engagement in physical activity (PA) or caffeine consumption (Lee, Mcenany, Weekes, 1999; Van den Bulck, 2004; Kuriyan, Bhat, Thomas, Vaz, and Kurpad, 2007; Moore, Kirchner, Drotar, Johnson, Rosen, and Redline, 2011; Mitchell, Pate, España-Romero, O'Neill, Dowda, and Nader, 2013; Al-Hazzaa, Musaiger, Abahussain, Al-Sobayel, and Qahwaji, 2014), all interact and at times, negatively influence sleep duration as adolescents get older (Carskadon, 1990a; Carskadon *et al*., 1993; Wolfson and Carskadon, 1998;

Wolfson *et al*., 2003a; Wolfson, Acebo, Fallone, and Carskadon, 2003b; Campbell *et al*., 2007; Galland, Short, Terrill, Rigney, Haszard, Coussens, and Biggs, 2018). The above-mentioned internal, biological changes and lifestyle, and environmental factors will be discussed below.

2.2.3.1 Changes in the circadian process during adolescence

The two-process model assists in an understanding of how developmental changes cause shifted sleep-wake patterns in adolescents (Crowley *et al*., 2007). Adolescents are known to experience a biological delay in the timing of sleep onset and awakening (Gau and Soong, 1995; Acebo, Sadeh, Seifer, Tzischinsky, Wolfson, Hafer, and Carskadon, 1999; Carskadon and Acebo, 2002; Crowley, Wolfson, Tarokh, and Carskadon, 2018). Changes in the circadian process may occur for various reasons such as a biologically mediated delay in the circadian phase (Carskadon, Vieira, and Acebo, 1993; Carskadon, Acebo, Richardson, Tate, and Seifer, 1997; Carskadon *et al*., 2004; Jenni and Carskadon, 2004; Knutson, 2005; Crowley *et al*., 2018); a later melatonin secretion phase (Carskadon *et al*., 1997; Laberge, Carrier, Lesperance, Lambert, Vitaro, Tremblay, and Montplaisir, 2000; Bartel, Gradisar, Williamson, 2015) as well as possible changes in light sensitivity and a longer intrinsic circadian period during adolescence (Duffy, Rimmer, and Czeisler, 2001; Duffy and Czeisler, 2002; Bartel *et al*., 2015) all of which will be discussed briefly.

Carskadon *et al*. (1998a) proposed that the delay of sleeping times in adolescents is related to a delay in the circadian phase. This proposition was made after Carskadon *et al*. (1993) demonstrated a correlation between self-reports of pubertal development and a circadian phase preference. Further evidence of this pubertal change in the circadian timing system originates from laboratory studies that have shown a positive association between pubertal stage and later circadian timing when there are no changes in sleep timing (Carskadon *et al*., 1993; 1997). Subsequently, many studies have since been conducted in different countries that consistently show that adolescents experience a biological delay in the timing of sleep onset and awakening that is associated with pubertal status and age (Carskadon and Mancuso, 1988b; Gau and Soong, 1995; Acebo *et al*., 1999; Carskadon and Acebo, 2002; Carskadon *et al*., 2004; Jenni and Carskadon, 2004; Knutson, 2005; Crowley *et al*., 2018).

This phenomenon has been termed a biologically mediated phase delay of the circadian rhythm that influences sleep timing (Carskadon *et al*., 1998a; Wolfson and Carskadon, 1998; Giannotti *et*

al., 2002; Reid *et al*., 2002; Crowley *et al*., 2007; Wolfson *et al*., 2007). Regardless of cultural differences in adolescent lifestyles, data from different countries are consistent in reports of the sleep phase delay during the teen years (Carskadon and Mancuso, 1988b; Gau and Soong, 1995; Carskadon *et al*., 1998a; Acebo *et al*., 1999; Laberge *et al*., 2001; Giannotti and Cortesi, 2002). Linked to this, studies have reported significant associations between grade levels and age and a likely shift along the spectrum of chronotype so that adolescents become more evening-oriented than they were pre-adolescence (Giannotti et al., 2002; Gau and Soong., 2003; Russo et al., 2007). Based on the findings from administered questionnaires to various adolescent groups, it has therefore been hypothesized that adolescents begin to experience the sleep phase delay and begin to transition to evening types at around the 7th Grade (Park et al., 1999; Shinkoda, Matsumoto, Park, and Nagashima, 2000; Gau and Soong., 2003; Russo et al., 2007) and that the average morningness-eveningness (M/E) score is higher in those students above the 10th Grade, therefore indicating a shift towards more eveningness (Shinkoda et al., 2000). This is linked to the biological phase delay discussed above and is perhaps also influenced by other psychosocial factors such as increasing academic pressures that are associated with advancing grades in school and increased social activities as a result of expanded social networks, discussed in more detail below (Wolfson and Carskadon, 1998). In addition to the changes in phase preference mentioned above, more mature adolescents may also have a later melatonin secretion onset and offset phase (Carskadon et al., 1997; Laberge et al. 2000; Bartel et al., 2015). Carskadon et al. (1997) assessed the presence of secondary sexual characteristics and found for example that in older adolescents there is a later melatonin secretion phase, a consistent finding in other studies (Laberge et al. 2000; Bartel et al., 2015).

Carskadon et al. (1999, 2004) have also suggested that the delay of sleep timing may also be due to adolescents having an increased sensitivity to evening light, a decreased sensitivity to morning light or that the circadian period across adolescent development might be lengthened. The lengthening of the intrinsic period of the circadian clock (i.e., longer internal day length) may also contribute to the developmental delay of the circadian phase which occurs during adolescence. Several studies have reported that the adolescent intrinsic circadian period ranges between (24.08-24.60) hr (Carskadon et al., 2004; Carskadon and Acebo, 2005; Carskadon, Labyak, Acebo, and Seifer, 1999) and this is longer than that of adults which ranges between (23.88-24.15) hr (Carskadon et al., 2004; Carskadon and Acebo, 2005; Duffy, Cain, Chang, Phillips, Münch,

Gronfier, C., ... and Czeisler, 2011; Wright, Hughes, Kronauer, Dijk, and Czeisler, 2001). Furthermore, some studies (for example, Duffy et al., 2001; Duffy and Czeisler, 2002) have reported a positive association between entrained circadian phase in young adults and the circadian period, specifically, that a later circadian phase was related to a longer period. Evening light is also associated with later bedtimes and shorter sleep durations (Bartel et al., 2015). This is most likely because evening light affords people the opportunity to engage in more evening activities, resulting in later bedtimes (Figueiro and Rea, 2010). Evening light can also affect circadian rhythm timing by delaying the circadian phase, principally by delaying melatonin secretion, therefore, making it difficult to sleep (Minors, Waterhouse, and Wirz-Justice, 1991; Bartel et al., 2015).

2.2.3.2 Changes in the homeostatic process

In addition to the evidence of a circadian phase delay, Carskadon et al. (1998b) reported maturational differences in the homeostatic regulation of sleep in adolescents. Following sleep deprivation, older adolescents showed a reduced amount of slow-wave sleep (Carskadon et al., 1998b). It has therefore been proposed that older adolescents stay awake longer because the accumulation of sleep pressure builds at a slower rate during this period of adolescence (Carskadon et al., 1998a; Jenni, Achermann, Carskadon, 2004; 2005). Similar findings have been demonstrated by sleep onset latency data from the study by Taylor et al. (2005).

In accordance with these findings, more recently Ong, Lo, Gooley, and Chee (2017) used slow wave energy as an index for sleep pressure. Slow-wave energy considers the cumulative amount of slow-wave brain activity across the entire period of sleep. They restricted sleep to five hours for five days in a sample of late adolescents (15–19 years old) and found that sleep pressure built up significantly slower. It is worth noting that two nights of recovery sleep of nine hours were not enough to compensate for the slow-wave energy lost over the restriction protocol (Ong et al., 2017). It can, therefore, be deduced that as adolescents mature, these processes favour later bedtimes (Taylor et al., 2005).

2.2.4 The role of personal and psychosocial factors in shaping sleep-wake behaviour in adolescents

There are different personal and contextual characteristics of adolescents that influence sleep patterns over and above the changes in the sleep regulatory mechanisms mentioned above. These

include but are not limited to sex differences, behavioral or lifestyle factors such as socializing physical activity engagement, caffeine consumption, and screen time as well as other extracurricular activities, which are discussed in more detail below.

2.2.4.1 Sex differences in sleep-wake patterns

Findings regarding sex differences among adolescents in sleep patterns are inconsistent (Crowley *et al*., 2007). Several studies report no significant sex differences in sleep patterns between sexes (Saarenpää-Heikkilä, 1995; Liu, Uchiyama, Okawa, and Kurita, 2000a; Paiva, Gaspar, and Matos, 2015), while other studies have found no sex differences in specific sleep parameters, for instance, in rising times (Carskadon *et al*., 1998a; Ghanizadeh *et al*., 2008); in sleep duration (Lee *et al*., 1999; Yang *et al*., 2005); and in bedtimes (Carskadon *et al*., 1998a; Lee *et al*., 1999; Yang *et al*., 2005). Some studies, however, report that middle and high school-age adolescent girls are more likely to report difficulties related to sleep (Manni, Ratti, Marchioni, Castelnovo, Murelli, Sartori, and Tartara 1997). This is along with other sleep problems such as longer sleep onset latencies (Lee *et al*., 1999; Laberge *et al*., 2001; Yang *et al*., 2005; Ghanizadeh *et al*., 2008); frequent daytime sleepiness (Giannotti *et al*., 2002; Yang *et al*., 2005; Owens *et al*., 2010); more nocturnal awakenings (Saarenpää-Heikkilä, Rintahaka, Laippala, and Koivikko, 1995; Giannotti, Cortesi, and Ottaviano, 1997; Ghanizadeh *et al*., 2008); shorter sleep durations (Gau and Soong, 1995; Giannotti *et al*., 1997; Cheung, Hui, Wing,1999; Fredriksen, Rhodes, Reddy, and Way, 2004); the increased prevalence of poor sleep quality (Cortesi, Giannotti, Caramadre, Bruni, and Ottaviano, 1997a; Giannotti and Cortesi, 2002); and later bedtimes (Ghanizadeh *et al*., 2008). These differences may be due to the differences that exist in pubertal status between girls and boys. Girls' sleep patterns could be more phase delayed in comparison to their less mature male counterparts (Laberge *et al*., 2001; Knutson, 2005). This means biologically induced changes in sleep start earlier for girls than boys.

In support of the above, Carskadon *et al*. (1993) reported a significant association between weekday bedtime and pubertal stage. According to their findings, Carskadon *et al*. (1993) conclude that pubertal maturation from the ages of 11 and 12 significantly affects phase preference in girls especially. Laberge *et al*. (2001) found that girls experience earlier changes in relation to weekday time in bed and weekend time in bed. And they also associated this difference between the sexes with the earlier onset of puberty in girls (Laberge *et al*., 2001). Other survey studies have

highlighted similar findings, noting that high school girls tend to wake up slightly earlier than their male classmates (Wolfson and Carskadon, 1998; Yang *et al*., 2005). This could be because they take longer to get ready for school or because girls often have more chores or family responsibilities (Carskadon 1990a; Link and Ancoli-Israel, 1995; Saarenpää-Heikkilä *et al*., 1995; Carskadon *et al*., 1998a; Wolfson and Carskadon, 1998; Lee *et al*., 1999; Van den Bulck, 2004; Yang *et al*., 2005; National Sleep Foundation, 2006). Even in early adolescents i.e., ages 10–14 (Patton *et al*., 2016), older girls tend to have earlier waketimes than the younger ones (Anders *et al*., 1978). On the weekends, girls have been reported to wake much later than boys and have longer total sleep durations because they have a greater sleep debt accumulated as a result of the earlier weekday waketimes (Yang *et al*., 2005; Russo *et al*., 2007; Wolfson *et al*., 2007).

Other studies report contrary findings that males may be more affected. For instance, Saarenpää-Heikkilä et al. (1995) showed that males tend to sleep later. Van den Bulck, (2004) conducted a meta-analysis of students aged between 9-18 years old and found sex differences in sleep duration with females sleeping 11 minutes more than their male peers on weeknights. Others have also found that girls sleep more than boys across adolescence (Carskadon et al., 1998a; Giannotti et al., 2002; Sadeh et al., 2003; Olds, Blunden, Petkand ov, Forchino, 2010). Ghanizadeh et al. (2008) have reported that boys are more likely to fall asleep in school than girls. According to Carskadon et al., (1998a) boys generally had later times of melatonin secretory onset than girls by about 50 minutes on average. The boys in this sample were more sleep-deprived than the girls and the boys were less likely to extend sleep during the weekends (Carskadon et al., 1998a). Males have also been reported to take more naps (Reid et al., 2002). In summary, results with regards to sex differences in sleep are inconsistent with some studies reporting insufficient sleep in females and others in males. Findings may also be influenced by the context in which research is undertaken and by the age of participants.

2.2.4.2 Physical activity and involvement in sport

There is evidence that athletic adolescents or those that engage in physical activity (PA)/exercise sleep better (Brand, Beck, Gerber, Hatzinger, and Holsboer-Trachsler, 2009; Brand, Beck, Gerber, Hatzinger, and Holsboer-Trachsler, 2010a; Foti, Eaton, Lowry, and McKnight-Ely, 2011; McKnight-Eily, Eaton, Lowry, Croft, Presley-Cantrell, and Perry, 2011). It also appears that the intensity of training or exercise also has a positive effect on sleep patterns (Suppiah, Low, and

Chia, 2015). This effect is also dependent on the timing of PA/exercise, with vigorous-intensity exercise shortly before bedtime having a negative effect on sleep (Driver, Helen, and Taylor*,* 2000). However, in general, teenage players in sports involving vigorous/high-intensity exercise have been found to be deeper and better sleepers (Brand *et al*. 2009, 2010a). Specifically, athletic learners report better sleep quality, shortened sleep onset latency, and fewer nocturnal awakenings (Brand, Gerber, Beck, Hatzinger, Pühse, and Holsboer-Trachsler*,* 2010b) in addition to earlier bedtimes (Bartel *et al*., 2015). According to Dworak, Diel, Voss, Hollmann, and Strüder (2007), deep sleep following vigorous exercise is due to modified brain mechanisms that impact the homeostatic regulation of sleep. Also, the association between PA and sleep could be modified by the timing of PA, as vigorous exercise performed close to bedtime may interfere with sleep (Driver *et al.,* 2000). Previous studies have also shown that active adolescents were more likely to get long sleep duration compared with inactive peers (Hitze, Bosy-Westphal, Bielfeldt, Settler, Plachta-Danielzik, Pfeuffer, Müller, 2009; Brand *et al*. 2010a; Foti *et al*. 2011; McKnight-Eily *et al*. 2011).

On the contrary, research has also shown that adolescents that participate in sport, similar to adults, also report less than recommended sleep durations and delayed weekend bed and wake times (Fischer, Nagai, and Teixeira, 2008; Suppiah et al., 2015). In the case of adolescents who partake in sports, their decreased sleep duration has been attributed to early morning training (Sargent, Lastella, Halson, and Roach, 2014) as well as having the increased pressure of trying to balance the demands of being an athlete and a student (Sargent et al. 2014). As already mentioned, since there are biological factors that lead to delayed bedtimes in adolescents (Jenni et al., 2005; b et al. 2007) those that have to wake early for training are not able to remedy this by attempting earlier bedtimes, given the delay in the circadian rhythm and the slow rise in sleep pressure. Furthermore, findings have also demonstrated that insufficient sleep increases tiredness and this may lead to reduced levels of physical activity and recovery from the physical exertion (Von Kries, Toschke, Wurmser, Sauerwald, and Koletzko, 2002; Knutson, 2005). Other cross-sectional studies have also reported that those children and adolescents who are short sleepers are less likely to participate in organized sport and more likely to spend more time engaged in sedentary behaviors (Von Kries et al., 2002; Garaulet et al., 2011).

2.2.4.3 Caffeine consumption

As children get older, their caffeine consumption increases, more so when they reach adolescence

(Lee *et al*., 1999; Bryant, Ludden, and Wolfson, 2010) usually in the form of coffee, soda, tea, or chocolate (Reid *et al*., 2002). Caffeine can also be found in some over-the-counter medicines and diet preparations (Lee *et al*., 1999). This is noteworthy because caffeine use is associated with sleep fragmentation (Dahl and Carskadon, 1995) and decreased sleep duration (Lee *et al*., 1999; Bertal, Gradisar, Williamson, 2015). This may be because caffeine increases alertness, and this decreases the ability to fall asleep (Calamaro, Mason, and Ratcliffe, 2009). Caffeine has been implicated in sleep problems through the following mechanism: adenosine regulates sleep and wakefulness by inhibiting the release of excitatory neurotransmitters, namely dopamine in the brain (Porkka-Heiskanen, Alanko, Kalinchuk, and Stenberg, 2002; O'Callaghan, Muurlink and Reid, 2018). Adenosine agonists increase sleep and decrease wakefulness. However, caffeine is an adenosine-receptor antagonist, which decreases sleep and increases wakefulness (O'Callaghan *et al*., 2018). Caffeine is said to increase alertness and decrease sleep onset by occupying adenosine receptors (Porkka-Heiskanen *et al*., 2002). This results in the blockage of adenosine activity and therefore the release of excitatory neurotransmitters in the brain (Porkka-Heiskanen *et al*., 2002; O'Callaghan *et al*., 2018). Adolescents also drink caffeine to counteract the effects of insufficient sleep, namely daytime sleepiness (Lee *et al*., 1999; Bryant *et al*., 2010). Taking about 300 mg of caffeine (i.e. approximately two cups of brewed coffee) can decrease sleep duration by two hours (Lee *et al*., 1999), possibly because the stimulatory effects of caffeine are known to last for 6-8 hours in adults (Lee *et al*., 1999).

Caffeine consumption is a regular occurrence among adolescents around the world. In a cross-sectional study conducted nationally among grades six through to ten in the United States, findings showed that over half of the adolescents were moderate to high caffeine consumers (Orbeta, Overpeck, Ramcharran, Kogan, and Ledsky, 2006). Ghanizadeh et al. (2008), report that approximately 54% of adolescents reported coffee consumption one or more times per week. In other high school samples (see for example Bryant et al., 2010; Pollak and Bright, 2003), over 90% of the students have reported regular caffeine consumption. Furthermore, the quantity of caffeine consumption has been shown to increase with age (Pollak and Bright, 2003). Children as young as seven consuming about 12 mg daily, which is increased to 25 mg by the age of 10 years old. By the time they reach adolescent age, caffeine consumption is doubled to about 53mg of caffeine daily, mostly in the form of soft drinks (Pollak and Bright, 2003).

Soda and energy drink companies often market their products to adolescents with their marketing strategy being centered on an energy boost to keep up with sports activities and busy schedules (Nestle, 2000; Reissig, Strain, and Griffiths, 2009). This marketing strategy seems to have been effective, for example, adolescents have reported using energy drinks because they think energy drinks boost their energy levels (O'Dea, 2003; Bertal et al., 2015). The increased popularity of energy drinks has significantly contributed to a rise in caffeine consumption among adolescents (O'Dea, 2003; Reissig et al., 2009). Frequent caffeine consumers have been found to report more interrupted sleep, short sleep duration, long sleep onset latencies, poor sleep quality, higher levels of daytime sleepiness in adolescents (Lee et al., 1999; Pollak and Bright, 2003; National Sleep Foundation, 2006; Orbeta et al., 2006; Ghanizadeh et al., 2008; Bertal et al., 2015).

2.2.4.4 The use of Electronic Devices (EDs)

Previous research has shown that media use such as television, computer game playing, and internet use affects sleep in adolescents (Van den Bulck, 2004; Gamble *et al*., 2014; Kalak *et al.,* 2014). More specifically, playing video/computer games, using the computer or phone for various reasons such as surfing the internet exposes adolescents to evening light, which has been associated with later bedtimes (Bartel *et al*., 2015). Simply, the mere presence of EDs in the bedroom has been linked to later bedtimes, shorter sleep duration, and higher levels of daytime sleepiness (Van den Bulck, 2004; Li, Jin, Wu, Jiang, Yan, and Shen, 2007; Mindell, Meltzer, Carskadon, and Chervin, 2009). These EDs are interactive and may cause arousal which may delay bedtimes (Cain and Gradisar, 2010; Short *et al*., 2013a; Gamble *et al*., 2014). Using these devices in bed may cause sleep disruptions by creating a learned association between the bed and being awake (Gamble *et al*., 2014). Many adolescents may also be awakened by alerts from their phones even if they had fallen asleep, resulting in sleep disturbances and reduced sleep durations (Madden, Lenhart, Duggan, Cortesi, and Gasser, 2005).

Gamble *et al*. (2014) administered an internet survey to Australian adolescents aged 11–17 yrs. The survey examined sleep patterns, sleepiness, sleep disorders, the presence of EDs in the bedroom, and frequency of use in bed at night. Findings showed that using EDs such as computers, cell phones, and televisions for long periods is associated with delayed sleep-wake schedules and later waketimes (Gamble *et al*., 2014). As discussed earlier, not only does evening light allow for activities late into the night, it also delays the circadian phase and melatonin secretion, resulting in

later bedtimes and difficulties initiating sleep (Minors *et al*., 1991; Figueiro and Rea, 2010; Bartel *et al*., 2015). Cain and Gradisar, (2010) reviewed 36 studies from different countries and reported that using EDs before sleep is associated with later bed and wake times as well as shorter sleep durations. ED use is also linked to poor subjective sleep quality (Munezawa, Kaneita, Osaki, Kanda, Minowa, Suzuki, and Ohida *et al*., 2011), greater caffeine consumption, and daytime sleepiness (Calamaro *et al*., 2009).

The internet and social media sites such as Facebook, Twitter, and Instagram are a big part of most adolescents' lives and can be associated with the use of computers and cell phones. Literature has established a negative association between social media use and sleep (e.g. Espinoza and Juvonen, 2011). For example, engaging with social media sites in bed before sleeping has been reported to be a strong predictor of poor sleep quality (Woods and Scott, 2016). Social media sites have no time restrictions, incoming alerts go on throughout the night and potentially disturb sleep especially since it is a common occurrence for adolescents to sleep with their phone in the bedroom often under their pillow or in their hand (Lenhart, Ling, Campbell, & Purcell, 2010; Woods and Scott, 2016; Bernard, 2020). Due to the consistent inflow of messages and alerts, adolescents often experience what is commonly known as “FOMO” or fear of missing out hence they feel the need to be online all the time in case they miss something (Bernard, 2020). Specifically, the use of social media has been associated with poor sleep quality, later bedtimes, and shorter sleep durations (Van den Bulck, 2004; Shochat et al., 2010).

Unstructured leisure activities may have possible effects on good sleep habits. Sleeping disturbances have also been linked to computer game playing (Tazawa and Okada, 2001). Based on research, television has been hypothesized as displacing sleep time and therefore, shortening sleep duration. Using Kubey’s (1986) concept of “unstructured time” it can be hypothesized that adolescents use television to occupy free time (Van den Bulck, 2000). The use of entertainment media can be categorised as “a residual category of leisure activity” (Van den Bulck, 2004, p.101). Unstructured activities are usually not time-bound and thus, they often take up more time than structured activities, which usually have fixed start and endpoints (Van den Bulck, 2004). It is, therefore, possible to assume that unstructured activities are more likely to result in time displacements than structured activities (Van den Bulck, 2004). Thus, it is important to consider the impact that media may have on sleeping patterns since media use at night or before bedtime

may pose time constraints on sleep (Van den Bulck, 2004).

2.2.4.5 Economic, social, environmental, and behavioral components

In addition to the above-mentioned factors, the quality and quantity of sleep may also be influenced by socioeconomic status (SES) (see, for example, Owens, Stahl, Patton, Reddy, and Crouch, 2006; Marco, Wolfson, Sparling, and Azuaje (2012). SES is a construct that has economic, social, environmental, and behavioral components. Some of these components such as income, education, and occupation, and neighborhood noise and lighting (Hill, Burdette, & Hale, 2009) have been implicated in sleep problems. Studies have assessed SES objectively using material resources and/or subjectively, achieved by determining how individuals position themselves in the social hierarchy (Jarrin, McGrath, and Quon, 2014).

In general, individuals from a lower SES have been associated with more reports of short sleep duration, poorer sleep quality, longer sleep onset latency, more daytime sleepiness, and weekend oversleep (Jarrin, McGrath, Silverstein, and Drake, 2013). This has been the case from children through to adults (Jarrin *et al*., 2013). Jarrin *et al*. (2014) sampled 239 children between the ages of 8-17 years, they found that as is the case with adults, low subjective SES is associated with shorter sleep durations, longer sleep onset latency, poorer sleep quality, and higher levels of daytime sleepiness in children and adolescents. Owens *et al*., (2006) studied 64 middle school students and reported a possible association between disrupted sleep habits and components of SES such as having parents that work evening and night shifts and sharing sleep spaces. Marco *et al*. (2012) sought to find associations between SES, and sleep in young adolescents. Their results indicated that those adolescents living in lower SES households had later bedtimes, shorter sleep duration, and more irregular sleep schedules (Marco *et al*., 2012). These adolescents also experienced greater discrepancies in sleep patterns between school nights versus weekend nights (Marco *et al*., 2012).

This trend has also been observed in older adolescents. Keyes, Maslowsky, Hamilton, and Schulenberg (2015) assessed 270 000 adolescents in the 10th and 12th grades from the United States for two decades. Adolescents from the lowest SES class were the least likely to report getting regular 7 hours of sleep in comparison to those in the middle and higher SES group (Keyes *et al*., 2015). Felden, Leite, Rebelatto, Andrade, and Beltrame, (2015) conducted a systematic review

using literature relating to sleep in adolescents of different SES from different countries. Based on the reviewed literature, adolescents from low SES families were not only more likely to develop sleep disorders such as insomnia but also had trouble initiating and/or maintaining sleep in addition to having shorter sleep durations (Felden *et al*., 2015). Importantly, reasons for socioeconomic disparities in sleep could relate to psychosocial factors, health factors, or stressful life events as well as the living environment (Thomas, Bardwell, Ancoli-Israel, and Dimsdale, 2006; Tomfohr, Pung, Edwards, and Dimsdale, 2012; Slopen and Williams, 2014). The context in which adolescents live contributes to their sleep habits (Marco *et al*., 2012). As already mentioned, the living environment is influenced by SES (Hale and Do 2007). Living in disadvantaged environments has been shown to increase the risk of unfavourable sleep outcomes in adults and in school-going children as well as in adolescents (Spilsbury, Storfer-Isser, Kirchner, Nelson, Rosen, Drotar, and Redline, 2006; Hale and Do, 2007). Specifically, noisy, unclean, and crime-ridden neighborhoods have been associated with poorer sleep quality (Hill *et al*., 2009). Although the mechanisms through which disadvantaged living environments impact sleep are not clear, it has been proposed that people living in disadvantaged neighborhoods may have difficulties initiating and/or maintaining sleep due to noise that occurs as a result of noisy/busy streets, and overcrowding in the household (Hale and Do, 2007; Muzet, 2007). Furthermore, perceived threats to personal safety in the surrounding environment could result in fear which may trigger the release of stress hormones such as cortisol which is known to promote wakefulness (Muzet, 2007; Hill *et al*., 2009). Consequently, stress, noise, and/or both, may then be implicated in insufficient and poor-quality sleep (Spilsbury *et al*., 2006). With regards to a home environment specifically, parenting practices, not possessing knowledge on sleep-promoting practices may also result in less parental supervision over bed and screen time for children and adolescents, which may, in turn, result in poor sleeping habits (Owens *et al*., 2006; Marco *et al*., 2012).

2.2.4.6 The intersection between socioeconomic status, race, living, and schooling environment in the South African context

The intersection between socioeconomic status, race, living, and schooling environment is particularly relevant in the South African context since disparities in socioeconomic status are attributed to a history of racial inequalities which have resulted in pervasive structural inequalities that continue to exist (Jansen and Amsterdam, 2006; Ndimande, 2016; Statistics South Africa, 2020). In the context of South Africa, economic disparities are evidenced in many ways, including

whether or not children have access to high-quality education or not (Ogbonnaya and Awuah, 2019). For elaboration purposes, in South Africa, public schools are grouped into five quintiles. Quintile one consists of schools in the poorest areas and so these schools are non-fee paying and funded by the government. Quantile five consists of schools in the wealthiest areas, these schools are therefore fee-paying schools and subsidized by the government (Hall and Giese, 2009). These quantiles are determined by the geographical area of the school and other socioeconomic measures such as average income, unemployment rates, and literacy levels (Ogbonnaya and Awuah, 2019). Independent or private schools, on the other hand, are privately governed and may or may not be subsidized by the state. In private schools, tuition fees tend to be higher than in public schools, and therefore it is difficult for the population groups earning the lowest to afford these schools (Jansen and Amsterdam, 2006). Other factors worth considering with regards to SES and neighborhood context are, for example, commuting distances to and from school and modes of transportation. In Johannesburg for example, de Kadt, Norris, Fleisch, Richter, and Alvanides (2014) reported that over a third of 1428 children in their cohort traveled for more than 6km to school and 60% attended school in a different suburb to the one they live in. Other studies in Cape town (Fataar, 2010) and Durban (Hunter, 2010) also reported a lot of time spent on traveling to and from school and this may curtail the amount of time available for sleep.

In other contexts, socioeconomic factors have also been suggested to play a role in explaining observed differences between different racial groups and sleep (Marco *et al*., 2012; Jarrin *et al*., 2013; El-Sheikh, Saini, Fuller-Rowell, and Buckhalt, 2016). This is of relevance in the South African context as the residential segregation between different groups of people as a result of racial and economic differences disproportionately exposes disadvantaged racial groups to poor living conditions (Hale and Do 2007). According to this line of research in other countries, racial minorities who are generally associated with lower SES tend to experience more sleep problems (e.g., Patel, Grandner, Xie, Branas, and Gooneratne, 2010). Durrence and Lichstein (2006) conducted a review of 30 studies and showed that in general, Black American adults are twice as likely to have longer sleep onset latencies, take longer naps, and demonstrate significant differences in their sleep depth in comparison to European Americans. Black Americans and Latinos, especially those from the lowest SES have been more likely to report poorer overall sleep, in comparison to White Americans (Patel *et al*., 2010). It has also been noted that disparities based on race have shown increases with time (Keyes *et al*., 2015). Black and Hispanic adolescents, along

with those in the lowest SES groups are less likely to get regular 7 hours of sleep but at the same time, are also more likely to report that they are getting enough sleep. This finding has led to the suggestion that there is a mismatch between actual sleep and perceptions of enough sleep (Keyes *et al*., 2015). However, it is also worth noting that some studies (see for example Roberts, Robert, and Chen, 2000; Roberts, Sul Lee, Hernandez, and Solari, 2004; Roberts, Roberts, & Chan, 2006; Fernando, Samaranayake, Blank, Roberts, & Arroll, 2013) show no agreement in associations between SES and race to sleep.

Furthermore, contrary to the above-reported findings, Felden et al. (2015) found that White adolescents from higher SES as measured by the level of family education were more likely to obtain inadequate sleep in comparison to other race groups. This is noteworthy because, in South Africa, race intersects with other characteristics such as socioeconomic status, sex, type of school, and whether the participants are boarders or day scholars. The implications for this, therefore, are that the South African labor market has been described as highly racialized with Black Africans earning the lowest wages, followed by Colored and Indians respectively with White people in South Africa earning the highest wages (Statistics South Africa, 2020). Despite policy changes implemented by the post-apartheid government, public schools are still racially segregated for many reasons. Many public schools are in township areas, which is the result of the historic residential segregation implemented by the apartheid regime and many lack important educational resources in comparison to private schools (Jansen and Amsterdam, 2006). This is of concern because, in light of what has been mentioned above, existing differences in socioeconomic status may also influence the sleep of adolescents from poorer backgrounds in the South African context. However, understanding the impact of these factors on sleep-wake behaviour is challenging given the complexity of the different interacting factors. While it is critical to acknowledge the impact of these factors, it is also critical to avoid trying to isolate their impact, given their intersecting nature. This is, however, beyond the scope of this thesis.

2.2.5 School-Related Factors

2.2.5.1 Grade level associations to sleep patterns

Research has shown that sleep patterns are related to student's grade levels. Sadeh et al. (2003) assessed the sleep patterns, sleep disruptions, and sleepiness of 140 4th and 6th graders and found that the 6th graders sleep later and are more likely to report daytime sleepiness relative to the 4th

graders (Sadeh et al., 2003). As already mentioned, advancements in a grade level are known to bring earlier waketimes (Yang et al., 2005; Ghanizadeh et al., 2008). However, learners typically do not go to bed earlier to compensate for this. Yang et al. (2005) for example administered a Sleep Habits Survey to 1457 Korean students in Grades 5 to 12 (mean age: 13.7 years) and found that students in the higher grade levels had later bedtimes both during the week and on weekends (Yang et al., 2005). Several other studies have reported later habitual sleep times with grades (Shinkoda et al., 2000; Van den Bulck, 2004; Ghanizadeh et al., 2008). When combined with early starts, this then leads to reduced total sleep time.

Gau and Soong (1995) surveyed 930 adolescents from Taipei and found that those students in higher grades reported reductions in sleep duration. This decrease in sleep duration has also been reported by several other studies (Carskadon et al., 1998a; Shinkoda et al., 2000; Yang et al., 2005; Ghanizadeh et al., 2008; Huang et al., 2010; Owens et al., 2010). Yang et al. (2005) reported very short sleep durations among Korean adolescents, namely 6.02, 5.62, and 4.86 hours for 10th-, 11th, and 12th-graders, respectively. Fredriksen et al. (2004) investigated how sleep patterns influence depressive symptoms, self-esteem, and the academic performance of 2,259 students. Sleep duration was found to have decreased over time. Sixth graders who had lesser sleep durations, also had less self-esteem, higher depressive symptoms, and poorer academic performance (Fredriksen et al., 2004).

Adolescents in higher grades often experience greater discrepancies in their bedtimes and waketimes during school nights and weekends (Shinkoda et al., 2000; Yang et al., 2005). Older adolescents, such as 9th -10th graders may be getting more sleep on the weekends because they are trying to make up for the chronic sleep debt that is accumulated during the week (Yang et al., 2005). Additionally, advancements in grade are associated with increased daytime sleepiness (Gau and Soong,1995; Shinkoda et al., 2000; Yang et al., 2005; Huang et al., 2010) and the frequency of nocturnal awakenings (Yang et al., 2005; Ghanizadeh et al., 2008).

2.2.5.2 School start times and their impact on sleep

In addition to the changes in sleep associated with changes in grade i.e. ageing, the impact of school start times on adolescent sleep cannot be ignored. In most countries, as is in South Africa, school start times are between 7:00 to 8:30 a.m. which means adolescents have to wake up at around 6:00

a.m. to 7:30 a.m. to get to school (Gradisar, Gardner, and Dohnt, 2011). This means, that if an adolescent wants to get an average sleep duration of 9 hours and wake up at approximately 7:30 am, they must sleep before 10:30 pm (Gradisar *et al*., 2011). This, however, may be impractical (Wahlstrom, 2002, Carskadon *et al*., 2004). This is due to factors mentioned above, including the natural circadian phase delay and slow rise in homeostatic pressure, which would make the onset of sleep at this time challenging as well as the other elements already mentioned. However, based on a review and meta-analysis conducted by Gradisar et al. (2011), on average, adolescents go to bed between 8:46 pm to 12:54 am, depending on their age.

It is well established that early school start times are in direct opposition to the phase delay tendency experienced by adolescents (Carskadon *et al*., 1998a; Reid *et al*., 2002; Wahlstrom, 2002; Wolfson *et al*., 2007; Owens *et al*., 2010; Minges and Redeker, 2016; Wheaton, Chapman, and Croft, 2016; Bowers and Moyer, 2017). During school days, sleep time is mainly determined by early school start times and in some instances, parental control over bedtime (Laberge *et al*., 2001). Commonly, in many countries, school tends to begin earlier for adolescents than for younger children and it gets earlier with higher grades (Crowley et al., 2007; Wolfson et al., 2007).

Overall, according to the literature, when school start times are very early, adolescents are required to have impractical bedtimes, and this, therefore, causes insufficient sleep duration (Allen, 1992; Carskadon et al., 1998a; Owens et al., 2010; Wolfson et al., 2007; Wahlstrom, Frederickson, and Wrobel, 1997). This then also results in reduced alertness, increased sleepiness, and possibly poor academic performance (Cortesi, Giannotti, Mezzalira, Bruni, and Ottaviano, 1997b; Wahlstrom et al., 1997; Wahlstrom, 2002; Wolfson and Carskadon, 2003). Additionally, some adolescents may reportedly miss school or become more prone to tardy behavior and inattention during class time (Carskadon, 1990a; Wolfson and Carskadon, 1998; Wahlstrom, 2002; Wolfson and Carskadon, 2003). Furthermore, they may also experience difficulties in learning and consolidating memories. This is in addition to other possible negative outcomes such as sleepiness, mental health problems, and immune system challenges (Crowley et al., 2018).

2.2.5.3 Academic pressures or stress

In addition to the early school start times, adolescents have various academic-related activities such as tutorials (sometimes occurring in the evening or at night), homework, tests, and

examinations, all of which are significant contributors to stress which may, in addition to the above-mentioned factors, impinge on sleep time (Gau and Soong, 1995; Yang *et al*., 2005; Suldo, Shaunessy, Thalji, Michalowski, and Shaffer, 2009; Noronha, 2016). Some major concerns for adolescents are academic performance, (Gau and Soong, 1995; Hui, 2001; Huan, See, Ang, and Har,2008), and gaining admission into a university (Yang *et al*., 2005). In addition to this, if they want to be an all-around achiever or have the opportunities available to them there are other activities such as music or cultural lessons, or sport to name a few that may be appealing to adolescents (Noronha, 2016). Parents or society tends to play a role by placing pressure on their children to excel in academics to qualify for well-paid professions (Smith, 2001; Yang et al., 2005; Ang and Huan, 2006). School systems are not without fault and have been recognized as giving students a lot of schoolwork (Noronha, 2016). To substantiate this, some students have reported late bedtimes (after 11 p.m.) as a result of excessive homework and examination preparations (Gau and Soong, 1995). Other school-related concerns worth considering for student well-being are the relationships between teachers and students, inadequate school facilities, overcrowding in the classroom, examinations, and perhaps long commuting times all of which may negatively impact sleep (Noronha, 2016).

2.3 The Perfect Storm: insufficient and ill-timed sleep

It is clear that various systemic factors affect adolescent sleep, which has been eloquently captured in the "Perfect Storm of insufficient and inappropriately-timed sleep" (Crowley et al., 2018). Carskadon (2011a) was the first to propose this model. As seen in Figure 2, this model describes how sleep changes from appropriately timed and of sufficient length in pre-adolescence to delayed and insufficient in adolescence. As initially explained, there are bioregulatory and psychosocial pressures that contribute to later bedtimes, while waketimes become earlier with increasing age and grades as a result of school start times (Yang et al., 2005) therefore resulting in shorter sleep duration across adolescence (Carskadon, 2011a).

More recently, Crowley et al. (2018) expanded upon and refined the model. According to this model, in maturing adolescents, evening alertness is sustained later into the night by bioregulatory pressures while simultaneously, psychosocial pressures such as parental control over bedtimes are decreased, academic obligations increase and social life activities are increased (Crowley et al., 2018). Potentially stimulating activities or those that produce additional light stimuli such as social

media usage or playing games can reinforce evening alertness and encourage late sleep times as adolescents mature (Crowley et al., 2018). Furthermore, it seems school start times continue to be the major contributing factor to poor adolescent sleep patterns (Crowley et al., 2018; Figure 3) Unfortunately, this ill-timed and insufficient sleep experienced during adolescents has implications for them, these will be discussed below.

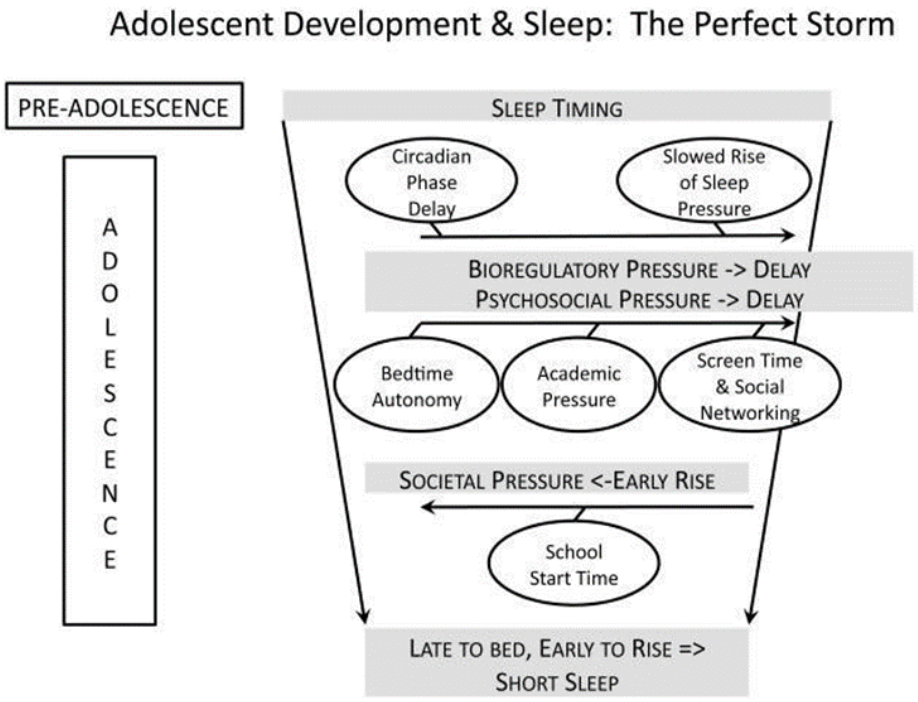


Figure 2. The bioregulatory, psychosocial, societal pressures that influence sleep timing from pre-adolescence to adolescence development (image taken from Carskadon, 2011a).

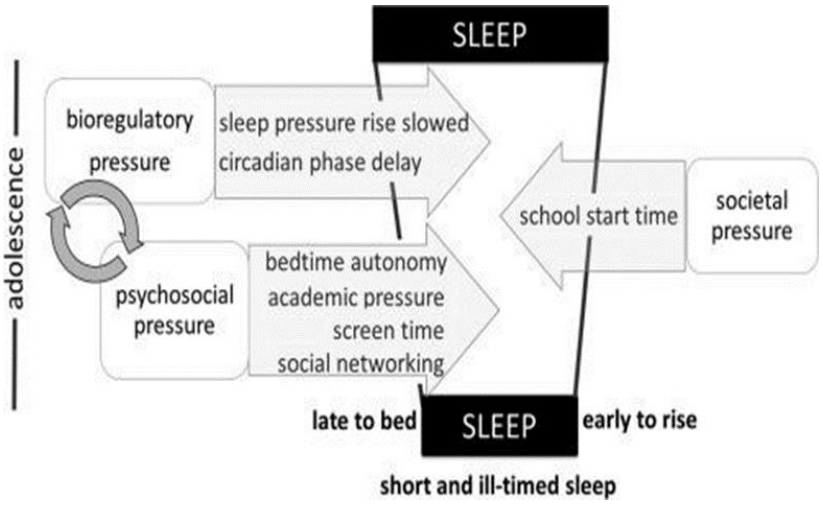


Figure 3. The Perfect Storm of insufficient and inappropriately timed sleep model (taken from Crowley *et al*., 2018).

2.3.1 Implications of ill-timed and insufficient sleep

2.3.1.1 Daytime sleepiness/ decreased daytime alertness

The most obvious and direct consequence of insufficient sleep is daytime sleepiness (Carskadon, 1990a; Ferber, 1990; Yarcheski and Mahon, 1994; Dewald et al., 2010). Typically, sleep disturbances are reported to be more frequent in 16-19-year-olds than in younger adolescents (Crowley et al., 2007). This pattern has been demonstrated by studies conducted in Canada (Laberge et al., 2001), Poland (Szymczak, Jasińska, Pawlak, and Zwierzykowska, 1993), Belgium (Van den Bulck, 2004), Australia (Henschel and Lack, 1987), Finland (Saarenpää-heikkilä et al., 1995), and Brazil (Andrade et al., 1993), which have shown increased frequency in sleep disturbances and that adolescents go to bed later as they get older. Anders et al. (1978) used the sleep habits questionnaire (SHQ) to survey 218 children, ages 10-13 years, and found that total night-time sleep on school nights begins to fall in early adolescence and that daytime sleepiness is not common in this age group although it increases linearly along with age (see also: Mary et al., 1980; Saarenpää-Heikkilä et al., 2000). The authors, therefore, concluded that chronic sleep deficits begin in early adolescence and this can have cumulative effects on their daytime alertness (Anders et al., 1978). Likewise, Campbell et al. (2007) report an increase in sleepiness with age across 3 years in adolescents. Other more contemporary studies have also reported frequent daytime sleepiness with increases in age (Giannotti et al., 2002; Meyer, Ferrari, Junior, Andrade, Pelegrini, and Felden, 2017; Liu et al., 2019).

It appears that adolescents experience a marked reduction in sleeping time and this may cause cumulative sleep debt, which refers to the deficit in sleep that occurs and accumulates due to getting less sleep than recommended (Van Dongen, Maislin, Mullington, and Dinges, 2003). Sleep debt can result in adolescent daytime sleepiness (Mary et al., 1980; Carskadon, Harvey, and Dement, 1981; Carskadon, Rosekind, Galli, Sohn, Herman, and Davis, 1989; Babkoff, Caspy, and Mikulincer, 1991; Gau and Soong, 1995; Dinges, Pack, Williams, Gillen, Powell, and Ott, 1997; Wolfson and Carskadon, 1998; Fallone, Owens, and Deane, 2002; Gibson, Powles, Thabane, O'Brien, Sirriani Molnar, and Trajanovic, et al., 2006; Chung and Cheung, 2008) and a host of other negative outcomes. Smaldone, Honig, and Byrne (2007) reported similar findings among adolescents in the USA. Research has shown that 5 hours of sleep can cause functional impairment in neurobehavioral performance (such as cognition and motor coordination) and that this impairment is cumulative over time (Dinges et al., 1997; Smaldone et al., 2007). Insufficient sleep can therefore also have negative implications for adolescent developmental processes, psychosocial function, levels of vitality and neurocognitive ability, and general performance and behaviour at school (Carskadon et al., 1998a; Wolfson and Carskadon, 1998; Laberge et al., 2001; Liu and Zhou, 2002).

2.3.1.2 School refusal syndrome' (SRS)

Adolescents tend to stay up later and experience some difficulties getting out of bed even if they may desire to wake up (Lee *et al*., 1999; Yang *et al*., 2005). For example, 5118 (83%) students reported that it took them up to 10 min to get out of bed on weekdays (Lee *et al*., 1999). Ferber (1990) termed this the 'motivated sleep phase delay'. The problem seems to self-correct, however, when learners do not have to attend school (Lee *et al*., 1999; Yang *et al*., 2005). This pattern has been termed 'school refusal syndrome' (SRS) (Ferber, 1990; Reid *et al*., 2002). The U.S. National Sleep Foundation conducted a telephone poll and found that approximately 70% of middle school and high school learners are woken up by adults on school mornings and this is because, as they get older, children are less likely to be able to wake spontaneously and to have early bedtimes (Anders *et al*., 1978; National Sleep Foundation, 2006).

2.3.1.3 Effects on school-related activities

Left unchecked, sleep debt that results from insufficient sleep during the week may have negative

implications for academic performance (Giannotti *et al*., 1997; Wolfson and Carskadon, 1998; Den Wittenboer, 2000; Carskadon, 2011b). In addition to short sleep durations, irregular sleep-wake schedules, late bed and early wake times, poor sleep quality as well as daytime sleepiness, also have negative associations with academic performance (Sadeh *et al*., 2003; Wolfson and Carskadon, 2003; Fallone, Acebo, Seifer, and Carskadon, 2005; Curcio, Ferrara, and De Gennaro, 2006; Gibson *et al*., 2006; National Sleep Foundation, 2006; Gradisar, Terrill, Johnston, and Douglas, 2008; Dewald *et al*., 2010).

While performance throughout the day is influenced by sleep-related brain processes (Dewald *et al*., 2010), short or disrupted sleep results in reduced brain activity which is necessary for neurocognitive functioning and this possibly explains the association between sleep and cognitive performance (Dewald *et al*., 2010; Brand and Kirov, 2011). Sleep-related problems have negative implications for the achievement of complex tasks, which would require abstract thinking, creativity, integration, and planning (Dahl, 1996; Giedd, 2015). Complex tasks involve the prefrontal cortex, which is sensitive to sleep loss (Beebe, 2011; Giedd, 2015). Insufficient sleep may, therefore, be responsible for impairing the functioning of the prefrontal cortex and therefore the ability to learn, and consequently, this may affect academic performance (Dewald *et al*., 2010).

It is however worth noting that the association between sleep and academic performance is also mediated and moderated by many other factors such as learner coping strategies, subjective teacher marking strategies, class schedules, academic workloads all of which make it a challenge to make comparisons across different types of schools (Wolfson and Carskadon, 1998). Sleepiness and insufficient sleep has not only been associated with impaired functioning but also school absenteeism (Meijer, Reitz, Deković, Van Den Wittenboer, and Stoel, 2010); attention problems, memory problems, and reduced concentration levels (Carskadon and Dement, 1987; Epstein, Chillag, and Lavie, 1995; Giannotti *et al*., 1997; Katz and McHorney, 2002; Le´ger *et al*., 2001; Le´ger *et al*., 2006; Roth *et al*., 2006).

2.3.1.4 Weekend Oversleep and 'social jetlag'

As mentioned, older adolescents tend to have later bed and wake times during the weekends (Anders et al., 1978; Giannotti et al., 2002; Crowley et al., 2007; Gradisar et al., 2011). Russo et al. (2007) administered the School Sleep Habits Survey to 1073 students in Italy and reported that

as age increased, there was a linear increase in the difference in sleep duration between school days and weekends. Similarly, Laberge et al. (2001) found that students in higher pubertal stages, wake up later during weekends and that they also have greater differences between their school day and weekend waketime in comparison to those in lower pubertal stages. This has been called the weekend bedtime delay (Crowley et al., 2007). Other studies have also reported this weekend bedtime delay (Anders et al. 1978; Bearpark and Michie 1987; Strauch and Meier, objec1988; Gau and Soong., 2003; Yang et al., 2005; Gamble et al., 2014; Paiva et al., 2015). Studies generally report up to two hours more sleep on weekend nights when compared to the weekdays and this has been reported in Poland (Szymczak et al., 1993); Finland (Saarenpää-heikkilä et al., 1995); Italy (Giannotti et al., 1997); Taiwan (Huang et al., 2010); China (Cheung et al., 1999; Gau and Soong., 2003) and North America (Wolfson and Carskadon, 1998). This irregularity in sleep occurs partly due to societal determinations of waketimes, such as school start times, which, for adolescents, interfere with individual sleep preferences (Carskadon et al., 2004; Wittmann, Dinich, Merrow, and Roenneberg, 2006; Malone, Zemel, Compher, Souders, Chittams, Thompson, and Lipman, 2016).

This results in a shifting of sleep-wake behaviour on weekends because of the week's activities which, in turn, means that when Monday comes, there is a shift again - this has been referred to as a 'social jetlag' (Roenneberg et al., 2004; Wittmann et al., 2006; Touitou, 2013). Evening types especially are more affected by social jetlag because society demands that they wake up early, without being able to initiate sleep at earlier times (Wittmann et al., 2006; Touitou, 2013). This is worrisome since evening type adolescents are known to experience more sleep problems and daytime sleepiness (Touitou, 2013). Furthermore, social jetlag has been linked to the consumption of caffeinated sodas and potentially higher scores of depressed moods (Wittmann et al., 2006).

2.3.1.5 Effects on mental health

In general, insufficient sleep in adolescents has been linked to poor mental health (Gau, Kessler, Tseng, Wu, Chiu, Yeh, and Hwu, 2007; Lee, Cho, Cho, and Kim, 2012; Zhang, Paksarian, Lamers, Hickie, He, and Merikangas, 2017). Poor quality and insufficient sleep disrupt the natural circadian rhythm and, in this way, impacts mental health negatively (Van Reeth, Weibel, Spiegel, Leproult, Dugovic, and Maccari, 2000). In the event of sleep restriction, mood can be altered due to the brain restricting the release of neurotransmitters (serotonin and norepinephrine) (Hill *et al.*, 2009; Moore

et al., 2011; Zhang *et al*., 2017). Insufficient sleep has also been linked specifically to depressed mood, anxiety, and attention-deficit/hyperactivity disorder (Wolfson and Carskadon, 1998; Dahl and Lewin, 2002; Gau *et al*., 2007; Walker and Harvey, 2010). In fact, some researchers have proposed that a bidirectional causal pathway may exist between depression and sleep loss (Dahl and Lewin, 2002; Lovato, Short, Micic, Hiller, and Gradisar, 2017). Sleeping for 6 hours or less has been linked not only to depressive symptoms (O'Brien and Mindell, 2005; Lofthouse, Gilchrist, Splaingard, 2009), but also to lower self-esteem, stress, and suicide ideation in adolescents (Fredriksen *et al*., 2004; Liu and Buysse, 2006; Chorney, Detweiler, Morris, and Kuhn, 2007; Fitzgerald, Messias, and Buysse, 2011; Lee *et al*., 2012; Lee Kang, Rhie, and Chae, 2013). In Finland, Merikanto Lahti, Puusniekka, and Partonen, (2013) showed that late bedtimes, especially those past 11:30 p.m. increase the prevalence of depression, irritable mood, headaches, and tiredness.

2.4 Tracking sleep in adolescents

There have been multiple measures developed for the assessment and analysis of sleep depending on the various aspects of sleep under study. This section will briefly highlight some of the key measures relevant to this study.

2.4.1 Polysomnography

Polysomnography (PSG) is the study of sleep through laboratory or ambulatory monitoring (Sadeh, 2015). Polysomnography studies usually occur in sleep laboratories over one or more nights with electrodes and sensors attached before bedtime and throughout the night for data collection (Sadeh, 2015). Electrodes and sensors are used to measure physiologic parameters of sleep, along with eye movements, muscle activity, heart physiology, respiratory function, and the brain dynamics of electroencephalography (EEG) (Marino, Li, Rueschman, Winkelman, Ellenbogen, Solet...and Buxton, 2013). Polysomnography is also used to assess daytime sleepiness through the multiple sleep onset latency test (Dement and Carskadon, 1982). This is accomplished by giving participants opportunities to fall asleep at certain times and then measuring sleep onset latency with the expectation that sleepy participants will fall asleep faster (Carskadon *et al*, 1998a; Sadeh, 2015). The MSLT has been used in various studies especially among adolescents and adults (Carskadon *et al*, 1998a). While polysomnography provides very detailed and objective

information about sleep and is crucial for the diagnosis of sleep disorders, it requires participants to sleep under unnatural conditions and it is quite expensive, and as such, is usually limited to 1-2 days (Sadeh, 2015).

2.4.2 Sleep surveys/questionnaires

Sleep surveys/questionnaires offer an inexpensive means of obtaining sleep data. There are several available sleep surveys/questionnaires. The School Sleep Habits Survey (SSHS) for example, was developed in 1994 by the Bradely Hospital/Brown University Sleep Research Lab (Sleep for Science Research Lab, n.d.). Other contributors to the SSHS are Kandel and Davies, (1982) as well as Carskadon, Seifer, and Acebo, (1991). The SSHS has been administered to a variety of study populations (Anders *et al*., 1978; Carskadon *et al*., 1993; Gau and Soong, 1995; Wolfson and Carskadon, 1998; Park, Matsumoto, Shinkoda, Nagashima, Kang and Seo, 2001; Carskadon and Acebo, 2002; Giannotti et al., 2002; Wolfson et al., 2003a; Yang et al., 2005; Russo et al., 2007; Owens et al., 2010; Shochat et al., 2010; Arora et al., 2014).

Other surveys that have been used among children and adolescent population include the Pediatric Sleep Questionnaire (Spruyt, Cluydts, and Verleye, 2004); Sleep Quality Scale (Abdel-Khalek, 2008); Daytime Functioning Scale (Abdel-Khalek, 2008); and the Sleep questionnaire for adolescents (Giannotti *et al*., 2002). However, survey reports do not always yield accurate responses regarding adolescent behaviors. Participants have been found to report shorter sleep durations than their actual sleep duration and longer sleep onset latencies than their actual sleep onset latencies in comparison to polysomnographic studies when using surveys (Wolfson *et al*., 2003a). Self-reports also have the added disadvantage of participants being more likely to report their most recent instead of their usual behaviors and giving responses that are socially desirable (Sadeh, Sharkey, and Carskadon, 1994). It is also worth noting that preconceived ideas held by the researcher administering the survey may have some influence on participant responses (Wolfson *et al*., 2003a). As daily sleep diaries offer participants the opportunity to quantify sleep-related measures daily, they are generally considered more reliable than one-time surveys and more correlated with polysomnographic recordings (Wolfson *et al*., 2003a).

2.4.3 Sleep Diaries

A sleep diary is a self-reported record of sleep habits over a period (Carney, Buysse, Ancoli-Israel, Edinger, Krystal, Lichstein, and Morin, 2012; Sadeh, 2015). Sleep diaries are used to record various sleep variables such as bed and wake times, total sleep time, and the number of nocturnal awakenings (Carney *et al*., 2012; Mallinson, Kamenetsky, Hagen, and Peppard, 2019). The Consensus Sleep-Wake Diary, for example, was developed by a group of insomnia experts with input from individuals with and without sleep disorders and with rigorous methodology (Carney *et al*., 2012). Sleep diaries have the added benefit of being completed at home as soon as the participant wakes up, thus potentially improving data quality since there is no need to recall events that have occurred some time ago (Sadeh, 2015). Self-reports from sleep diaries and sleep questionnaires have been found to be a reliable source of information among high school learners (Gaina, Sekine, Chen, Hamanishi, and Kagamimori, 2004). Sleep diaries are also often used to control the quality of the data derived from actigraphs and to assist in data analysis (Sadeh, 2015). Like other self-report data, sleep diary entries are also subject to response biases, participants may not comply and remember to fill in the diary at stipulated times daily (Thurman, Wasylyshyn, Roy, Lieberman, Garcia, Asturias, and Mednick, 2018). Sleep diaries also pose a burden on the participants, in that they must be filled for certain periods. Furthermore, the nature of questions may be simple, but it may prompt inaccurate answers as questions don't usually ask for exact times and so participants may round off their sleep duration estimations (Mallinson et al., 2019).

2.4.4 Actigraphy

Actigraphy makes use of small, lightweight, and unobtrusive devices that can collect information about time-based physical activity (as based on accelerations) (Acebo et al., 1999; Sadeh, 2015). Actigraphy employs the use of validated algorithms for the transformation of information about activities to sleep-wake estimates (Acebo et al., 1999; Marino et al., 2013). Essentially, actigraphs continuously measure periods of wakefulness and those of sleep through detecting motions, specifically through acceleration sensors that detect and convert a physical motion to numeric data, which is sampled frequently and aggregated at constant intervals (Sadeh, Hauri, Kripke, and Lavie, 1995). This information is then stored in the internal memory of the actigraph until it is downloaded into software for analysis (Sadeh et al., 1995). They are therefore able to mark bed and wake times

as well as to measure variables that may be used to describe sleep quality if the participant remembers to push the marker button (Sadeh, 2015). Actigraphs are useful in recording sleep parameters such as total time in bed, average sleep duration, sleep efficiency, sleep percentage, wake after sleep onset (WASO), and sleep onset latency (Martin and Hakim, 2011).

Studies have demonstrated that actigraph data often reaches over 90% of agreement levels with PSG sleep periods (Sadeh, Alster, Urbach, and Lavie, 1989; Cole, Kripke, Gruen, Mullaney, and Gillin, 1992; Sadeh *et al*., 1994). Comparisons between actigraphy and polysomnographic recordings usually over 5 to 7 nights yield agreement rates ranging between 78% to 90% (Kripke, Mullaney, Messin, and Wyborney, 1978; Mullaney, Kripke, and Messin, 1980; Sadeh *et al*., 1989; Cole *et al*., 1992; Sadeh *et al*., 1994). Actigraphy has been used in infants, children, and adolescents (Sadeh *et al*., 2003; Tikotzky and Sadeh, 2001, 2009; Wolfson *et al*., 2003a; Acebo, Sadeh, Seifer, Tzischinsky, Hafer, and Carskadon, 2005; Meltzer, Montgomery-Downs, Insana, and Walsh, 2012). Furthermore, actigraphy can be used to assess sleep during naturalistic studies of sleep deprivation (Fallone *et al*., 2002; Sadeh *et al*., 2003). For the most part, actigraphy has the advantage of collecting data continuously with little inconvenience to the participant as they go about their daily lives (Sadeh et al., 1995; Sadeh, 2015). On the other hand, actigraphy is not without limitations, as the method may fail to discriminate spurious motor activity counts that occur as a result of external motion such as sleeping in a car or periods of wakefulness not associated with any movements (Sadeh, 2015).

2.5 Summary and study rationale

While there has been extensive research in other contexts demonstrating that adolescents have challenges with sleep for many systemic reasons, there has been comparatively little in South African adolescents who may experience similar challenges to other adolescent groups, but also unique context-specific ones. Despite the serious implications that insufficient sleep may have on adolescent well-being and functioning, there is comparatively little being done in the way of investigating the sleep-wake behavior of adolescents in the South African context. Therefore, this study aimed to characterise the sleep-wake behaviour of a sample of late adolescents from public and private schools in Makhanda in the Eastern Cape of South Africa.

CHAPTER III

METHODS

This study was comprised of two distinct Phases. The aim of Phase one was to analyze and describe the sleep-wake habits or patterns of a sample of Grade 12 adolescents from local private and public high schools based on self-reported data from the School Sleep Habits Survey (SSHS). The aim of Phase two was to characterize sleep-wake behavior in a sample of Grade 11 female boarders using actigraphy and sleep diaries.

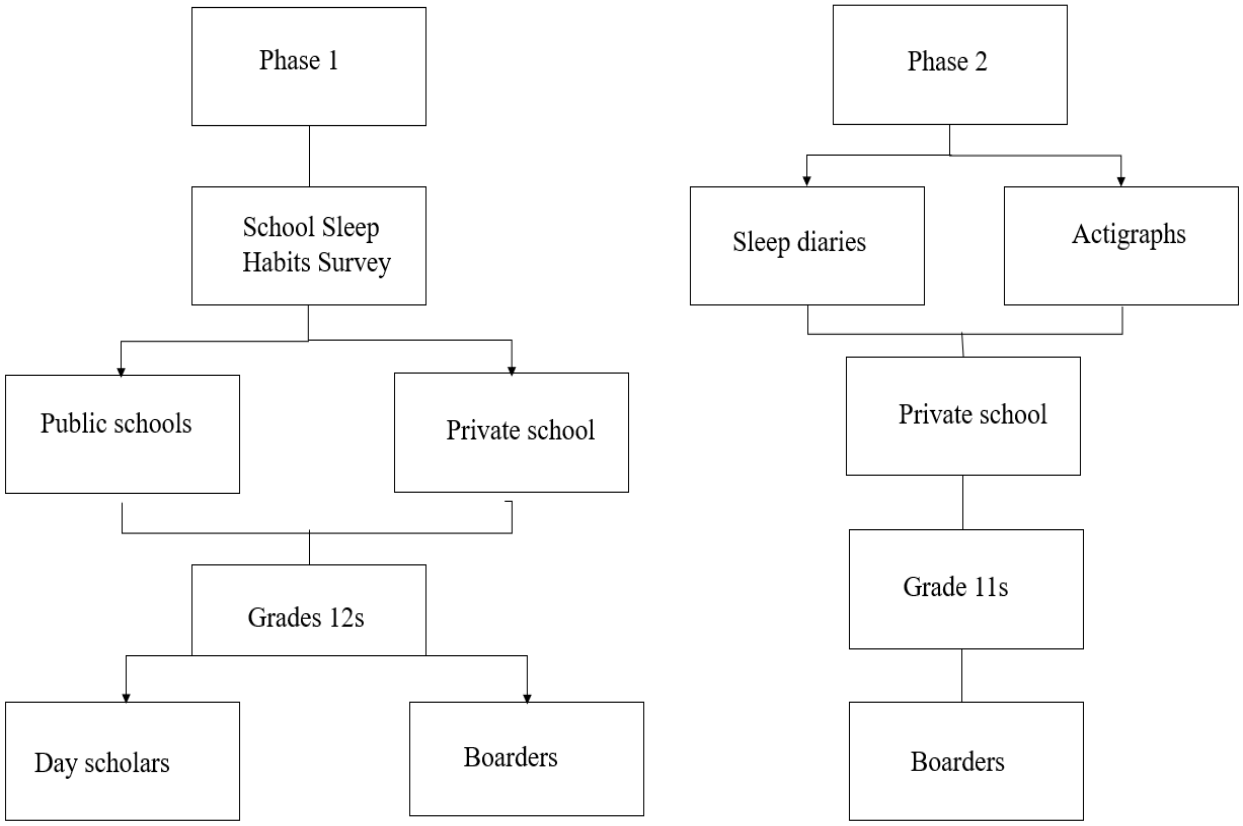


Figure 4. A schematic representation of Phases one and two of the study

3.1 Phase One

3.1.1 Study Design

Phase one adopted a cross-sectional design to characterise Grade 12 learners' (final year students) sleep-wake behaviour across various public and private schools. Some of the schools sampled in this study had boarding facilities and consisted of both day scholars and boarders. Data collection took place at various times during the year when there were no scheduled examinations, which may have interfered with the normal sleep-wake habits of the learners.

3.1.1.1 Study setting

All schools sampled were situated in Makhanda (Grahamstown), a town in the Eastern Cape, South Africa. Three of the schools sampled were private/independent schools, and another two were public schools. One school was a girls' only school, two schools were boys' schools and two others were co-educational schools. All of the schools sampled had boarding facilities, three of which were primarily boarding schools. The schools had between 200 and 700 learners.

3.1.2 Measures

3.1.2.1 School Sleep Habits Survey

A School Sleep Habits Survey (SSHS) (Wolfson and Carskadon, 1998) was chosen and administered to high school Grade 12 students in public and private schools. The SHSS was developed in 1994 by the Bradely Hospital/Brown University Sleep Research Lab (Sleep for Science Research Lab, n.d.) and it has been administered in a variety of adolescent study populations (see for example Carskadon and Acebo, 2002; Anders et al., 1978; Arora et al., 2014; Gau and Soong, 1995; Shochat et al., 2010; Giannotti et al., 2002; Owens et al., 2010; Russo et al., 2007; Short et al., 2013b; Wolfson and Carskadon, 1998; Wolfson et al., 2003a; Yang et al., 2005). The survey included questions that capture demographic information, including age, sex, height, mass, grade, ethnicity, school performance, sleep duration, sleep-wake timing, and sleep onset latencies at different times of the week. It also included questions about other sleep variables, such as nocturnal awakenings, frequency of daytime napping, and self-perceptions of sleep quantity, quality, and sleepiness problems. And it also incorporated scales to assess daytime sleepiness, sleep-wake behavior problems, depressive mood, and chronotype (Kandel and Davies, 1982; Wolfson and Carskadon, 1998; Crowley et al., 2007). Furthermore, it captured information related to lifestyle habits such as sports participation, caffeine consumption, and the use of electrical

devices before bedtime. The administration of the survey was either in hard copy or in soft copy. For the soft copy, the survey was accessed through the google forms platform. Please refer to Appendix A for the original versions of the survey.

3.1.2.2 Amendments to SSHQ to suit the South African context

Prior to the start of the data collection, some questions had to be amended to ensure that the survey was appropriate for the South African context, mainly to ensure that the learners could understand the questions. These are outlined below, in Table 2, in a sequential manner.

Table 2. An overview of original and amended questions from the school sleep habits survey.

Question from the Original Sleep Habits Survey (refer to Appendix A for the original version of the survey)	**Amended Question (**refer to Appendix B for the modified version of the survey)	**Reason for modification**
5.What is your height? feet inches.	Height (cm/m):	Centimetres and meters (cm/m) are the most used and understood units of measurement for height in South Africa.
6. What is your weight? Pounds.	Weight (kg):	Kilograms (kg) are the most used and understood units of measurement for height in South Africa.
9.What best describes your racial/ethnicbackground? ● White/Caucasian ● Black/African American ● Hispanic/Latino ● Asian/ Asian American ● Native American/ Amerindian ● Multiracial ● Other:	Racial/Ethnic background: ● White ● Black/African ● Colored ● Indian ● Other	This is per the Department of Home Affairs Classification for ethnicity in SouthAfrica.
11. Who lives in your home other thanyou: ● Mother/ Stepmother ● Father/ Stepfather ● Older brother(s)/sister(s) ● Younger brother(s)/sister(s) ● Other family members(s)	Who lives in your home other than you: ● Mother/ Stepmother ● Father/ Stepfather ● Sibling(s) ● Other family members(s) ● Hostel/Boarding	Several schools in the Makhanda area have boarding facilities so, for some students, home is a hostel/boarding school.

	school	
12. Does your mother work outside of thehome?	Does your mother/guardian work outsideof the home?	Approximately 20% of the children in South Africa do not live with their biological parents (Statistics South Africa,2018).
14. Are your grades in school mostly: ● As ● As and Bs ● Bs ● Bs and Cs ● Cs ● Cs and Ds ● Ds ● Ds and Fs	Are your grades in school mostly: ● 80-100% ● 70-79.9% ● 60-69.9% ● 50-59.9% ● 40-49.9% ● 30-39.9% ● 0-29.9%	As per the academic grading system utilized in high schools in High Africa (Department of Basic Education Republicof South Africa., 2012).
19. Do you take Ritalin or some other medication to help with concentration or a learning problem?	Do you take Ritalin/Concerta or some other medication to help with concentration or a learning problem?	Much like Ritalin, Concerta is also commonly used in South Africa for the same indication (Truter and Kotze, 2005;Snyman and Truter, 2012).
23. There are many reasons for doing things at one time or another. What is the **main reason** you usually go to bed at this time on school days? (mark one) 31. There are many reasons for doing things at one time or another. What is the **main reason** you usually go to bed at thistime on weekends? (choose one) ● My parents have set my bedtime ● I feel sleepy ● I finish my homework ● My TV shows are over ● My brother(s) or sister(s) go to bed ● I finish socializing ● I get home from my job ● Other:	There are many reasons for doing things at one time or another. What is the **main reason** you usually go to bed at this time on school days? (mark one) There are many reasons for doing things at one time or another. What is the **main reason** you usually go to bed at this time on weekends? (mark one) ● My parents have set my bedtime ● I feel sleepy ● I finish my homework ● My TV shows are over ● My brother(s) or sister(s) go tobed ● I finish socializing	The sample also included participants attending boarding school.

	• I get home from my job	
23. There are many reasons for doing things at one time or another. What is the **main reason** you usually go to bed at this time on school days? (mark one) 32. There are many reasons for doing things at one time or another. What is the **main reason** you usually go to bed at thistime on weekends? (choose one) • My parents have set my bedtime • I feel sleepy • I finish my homework • My TV shows are over • My brother(s) or sister(s) go to bed • I finish socializing • I get home from my job • Other:	There are many reasons for doing things at one time or another. What is the **main reason** you usually go to bed at this time on school days? (mark one) There are many reasons for doing things at one time or another. What is the **main reason** you usually go to bed at this time on weekends? (mark one) • My parents have set my bedtime • I feel sleepy • I finish my homework • My TV shows are over • My brother(s) or sister(s) go tobed • I finish socializing • I get home from my job • Lights out at hostel/boarding school • Other:	The sample also included participants attending boarding school.

25. What is the **main reason** you usually wake up at this time on school days? (choose one) 33. What is the **main reason** you usually wake up at this time on weekends? (chooseone) ● Noises or my pet wakes me up ● My alarm clock wakes me up ● My parents or other family members wake me up ● I need to go to the bathroom ● I don't know, I just wake up ● Other	What is the **main reason** you usuallywake up at this time on school days? (mark one) 30. What is the **main reason** you usually wake up at this time on weekends? (markone) ● Noises or my pet wakes me up ● My alarm clock wakes me up ● My parents or other family members wake me up ● I need to go to the bathroom ● I don't know, I just wake up ● ***The bell in hostel/boarding school*** ● Other:	The sample also included participants attending boarding school.
27. How do you usually get to school? ● Walk ● Take the bus ● Get a ride with a parent ● Get a ride with friend(s) ● Drive my car	How do you usually get to school? ● Walk ● Get a ride with friend(s) ● Take the school bus ● Ride my bicycle ● ***Take a taxi*** ● Get a ride with a parent/familymember	Public taxis are a common means of transport among South African learners (Statistics South Africa, 2018)

3.1.3 Ethical considerations

The research protocol was approved by the Ethics Review Committee of Rhodes University (Clearance number 2019-0168-461, see Appendix C). Permission to approach public high schools

in Grahamstown/Makhanda was also sought and granted by the Department of Education in the Eastern Cape (see Appendix D for Ethical Clearance from the Department of Education). School Principals and other relevant stakeholders also granted permission to approach Grade 12 adolescents in their respective schools. Provisions were made to protect participant's rights to privacy and anonymity and to preserve confidentiality - the anonymity of participants was protected as the surveys did not require any personal information and as such no personal information was stored.

3.1.4 Participant recruitment and characteristics

3.1.4.1 Approaching schools and participant recruitment

Following ethical clearance, invitations for participation were sent out through emails to all the schools in Makhanda (see Appendix F). Based on schools that expressed interest, meetings were set up with school principals and/or other stakeholders in which further details such as the background to the study, the intended methods for data collection, and its importance were discussed.

Following these discussions and gatekeeper permission, parents/guardians were sent letters that entailed details of the study and requesting permission that their child participates in the study. At the end of the letter was a statement of consent for the parent (refer to Appendix E). Verbal and written information was also given to learners about the study in the respective schools at times deemed appropriate by the principals in their classrooms or during meetings scheduled for all Grade 12 learners. Verbal information to learners and letters included background information on the study, considerations for participation, possible benefits of participation, overall objectives, their rights around participation, the protocol for the collection of data, and a declaration statement if they chose to participate (refer to Appendices G and H, the letters were in English, isiXhosa, and Afrikaans). Participants were verbally informed and through letters that participation was voluntary and that they may withdraw from the study at any given point should they want to (refer to Appendices G and H for written and verbal information given to learners for Phase one). This was reiterated on the first page of the survey. All Grade 12 learners willing to participate were permitted to do so if they were pupils at the participating schools, had willingly provided assent and their parents had not requested that they do not fill in the survey. There were no exclusion criteria other than the fact that they needed to be in Grade 12 as it was decided that individual screening of minors who have volunteered to participate would be inappropriate and that this may

bring about feelings of discrimination.

3.1.5 Procedure

For Phase one, Grade 12 learners from five high schools were asked to complete the survey anonymously as a classroom exercise at times deemed appropriate by the schools. Depending on the arrangement with the school, surveys were either administered in hard copy or online through google forms. Hard copies were distributed on school premises and completed at designated classrooms with the help of school teachers. For those that opted for online administration, the school principal sent the link to the survey to all Grade 12s via email, and students were asked to bring in their smartphone devices to fill in the survey at designated times. Learners were given privacy when filling in the survey, while the researcher waited outside in case, they had any questions. Once learners had completed the hard copy surveys, they were collected by the researcher.

3.1.6 Data Processing

3.1.6.1 Data Reduction and Statistical Analysis

The data from the hard copies were captured manually into Microsoft Excel, while data from google forms were imported into Microsoft Excel. If a question was not answered, it was left blank. Body Mass Index (BMI) is an indicator of a person's total body fat and it was used to categorize people as being underweight, normal, overweight, or obese (Mandal, 2019). BMI was calculated by dividing weight in kilograms by height in meters squared i.e. mass (kg) / [height (m)]^2 (Rolland-Cachera, Cole, Sempe, Tichet, Rossignol, & Charraud, 1991; Mandal, 2019). Normal range scores fall between 18.5 and 24.9 and anything below that was considered underweight. If the BMI score was between 25 and 29.9, this was considered underweight and the score was above 30, it indicated obesity (Mandal, 2019). Following this, categorical data was coded/grouped into numerical values to allow for analysis. Self-reported hours and minutes were presented in the 12-hour format for analysis. Weekend Bedtime Delay (WBD) was calculated as the difference between weekday and weekend bedtime. Weekend Waketime Delay (WWD) was calculated as the difference between weekday and weekend waketime as per other studies in this area (e.g., Wolfson and Carskadon, 1998; O'Brien and Mindell, 2005; Mateo, Díaz-Morales, Barreno, Prieto, and Randler, 2012).

To obtain a total scale score from the Sleep-Wake Problems Behaviour Scale as described by

Wolfson and Carskadon, (1998), scores of 10 of the items on question 42 (refer to Appendix B) were numerically coded with 5 being every day/night and 1 being never (Wolfson and Carskadon, 1998; Owens *et al*., 2010; Wolfson *et al*., 2007). These were then added together. The sleep-wake-problems behaviours scale was scored from 10-40 and higher scores indicated more sleep-related problems (Giannotti *et al*., 2002; Wolfson *et al*., 2007; Wolfson and Carskadon, 1998; Yang *et al*., 2005).

To obtain a total scale score from the Sleepiness Scale, 10 of the items in question 40 (refer to Appendix B) were numerically coded from 1 to 4 and summed as described by Wolfson and Carskadon, (1998). Scores on the sleepiness scale ranged from 10 to 40 and increasing scores indicated more increased levels of sleepiness (Owens *et al*., 2010; Wolfson *et al*., 2007; Yang *et al*., 2005).

All the 6 items in question 43 (refer to Appendix B) were numerically coded from 1 to 3 and summed to obtain a total Depressive Mood Scale score as described by Wolfson and Carskadon, (1998). This scale was scored from 6-18 and higher scores were an indication of a more depressed mood (Wolfson et al., 2007; Yang et al., 2005).

To obtain a total scale score from the Morningness/Eveningness (M/E) Scale, used to assess the time of day that an individual prefers to engage in daily activities or that they feel allows them to function at their optimum levels. Items from questions 44-53 (refer to Appendix B) were numerically coded and added as described by Wolfson and Carskadon, (1998). The M/E scale was scored from 10-42 and higher scores indicated a greater preference for the morning (Yang et al., 2005).

Thereafter, descriptive statistics (the mean and standard deviation as well as medians and interquartile ranges) were calculated for sleep and other variables. Following this, inferential statistics were performed using Statistica (Statsoft, Inc.; Tulsa, OK74104, USA). First, the data set was tested for normality using the Shapiro-Wilk test for normality. Results indicated that the data did not follow a normal distribution. Thus, analyses were performed using nonparametric statistical tests. To test the difference between weekday and weekend bedtimes, waketimes, sleep onset latencies, and durations, the Wilcoxon matched-pairs signed rank test was used (Refer to Table 3).

For the comparison of independent groups such as sex, day scholars compared to boarders and public compared to private school learners for all sleep variables on the weekday and weekend the Mann- Whitney U test was used (Refer to Table 4). To measure the association between ordinal variables, the Kendall Tau-b correlation coefficient was used (Refer to Table 5). Furthermore, to test the relationships between categorical variables such as sex and school type (public vs. private school), the Chi-Square test was used (Refer to Table 6). Tables 3 to 6 below summarise the tests used for statistical analysis and relevant variables for Phase one. Significance was set at $p < 0.05$.

Table 3. Variable pairs were compared using a Wilcoxon matched-pairs signed rank test. Significance was set at $p < 0.05$.

Test	Pair of Variables
Wilcoxon matched-pairs signed rank test	Weekday and Weekend sleep variables

Table 4. A summary of the statistical tests applied to compare mean differences between independent groups within the sample. Significance was set at $p < 0.05$.

Test	Independent (grouping) Variable	Dependent Variables
Mann -Whitney U test	1. Sex 2. Boarders vs. day scholars 3. Public vs. Private school students 4. Engagement in organized sports or physical activity.	Weekday sleep variables Weekend sleep variables Sums obtained from the sleepiness, sleep-wake problems, depressive mood, and morning eveningness scales. Mean self-reported time for leaving home/hostel on school days.

Table 5. A summary of the statistical tests applied to measure the correlation coefficients between ordinal variables.

Test	Independent/Predictor Variable	Dependent Variables
Kendall Tau-b	1. Body Mass Index 2. Academic Performance 3. Frequency of consumption soda with caffeine 4. Frequency of consumption coffee or tea with caffeine 5. Frequency of electronic device usage before bedtime 6. Time spent on device before bedtime	Weekday sleep variables Weekend sleep variables Weekend Bedtime Delay Weekend Waketime Delay Sums obtained from the sleepiness, sleep-wake problems, depressive mood, and morning eveningness scales.

In interpreting Kendall's Tau's correlation coefficients, $\tau b = 0.07$ indicates a weak association; $\tau b = 0.21$ indicates a medium association, and $\tau b = 0.35$ indicates a strong association (Brossart, Laird, and Armstrong, 2018).

Table 6. A summary of the statistical tests applied to test the relationships between categorical sleep variables and personal characteristics. Significance was set at $p < 0.05$.

Test	First list of grouping variables	Second list of grouping variables
Pearson's Chi-Squared Test	1. Main reasons given for weekday and weekend waketimes	Sex Boarders and day scholars Public and Private schools
	2. Main reasons given for weekday and weekend bedtimes	
	3. Distribution of boarders and day scholars	
	4. Perceived sleep quality	
	5. Perceived sleep quantity	
	6. Nocturnal awakenings	
	7. Frequency of daytime naps	
	8. Perceived sleepiness problem	

3.2 Phase Two

3.2.1 Study design

Phase two adopted an observational descriptive design. It involved tracking the sleep-wake behaviour of a sample of Grade 11 learners over 9 days using sleep diaries and actigraphy.

3.2.1.1 Study setting

The chosen school was a girl's school with both boarders and day scholars situated in Makhanda, Eastern Cape. The initial plan was to compare the sleep-wake behavior of Grade 12 boarders and day scholars. However, the Grade 12s were nearing their exam period and in consultation with the specific school involved, it was agreed that Grade 11 learners would be approached as they were not near to writing their exams. The data collection for this phase of the study began in late 2019 and focussed on the sleep-wake behaviour of boarders at a private girl's school. The second part of this phase would have involved following the sleep-wake behaviour of day scholars in the same grade for the same period in early 2020. Unfortunately, just prior to the start of this part of the data collection, the project was halted due to the global COVID-19 pandemic and the associated Level 5 lockdown orders that were issued by the South African government. This resulted in schools being closed from 18 March 2020. As a result, the aim of Phase two of this study was adjusted to characterize the sleep-wake behavior of 14 female boarders attending a private high school in Makhanda.

3.2.2 Measures

3.2.2.1 Actigraphy recording

Phase two of the project included 9 days of actigraph recording using the ActTrust Wrist Actimeter (Condor Instruments, 2017. *ActTrust USER-MANUAL*). The device measures activity, wrist temperature, and light exposure and can be worn in one of the limbs and it is used to assess sleep parameters.

Actrigraphs employ the use of validated algorithms for the transformation of information about activities to sleep-wake estimates (Acebo *et al*., 1999). In this study, participants pressed the marker button to mark bed and wake times. These devices were worn by the participants for nine days. The watches were issued to the participants on a Friday, which meant that the first two days were a weekend, followed by five-week days and the last 2 days were a weekend,with the watches

being collected from the participants on the following Monday. This time frame was chosen based on previous research which has demonstrated that reliable actigraph estimates can be collected for at least 5 days (Acebo *et al*., 1999; Mazza, Bastuji, and Rey, 2020). For example, Acebo *et al*. (1999) conducted a study aimed at providing estimates of reliability for aggregated values from one to seven recording nights for five commonly used actigraphic measures of sleep patterns using data from three studies that obtained actigraph data for nights on children and adolescents on their normal sleep-wake schedules. They concluded that if studies wish to collect reliable actigraph measures of sleep for adolescents and children then they ought to record for at least one full week (Acebo *et al*., 1999). The devices used in this study, the ActTrust watches, were set to use the Cole-Kripke algorithm. This algorithm is based on Cole *et al*.(1992) which determines if each epoch is wake or sleep. On the actigraphs, activity sampling mode was configured at Proportional Integral Mode/ Time Above Threshold/ Zero Crossing Mode at a sampling interval of 60 seconds. The time zone was set to Greenwich Mean Time (GMT +2).

To calculate the start time for the light phase start time of the dark phase, latitude was set at 33.3042˚, and longitude was set at 26.5328˚ because these are the coordinates for the Makhanda area. The main sleep period was set to be recorded during the nighttime with a minimum sleep period of 30 minutes and only one main sleep period as per standard settings (Condor Instruments, 2017. *ActTrust USER-MANUAL*). Participants were encouraged to wear their actigraphs on their non-dominant wrists because most studies have used the nondominant wrist (or leg with young children) (Sadeh *et al*., 1995), even though it has been argued that actigraphic data is not affected by placement (Sadeh *et al*., 1989; Paavonen, Fjällberg, Steenari, and Aronen, 2002). The wrist actigraph recorded averages of the following sleep parameters: bedtime, waketime, total sleep duration (hours), sleep onset latency (minutes), percentage of sleep efficiency expressed as a percentage, wake after sleep onset (minutes), and the number of awakenings.

3.2.2.2 Sleep diary

This phase of the project also included the Core Consensus sleep diary (Carney et al., 2012). completion in addition to actigraph recording. The morning part of the sleep diary included the following main questions: the time of getting into bed; the time at which the individual attempted to fall asleep; sleep onset latency; the number of awakenings; duration of awakenings; time of final awakening; final waketime; and perceived sleep quality rated via Likert scale (Carney et al., 2012,

see Appendix I for the Consensus Sleep Diary with instructions). The evening part of the diary provided information about daytime activities such as caffeine, and medication use or napping (Carney et al., 2012). Both morning and evening diaries were accompanied by instructions of how and when to complete the diaries. Learners were asked to complete a sleep diary in the morning as soon as they woke up and at night, just before bedtime.

3.2.3 Ethical considerations

The research protocol was approved by the Ethics Review Committee of Rhodes University (Clearance number 2019-0168-461, see Appendix C). The School Principal granted permission to approach Grade 11 adolescents in the school. The school principals sent out emails to the parents informing them of the study and requesting their permission for their daughters to participate in the study. Furthermore, written assent was obtained from learners before participation in the study. It was also stressed to participants that their participation in the study was completely voluntary and that they could choose to withdraw from the study at any point should they wish to. Provisions were made to protect participant's rights to privacy and anonymity and to preserve confidentiality. Thus, the anonymity of participants was protected as neither the actigraphs nor the sleep diaries required any personal information, and as such no personal information was stored.

3.2.4 Participant recruitment and inclusion criteria

For Phase two, purposeful sampling based on an existing contact was utilized, which meant that a school was selected based on having expressed interest in getting involved in Phase two of the study. A meeting was set up with the school principal in which further details such as the background of the study, the intended methods of data collection, and its importance were discussed.

For Phase two of the study, participants were randomly selected from a Grade 11 sample following permission from the school principal and governing bodies. There were no exclusion criteria as it was decided upon that individual screening of minors who have volunteered to participate would be inappropriate and would bring about feelings of discrimination. Learners who were keen to participate had their names put through a random list generator so that the sample could be randomly selected. Invited learners were then given verbal and written information in their

respective classrooms at times set by the school principal (see Appendices K and L). The information consisted of a brief background of the research project, the main research aims were outlined, and the procedure was explained in detail.

3.2.5 Procedure

The participants were given the sleep diaries and actigraphs to take home and use for the weekend (Saturday and Sunday) so that they become familiar with the actigraphs and filling in the sleep diaries. The researcher then inquired with them on Monday to attend to any questions and difficulties experienced. Following this, the participants were given a full week. Monday to Sunday to wear the actigraphs and complete the sleep diaries. The researcher contacted participants using a WhatsApp group each morning to encourage compliance in diary completion. Participants were asked to wear the actigraphs continuously as they went about their daily activities and throughout the night and were asked to only take off the actigraphs during bath/shower time, and/or when swimming. Furthermore, participants were asked to press the event button shortly before bedtime and shortly after waketime. This was used to define actigraphic bed and wake times. After the 9 days of data collection, the researcher collected the Wrist actigraph as well as the sleep diaries. Participants were then thanked and given a small token of appreciation for their efforts. Data from the actigraphs were downloaded using an ActDock accessory and then printed for comparison against the sleep diary.

3.2.6 Data Processing

3.2.6.1 Data Reduction and Statistical Analysis

Data from the ActTrust was extracted with the ActDock accessory and analyzed using the ActStudio software version 1.0.9 (Condor Instruments, 2017. *ActTrust USER-MANUAL*). In the event that there was a problem with the data, such as incorrect dates on the recorded data (e.g., the year is shown as 1970), while it was being loaded, the software was used to treat these inconsistencies in data. This was done by selecting “treat” on the pop-up window - this option corrected all incorrect dates or times. If the participants did not press the event button, bed and waketimes were then defined by the Condor Instruments algorithm (Condor Instruments, 2017. *ActTrust USER-MANUAL*). Following extraction, data were analyzed. Daily sleep performance variables such as bedtime, waketime, total sleep time, sleep latency, sleep efficiency, nocturnal awakenings, and wake after sleep onset (WASO) were calculated based on the results obtained

from the Statistics analysis on the ActStudio software.

Data obtained from the data reduction process were then uploaded to Microsoft Excel, along with data obtained from the sleep diaries. Reported hours and minutes were indicated in the 12:00 format. Following this, means and standard deviations, as well as medians and interquartile ranges, were calculated from both actigraph and sleep diary data. Thereafter, data was uploaded to Statistica (Statistica, Statsoft, Inc.; Tulsa, OK74104, USA). First, the data set was tested for normality using the Shapiro-Wilk test for normality, results indicated that the data did not follow a normal distribution. Thus, the analysis used nonparametric tests. To test the difference in the medians of two dependent samples, the Wilcoxon matched-pairs test was used. Refer to Table 7 for specific tests and variables compared.

Table 7. A summary of the statistical test used to compare the relevant variables for Phase two. Significance was set at $p < 0.05$.

Test	Pair of Variables
Wilcoxon matched-pairs signed ranks test	Actigraph weekday and weekend sleep variables Sleep diary weekday and weekend sleep variables Comparison between Actigraph and Sleep diary weekday sleep variables Comparison between Actigraph and Sleep diary weekday sleep variables.

CHAPTER IV

RESULTS

4.1 Phase One

Firstly, sample characteristics are outlined. Thereafter, weekday and weekend sleep-wake behaviour are reported on and compared. This is followed by an analysis of results based on personal and other characteristics including sex (male vs. female), type of scholar (day vs. boarders), and school (public vs. private) in relation to sleep variables. Following this, other sleep variable data, such as sleepiness, sleep-wake problems, depressive mood as well as morningness/eveningness are presented in relation to the above-mentioned demographic data. Thereafter, results from other sleep variables such as sleep quality, sleep quantity, nocturnal awakenings, and frequency of daytime naps are reported. Lastly, the relationship between sleep variables and sport or physical activity, caffeine consumption, and electrical device use are presented.

Given the extensive amount of data and results and to reduce the number of tables and figures in this section, only statistically significant effects and moderately correlated relationships are displayed. Although only statistically significant effects are reported in the text below, all statistical effect tables are included in Appendix M. Sleep variables such as bed and wake times are reported using a 24-hour time format.

4.1.1 Sample Characteristics

A total of 231 responses were received from learners in the participating schools. All participants were Grade 12s (final year of high school) from three private schools and two public schools. The sample consisted of both females (n=94) and males (n=137) aged between 17-19 years. 32 % (n=73) participants self-identified as either Black/African; 54% (n=125) as White; 13 % (n=32) as Colored and only one learner identified as Indian. 42 % (n=95) of the learners were day scholars and the remaining 58 % (n=130) of the sample consisted of learners who lived in boarding houses or hostels. 66 % (n=152) of the sample consisted of students from private schools and the remainder 34 % (n=79) were from public schools. While males were evenly distributed between

day scholars and boarders, the majority (69 %, n=62) of the females were boarders (Table 8).

Table 8. Distribution of day scholars and boarders by sex.

	Males % (n)	**Females % (n)**
Day scholar	50 (67)	31 (28)
Boarder	50 (68)	69 (62)

Table 9. Distribution of boarders and day scholars between public and private schools.

	Day scholar % (n)	**Boarder % (n)**
Public School	82 (64)	18 (14)
Private School	21 (31)	79 (116)

4.1.1.1 Self-Reported Academic Performance

With regards to academic performance, 35 % (n=80) of the learners identified their Grade Point Average (GPA) as ranging from 60-69 %, while 31 % (n=70) reported ranges between 70-79% with 16% (n=37) reporting ranges of 50-59 % and 15% (n=34) reporting the highest range of 80-100 %. The remainder varied between 40-49 % (n=3) and 30-39 % (n=2) Table 10).

Table 10. Academic Performance reported by the Grade 12s.

Self-Reported Academic Performance (%)						
0-29	30-39	40-49	50-59	60-69	70-79	80-100
0	2	3	37	80	70	34

4.1.1.2 Calculated Body Mass Index (BMI)

23 % (n=54) did not know their height and/or weight and therefore BMI could not be calculated for them. 7 % (n=16) presented BMI values under 18.5 (underweight), 22 % (n=50) were either overweight or obese and the remainder 48 % (n=111) fell on the normal BMI ranges. Overall, learners reported a mean body mass index (BMI) of 24 (±5.5) which is in the normal ranges (Table 11).

Table 11. Frequency of Body Mass Index (BMI) categories (n= 222).

Body Mass Index % (n)			
Underweight	Normal	Overweight/Obese	Unknown
3.2 (7)	50 (111)	23 (50)	24 (54)

4.1.1.3 Self-reported cases of disability or chronic illness, ADHD or a learning disability, and the use of medication.

15 % of the sample reported having some disability or chronic illness. 17 % reported having Attention Deficit Hyperactivity Disorder (ADHD) or a learning disability, while 18 % reported taking medication to help with concentration or a learning problem (Table 12).

Table 12. Self-reported cases of disabilities or chronic illnesses; Attention Deficit Hyperactivity Disorder (ADHD) or a learning disability as well use of Ritalin/Concerta or some other medication within the total cohort.

Disabilities or chronic illnesses % (n).	Attention deficit hyperactivity disorder (ADHD) or a learning disability % (n).	Ritalin/Concerta or some other medication to help with concentration or a learning problem % (n).
15 (34)	17 (38)	18 (41)

4.1.1.4 Perceived Health Status

Most of the learners (80 %) considered themselves as having good/excellent health while the remainder perceived their health as fair (Table 13).

Table 13. A summary of learners' perceived health.

Self-Reported Health Status %(n)		
Fair	Good	Excellent
20 (44)	44 (95)	36 (78)

4.1.1.5 Self-reported maturation

In terms of self-reported maturation, 60 % reported their growth in height as seeming to be complete. 45 % reported other signs of physical maturation as seeming complete and 31 % reported other signs of physical maturation as still underway (Table 14).

Table 14. A summary of responses related to self-reported maturation

	Has not yet began to spurt % (n)	**Has barely started % (n)**	**Is definitely underway %(n)**	**Seems complete % (n)**	**I don't know % (n)**
Perceived growth in height	4 (8)	2.6 (6)	10(23)	60(138)	20(45)
Other signs of physical maturation	0.9(2)	4.3(10)	31(71)	45(104)	15(34)

4.1.1.6 Self-reported time for leaving home/hostel on school days

On average, learners reported leaving home/hostel at 07:06 a.m (±00:20) for school. Males reported leaving home significantly later (15 minutes) than females (p=0.02; z=-2.2) and boarders left the hostel significantly later (20 minutes) than day scholars (p<0.01, z=3) (Table 15). School start times for these schools were between 07:15 and 07:30 a.m.

Table 15. The differences in reported time for leaving home/hostel on school days for the subgroups. Plain font: mean and standard deviation, *italic font: median and quartile range 1 and 3*.

Self-reported time for leaving home/hostel on school days (a.m)								
Sex			**Type of scholar**			**Type of school**		
Females	Males	***P-value***	Day Scholar	Boarder	***P-value***	Public school	Private school	***P-value***
07:18 (±07:24) *07:12 (07:00-07:20)*	07:03 (±06:23) *07:02 (07:00-07:20)*	0.02*	06:58 (±06:24) *07:05 (07:00-07:15)*	07:18 (±07:12) *07:15 (07:00-07:21)*	<0.01 *	06:59) (±06:23) *07:02 (07:00-07:15)*	07:15 (±07:08) *07:10 (07:00-07:20)*	0.06

4.1.1.7 Self-reported means of transportation to school

Over 60 % (n=139) of the learners reported walking to school and 27 % (n=62) reported getting a ride from parents/family members. 6 % (n=13) indicated the use of a taxi and the remainder either gave no response (n=13), rode a bicycle (n=2), used a school bus (n=1) or got a ride from friends (n=1).

4.2 Self-Reported Sleep Behaviors

4.2.1 Comparison of weekday and weekend sleep-wake behaviour

The following section will highlight differences in weekday and weekend sleep variables across the sample as indicated in Table 16.

Table 16. A summary of the differences in weekday and weekend self-reported sleep-wake behaviour (n=231). Plain font: mean and standard deviation, *italic font: median and quartile range 1 and 3*.Significant differences are denoted by the use of an asterisk*.

	Weekday	**Weekend**	***P-value***
Self-reported bedtimes	11:00 p.m. (±00:50) *11:00 p.m. (10:30 p.m-11:30 p.m.)*	11:55 p.m. (±01:11) *12:00 a.m. (11:00 p.m-12: 37 a.m.)*	<0.01 (z=9.4) *
Weekend Bedtime Delay(hr:mins)	00:55 (±00:21) *01:00 (00:30-01:30)*		
Self-reported waketimes	06:07 a.m. (±00:42) *06:20 a.m. (06:00 a.m.- 06:30 a.m.)*	08:18 a.m. (±01:28) *08:00 a.m. (07:00 a.m.- 09:00 a.m.)*	<0.01 (z=13) *
Weekend Waketime Delay (hr:mins)	02:10 (±00:43) *01:43 (01:00-03:20)*		
Self-reported sleep duration (hr:mins)	06:42 (±01:06) *07:00 (06:00-07:18)*	08:06 (±01:30) *08:00 (07:00-09:00)*	<0.01 (z=10) *
Overall ideal sleep duration(hr:mins)	08:18 (±01:30) *08:00 (08:00-09:00)*		
Self-reported sleep onset latency (minutes)	24 (±24) *16 (3-30)*	21 (±26) *15 (2-20)*	<0.01 (z=4.7) *

Learners reported significantly later bedtimes ($p<0.01$, $z=9.4$; Table 16) on weekends, compared to weeknights (Table 16). As a result, the Weekend Bedtime Delay (WBD) was approximately 1hr. Similarly, learners reported waking significantly earlier during the week, relative to the weekend ($p<0.01$, $z=13$; Table 16), resulting in a WWD of 1hr: 43mins.

In comparing reported sleep durations on weekdays and the weekends, sleep duration was significantly shorter ($p<0.01$, $z=10$) on weekdays relative to weekends. On weekdays, the majority of the learners (87 %; n=202) reported getting less than 8 hours of sleep. Only 13 % (n=29) reported getting 8 or more hours of sleep during weeknights. Only 30 % (n=69) of the sample reported getting less than 8 hours of sleep, while 70 % (n=162) reported getting 8 or more hours of sleep during the weekend. Comparing reported sleep onset latency during the week and on the weekends, sleep onset latency was significantly longer on weekdays ($p<0.01$, $z=4.7$).

4.2.1.1 Overall self-reported reasons for bedtimes

With reference to Figure 6, on weeknights, the most prevalent reasons reported for bedtimes were "I feel sleepy" as selected by 31 % (n=71) of the learners and "I finish my homework" as selected by a slightly higher percentage (36 %; n=84) of the learners. On the weekends, however, while 36% (n=83) still reported the main reason as "I feel sleepy", 39 % (n=89) selected "I finish socializing (in person or over an electronic device") as their main reason for weekend bedtime.

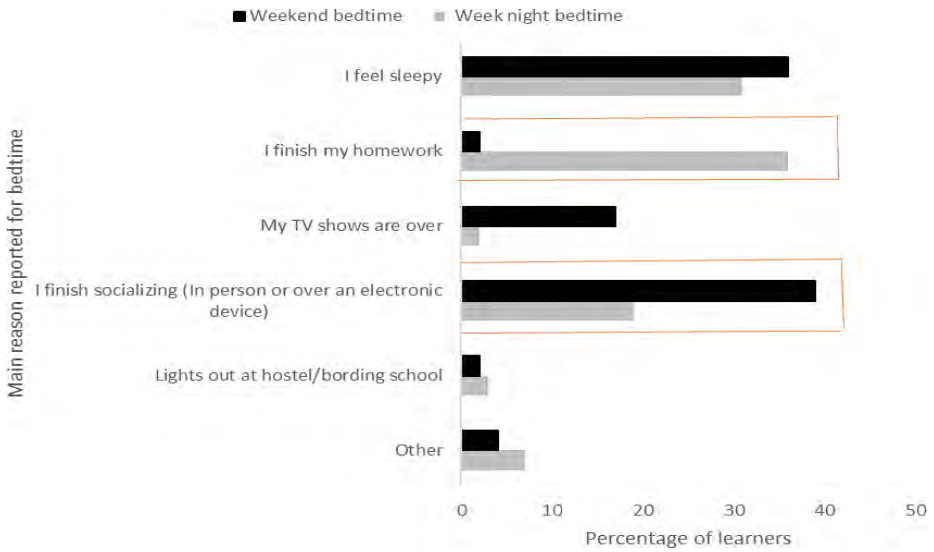


Figure 5. Main reasons for bedtimes on the week and weekend nights (n=230). The red block is used to highlight the most prominent differences.

4.2.1.2 Overall self-reported reasons for waketimes

On weekdays, nearly two-thirds of the learners (61 %; n=140) reported waking up because of an alarm. On the weekends, however, a little less than half (49 %); n=114) selected “I don't know. I just wake up” as the main reason for their waketimes (Figure 6).

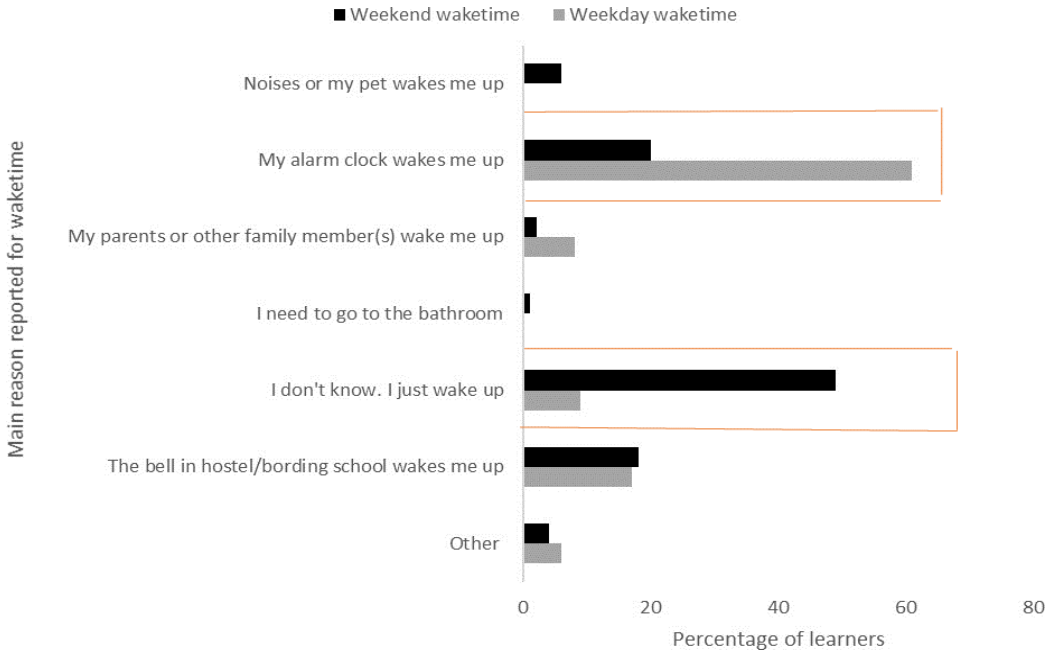


Figure 6. Main reasons for waketimes on weekdays and weekends (n=231). The red block is used to highlight the most prominent differences.

4.2.2 The effects of personal and other characteristics in relation to sleep variables

The following section will highlight the effects of certain demographic characteristics and contextualfactors on specific sleep variables during the weekend and weekdays. Specifically, it will report onthe effects of learner sex, boarders as compared to day scholars, and type of school (public compared to private schools).

4.2.2.1 Effects of learner sex on sleep-wake behaviour

The only variable that differed significantly between the sexes was weekday waketimes ($p<0.01$, $z=-3.1$) where females woke later than males.

Table 17. Effects of sex of learners on self-reported sleep variables during the week and weekend. Plain font: mean and standard deviation, *italic font: median and quartile range 1 and 3.* Significant differences are denoted by the use of an asterisk*

Sex	Sleep duration (hrs:mins)	*P-value*	Sleep onset latency (minutes)	*P-value*	Bedtimes	*P-value*	Waketimes	*P-value*
Weekday								
Male	06:42 a.m. (±01:05) *07:00 (06:00-07:18 a.m.)*	0.66	22 (±19) *15 (10-30)*	0.24	10:57 p.m. (±00:50) *11:00 p.m. (10:30-11:30 p.m.)*	0.29	06:04 a.m. (±01:22) *06:15 a.m. (05:30-06:30 a.m.)*	<0.01 *
Female	06:42 (±01:00) *07:00 a.m. (06:00-07:18 a.m.)*		26 (±30) *18 (15-30)*		11:03 p.m. (±00:49) *11:00 p.m. (10:30-11:30 p.m.)*		06:18 a.m. (±00:27) *06:30 a.m. (06:02-06:30 a.m.)*	
Weekend								
Male	08:06 a.m. (±01:36) *08:00 (07:30-09:00 a.m.)*	0.59	19 (±21) *12 (10-20)*	0.16	12:00 a.m. (±01:18) *12:00 a.m. (11:00 p.m.-01:00 a.m.)*	0.29	08:18 a.m. (±01:54) *08:00 a.m. (07:00-09:00 a.m.)*	0.07
Female	08:06 a.m. (±01:36) *08:00 (07:00-09:00 a.m.)*		23 (±31) *15 (10-30)*		11:48 p.m. (±01:01) *11:45 p.m. (11:00 p.m.-12:30 a.m.)*		08:25 a.m. (±01:17) *08:00 a.m. (07:30-09:00 a.m.)*	

Differences between the sexes in main reasons given for bed and wake times

The main reasons for reported bedtimes did not differ between male and female learners during weekdays (p=0.72, χ^2=3.6, df=6; Table 3b in Appendix M), and on the weekends (p=0.65, χ^2=4.2, df=6; Table 3c in Appendix M). However, in terms of reported reasons for waking, on weekdays, female learners (71 %, n=67, Table 18) were more likely to report waking up due to an alarm clock, relativeto male learners (53 %, n=73, Table 18). Males were more likely to report "The bell in hostel/boarding school wakes me up" as their main reason for their waketimes on school days

relative to 10% of their female learners. Therefore, it appears as though males were more dependent on the hostel bell forwaking them up relative to females, who opted for setting an alarm clock.

Table 18. Sex differences in the main reasons given for weekday waketimes.

Main reason self-reported for weekday waketime	My alarm clock wakes me up% (n)	I don't know. I just wake up % (n)	The bell in hostel/boarding school wakes me up % (n)
Males	53 (73)	10 (14)	22 (30)
Females	71 (67)	6.4 (6)	10 (9)

On the weekend, there was an association between sex and self-reported reasons for waking up. Males were more likely to report being woken up by the school bell while females were more likely to report being woken by their alarm clock ($p=0.02$, $\chi^2=15$, $df=6$; Table 19). 55 % (N=75) of male learners and a little less than half (42 %, n=39) female learners reported "I don't know. I just wake up" as their main reason for weekend waketimes (Table 19).

Table 19. Sex differences in the main reasons given for weekend wake times.

Main reason self-reported for weekend waketime	My alarm clock wakes me up % (n)	I don't know. I just wake up % (n)	The bell in hostel/boarding school wakes me up % (n)
Males	16 (22)	55 (75)	30 (30)
Females	25(24)	42 (39)	13 (12)

4.2.2.2 Differences between boarders and day scholars in sleep-wake behaviour

This section of the results focuses on differences in sleep duration, sleep onset latency, bedtimes, and waketimes between learners living in boarding houses/hostels and day scholars.

Table 20. A summary of the differences between boarders and day scholars in relation to self-reported sleep variables. Plain font: mean and standard deviation, *italic font: median and quartile ranges 1 and 3*. Significant differences are denoted by the use of an asterisk*

Type of scholar	Sleep duration (hours)	*P-value*	Sleep onset latency (minutes)	*P-value*	Bedtimes	*P-value*	Wake times	*P-value*
Weekdays								
Day	06:36 (±01:18) *06:48 (06:00-07:24)*	0.35	26 (±23) *19 (10-30)*	0.66	10:53 p.m. (±00:57) *11:00 p.m. (10:00 p.m. - 11:30 p.m.)*	0.10	05:58 a.m. (±01:15) *06:00 a.m. (05:30 a.m. - 06:20 a.m.)*	<0.01*
Boarder	06:48 (±00:54) *07:00 (06:30-07:18)*		23 (±24) *15 (10-30)*		11:04 p.m. (±00:43) *11:00 p.m. (10:30 p.m. - 11:30 p.m.)*		06:24 a.m. (±00:23) *06:30 a.m. (06:20 p.m. - 06:40 a.m.)*	
Weekend								
Day	08:30 (±01:48) *08:36 (08:00-09:30)*	<0.01*	24 (±29) *15 (10-30)*	0.44	12:10 a.m. (±01:23) *12:00 a.m. (11:00 p.m. - 01:00 a.m.)*	<0.01*	08:51 a.m. (±01:44) *09:00 a.m. (08:00 a.m. - 10:00 a.m.)*	<0.01*
Boarder	07:48 (±01:12) *08:00 (07:00-08:12)*		18 (±24) *10 (10-20)*		11:43 p.m. (±00:59) *11:30 p.m. (11:00 p.m. - 12:00 a.m.)*		07:58 a.m. (±01:31) *07:37 a.m. (07:00 a.m. - 08:26 a.m.)*	

Comparing reported sleep parameters between boarders and day scholars, on the weekends, sleep duration was significantly shorter ($p<0.01$, $z=-4.1$; Table 20) for boarders than day scholars. On weekdays, day scholars reported significantly earlier waketimes than boarders ($p<0.01$, $z=8.1$) as shown in Table 20. However, on weekends, day scholars reported significantly later waketimes

than boarders ($p<0.01$, $z=-4.1$; Table 20). This resulted in day scholars having a WWD of about 3hrs, which was significantly longer ($p<0.01$, $z=-6.9$) than the boarders who had a WWD of about 1hr 30mins long. Furthermore, on the weekends, day scholars reported going to bed significantly later than boarders ($p<0.01$, $z=-2.7$, Table 20). No further differences between the groups were observed.

Self-reported reasons for weekday bedtime by day scholars and boarders

While boarders and day scholars were evenly distributed in their reports about going to sleep because they were sleepy or because they were done with homework, boarders were more likely to report going to bed because they finished socialising than day scholars ($p<0.01$, $\chi^2=19$, $df=6$; Table 21). There were also no significant associations between day scholars and boarders with regards to the main reasons reported for bedtime on weekend nights ($p=0.36$, $\chi^2=6.6$, $df=6$; refer to Table 4c in Appendix M).

Table 21. Reasons for weekday bedtime reported by day scholars and boarders.

The main reason reported for weekday bedtime	I feel sleepy % (n)	I finish my homework % (n)	I finish socializing (In person or over an electronic device) % (n)
Day scholars	33 (31)	41 (38)	9.7 (9)
Boarders	31(40)	34 (43)	24 (31)

Self-reported reasons for weekday and weekend waketimes by day scholars and boarders

63 % (N=82) of the boarders and 57 % (N=54) of the day scholars reported the main reason for their weekday waketimes as "My alarm clock wakes me up"; 25 % (N=32) boarders reported waking up mainly because "The bell in hostel/boarding school wakes me up". There was an association between scholar type and self-reported reasons for weekend waketimes ($p<0.01$, $\chi2=49$, $df=6$). More specifically, there were 25% (n=39) more day scholars who reported 'just waking up' than boarders. Boarders were more likely to report waking up because of an alarm clock (28%, n=37) relative to day scholars (8%, n=8). Furthermore, 29% (n=38) boarders also reported waking up because of the bell in hostel/boarding school.

4.2.2.3 Public and Private school differences in sleep-wake behaviour

Comparing self-reported mean sleep durations between public and private schools, there were no significant differences in weekday sleep duration (p=0.4, z=-0.9; Table 22) and in weekday sleep onset latency (p=0.48, z=-0.7; Table 22). However, on weekdays, bedtimes reported by public school learners were significantly earlier (p<0.01, z=3.9; Table 22) relative to learners in private schools.In addition, public school learners reported a significantly earlier mean weekday waketime (p<0.01, z=10; Table 22) than private school learners.

Table 22. A summary of the differences between public and private schools in relation to sleep variables. Plain font: mean and standard deviation, *italic font: median and quartile ranges 1 and 3*. The asterisk is used to demonstrate the statistically significant differences.

Type of school	**Sleep duration (hrs: mins)**	***P-value***	**Sleep onset latency (minutes)**	***P-value***	**Reported bedtimes**	***P-value***	**Reported waketimes**	***P-value***
Weekday								
Public School	06:42 (±01:24) *07:00 (06:00-07:42)*	0.40	24 (±20) *20 (10-30)*	0.47	10:44 p.m. (±01:00) *11:00 p.m. (10:00 p.m. - 11:00 p.m.)*	<0.01 *	05:32 a.m. (±00:51) *05:45 a.m. (05:00 a.m. - 06:00 a.m.)*	<0.01 *
Private School	06:42 (±00:54) *07:00 (06:00-07:12)*		24 (±26) *15 (10-30)*		11:08 p.m. (±00:41) *11:00 p.m. (10:32 p.m. - 11:30 p.m.)*		06:29 a.m. (±01:03) *06:30 a.m. (06:20 a.m. - 06:40 a.m.)*	
Weekend								
Public School	08:36 (±02:00) *09:00 (08:000 - 10:00)*	<0.01*	22 (±24) 15 (10-30)	0.30	12:16 a.m. (±01:31) *12:00 a.m. (11:00 p.m. - 01:37 a.m.)*	<0.01*	08:54 a.m. (±01:54) *09:00 a.m. (07:30 a.m. - 10:00 a.m.)*	<0.01*
	07:48				11:44 p.m.		08:04 a.m.	

Private School	(±01:12) *08:00 (07:00-08:24)*		20 (±27) *10 (10-20)*		(±00:56) *11:30 p.m. (11:00 p.m.-12:00 a.m.)*		(±01:28) *08:00 a.m. (07:00 a.m. - 09:00 a.m.)*	

On the weekends, public school learners reported a significantly longer mean sleep duration (approximately an hour longer) when compared to private school learners ($p<0.01$, $z=-4.9$). There were no significant differences in sleep onset latency between public and private school learners during weekends ($p=0.31$, $z=-1$; Table 22). Learners in public schools reported going to bed significantly later on the weekends ($p=0.01$, $z=-2.7$) relative to those in private schools. In accordance with the differences observed in weekend and weekday bedtimes, Weekend Bedtime Delay was about 1hr among those learners in public schools and 30mins for those in private schools ($p<0.01$, $z=-6.2$). In addition, public school learners also reported waking significantly later (1 hr later, $p<0.01$, $z=-4.4$: Table 22) than private school learners on weekends.

Self-reported reasons for weekday and weekend bedtime by public and private school learners

There was no significant association between public and private school learners with regards to the main reasons reported for bedtime on weekdays ($p=0.13$, $\chi^2=10$, $df=6$; Table 5b in Appendix M) and weekends ($p=0.60$, $\chi^2=5$, $df=6$; refer to Table 5c in Appendix M).

Self-reported reasons for weekday and weekend waketime by public and private school learners

Regarding weekday waketimes, there was an association between type of school and the reported reasons for waking ($p<0.01$, $\chi^2=38$, $df=5$; Table 23). Private school learners were more likely to report being woken up by the school bell and their alarm clock relative to public school learners. On the weekends, private school learners were again more likely than public school learners to report being woken up by their alarm clock and the school bell.

Table 23. Reasons for weekday and weekend waketimes reported by public and private school learners.

	My alarm clock wakes me up % (n)	The bell in hostel/boarding school % (n)
Weekday		
Public School	58 (46)	2.5 (2)
Private School	62 (94)	24 (37)
Weekend		
Public School	5.1 (4)	6.3 (5)
Private School	28 (42)	24 (37)

4.2.3 Results obtained from the sleepiness, sleep-wake problems, depressive mood, and morning eveningness scales.

This section reports on the results obtained from the sum scores calculated from the SSHS in relation to the demographic characteristics. First, the focus is on reporting overall sums obtained from the sleepiness, sleep-wake problems, depressed moods, and Morningness Eveningness scale. Thereafter, comparisons are made between the sexes, types of scholars, and type of school.

Data from the sleepiness, sleep-wake problem, depressed mood, and M/E scales are presented in Table 24 below. The results obtained from the sleepiness scale are indicative of relatively low daytime sleepiness prevalence in this sample (Table 24). The score obtained from the sleep-wake problem scales was mid-range. The score on the depressed mood scale indicated a trend towards high self-reported depressive symptoms (Table 24). The score on the M/E scale demonstrated that this sample population reflects a preference for evenings. (Table 24).

Table 24. Overall and demographic groups in relation to other sleep variables obtained from the survey. Plain font: mean and standard deviation, *italic font: median and quartile range 1 and 3.* The asterisk is used to demonstrate the statistically significant differences. Significant effects are indicated using an asterisk.

Scales		**Sex**			**Type of scholar**			**Type of school**		
	Overall	**Females**	**Males**	***P-value***	**Day scholar**	**Boarder**	***P-value***	**Public school**	**Private school**	***P-value***
Sleepiness	17 (±5) *16 (14-19)*	17 (±5.0) *17 (14-20)*	17 (±5.1) *15 (13-19)*	0.16	17(±5.0) *16 (14-19)*	17 (±5.1) *16 (14-20)*	0.88	16. (±4.0) *15 (13-19)*	17 (±5.5) *16 (14-20)*	0.32
Sleep-wake problems	27 (±8.4) *27 (21-32)*	29 (±8.2) *28 (23-34)*	25 (±8.2) *25 (21-31)*	<0.01*	24 (±7.5) *25 (20-29)*	29 (8.5) *28 (23-33)*	<0.01*	23 (±7.0) *24 (19-27)*	29 (±8.3) *28 (23-34)*	<0.01*
Depressed mood	13 (±2.9) *12 (11-15)*	14 (±3.0) *14 (12-16)*	12 (±2.7) *12 (10-14)*	<0.01*	13 (±3.0) *13 (11-15)*	13 (±3.0) *12 (11-15)*	0.7	12 (±3.0) *12 (10-14)*	13 (±3.0) *12 (11-15)*	0.02 *
Morningness-Eveningness	27 (±5) *26 (23-30)*	26 (±4.9) *26 (23-29)*	27 (±5.0) *27 (24-40)*	0.02*	27 (±4.8) *27 (24-30)*	26 (±5.2) *26 (23-29)*	0.13	28 (±5.1) *28 (25-32)*	26 (±4.8) *26 (23-28)*	<0.01*

4.2.3.1 Sex differences

There were no significant differences among the sexes in relation to the sleepiness scale (p=0.16, z=-1.4). However, female learners scored significantly higher on the scale of the sleep-wake problem (p<0.01, z=-2.9), and on the depressed mood scale (p<0.01, z=-4.7), indicating a higher propensity for experiencing problems/disturbances in sleep and more prevalent depressive mood symptoms. With regards to the morning eveningness scale, male learners scored significantly

higher (p=0.02, z=2.4) than females, indicative of this group being more likely to lean towards morning preference (Table 24).

4.2.3.2 Differences between boarders and day scholars

There were no significant differences between boarders and day scholars in relation to the scores obtained from the sleepiness scale (p=0.88, z=0.2), depressed mood scale (p=0.7, z=0.4), and the morningness-eveningness scale (p=0.13, z=-1.5). However, boarders scored significantly higher on the scale of the sleep-wake problem (p<0.01, z=3.9) indicating a higher risk of experiencing problems/disturbances in sleep (Table 24).

4.2.3.3 Differences between public and private school learners

There were no significant differences between public and private school learners in relation to the scores obtained from the sleepiness scale (p=0.32, z=1). However, private school learners scored higher on the scale of the sleep-wake problem (p<0.01, z=5.4) and the depressed mood scale (p=0.02, z=2.3), which may indicate a higher likelihood of experiencing problems/disturbances in sleep and more prevalent depressive mood symptoms respectively. With regards to the morning eveningness scale, public school learners scored significantly higher (p<0.01, z=-3.6). Thus, indicating that public school learners were more likely to towards morning preference (Table 24).

4.2.4 Other sleep variables

This section describes results obtained from other sleep variables, namely, nocturnal awakenings, frequency of daytime napping, perceived sleep quantity, perceived sleep quality, and perceived sleepiness problem.

4.2.4.1 Perceived sleep quality

More than half (65 %; n=151) learners perceived themselves as being good quality sleepers. There were no significant associations between male and female learners (p=0.45, χ^2=0.58, df=1), type of school (p=0.17, χ^2 =1.84, df=1), and type of scholar (p=0.53, χ^2=0.39, df=1) in relation to perceived sleep quality.

4.2.4.2 Perceived sleep quantity

75 % (n=174) of learners reported getting too little sleep while 1.0 % (n=2) reported getting too

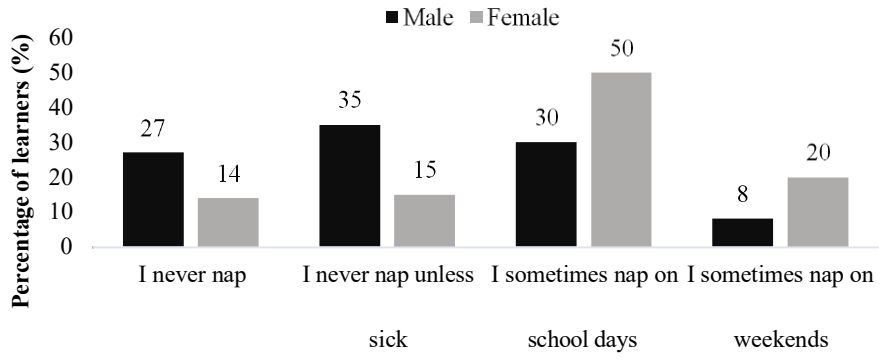
much sleep. Sex (p=0.07, χ^2=5.41, df=2) and type of scholar (p=0.06, χ^2=5.74, df=2) showed no effect on perceived sleep quantity. However, there was a significant association between school type and perceived sleep quantity (p=0.01, χ^2=9.35, df=2) in that more learners from private schools (82% n=124) reported getting too little sleep in comparison to those in public schools (63%; n=50).

4.2.4.3 Nocturnal awakenings

Less than half (41 %; n=93) of the total sample of students reported no occurrences of nocturnal awakenings. 28% (n=64) reported waking up at least once and 19 % (n=44) of the learners report waking up two or three times while just 2.6 % (n=6) indicated waking up more than three times. 8.8 % (n=20) of the sample reported having no idea how often they awaken in between their sleep. The frequency of nocturnal awakenings demonstrated no significant association with sex (p=0.49, χ^2=3.41, df=4; Table 8g in Appendix M), type of school (p=0.06, χ^2=9.08, df=4; Table 8i in Appendix M), and type of scholar (p=0.25, χ^2=5.38, df=4; Table 8h in Appendix M).

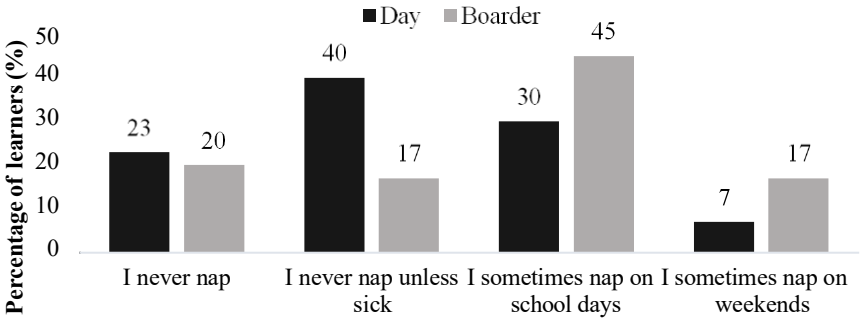
4.2.4.4 Frequency of daytime naps

Overall, 38 % (n=88) of learners reported sometimes napping on school days while fewer (13 %, n=30) reported napping on the weekends. The remainder reported never napping (22 % n=50) or only napping when sick (27 %, n=62). There were significant associations between learner sex (p<0.01, χ^2 =27, df=4), type of school (p<0.01, χ^2=40, df=4), and type of scholar (p<0.01, χ^2=19, df=4) and the reported frequency of napping. With regards to sex differences, female learners (51%; n=47) reported more frequent napping than males (30 %; n=41) on school days, while males were more likely to report never napping or only napping when they are sick when compared to female learners. On the weekends, more female learners (20 %; n=19) reported napping relative to their male counterparts (8 %; n=11; Figure 7A.). Day scholars were more likely to report only napping when sick than boarders, while more boarders (46 %; n=59) reported napping on school days relative to day scholars (29 %; n=28; Figure 7B). On the weekends, more boarders (17%; n=22) reported napping on school days relative to day scholars (7 %; n=7; Figure 7B.). More of private school learners (44 %; n=67) reported sometimes napping on school days in comparison to public school learners (27%; n=21) and on the weekend, 20 % (n=30) of private school learners reported napping while none of the public-school learners reported napping during the weekend (Figure 7C.).



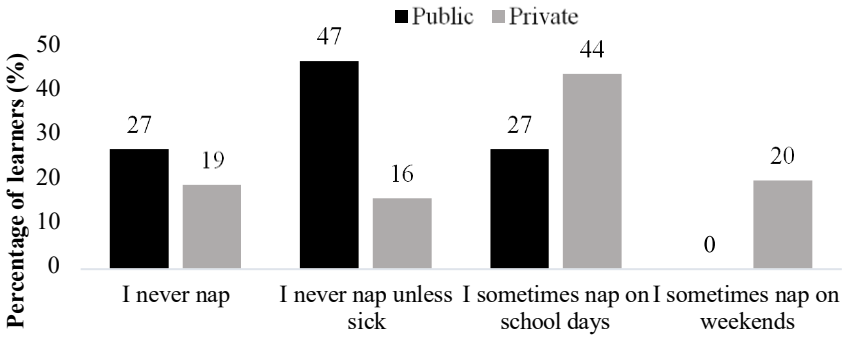
Frequency of daytime naps

A.



Frequency of daytime naps

B.



C.

Figure 7. The number of learners reporting differences in frequency of daytime napping between males and females (A; $p<0.01$, $\chi 2 = 27$, $df=4$), day scholars and boarders (B; $p<0.01$, $\chi^2=19$, $df=4$) as well as between private and public-school learners (C; $p<0.01$, $\chi 2=40$, $df=4$).

4.2.4.5 Perceived daytime sleepiness problem

45 % (n=103) learners reported having a little problem with daytime sleepiness, with 29 % (n=66) reporting having more than a little problem. 14 % (n=33) considered themselves as having a big problem, while just 4.8 % (n=11) reported having a very big problem with sleepiness during the day. The remainder 7.2% (n=17) reported no problem at all with daytime sleepiness.

Personal and contextual characteristics, specifically sex (p=0.01, χ^2=14, df=4), and type of school (p=0.01, χ^2=16, df=4) demonstrated significant associations with the frequency of perceived sleepiness problems, but this was not the case for the type of scholar (p=0.35, χ^2=4.42, df=4). More females (30%; n=28) reported having either a big problem or a very big problem with sleepiness relative to males (12%; n=16; Figure 8A.). More private school learners (25%; n=38) reported having either a big problem or a very big problem with sleepiness relative to public school learners (7.8%; n=6; Figure 8B.).

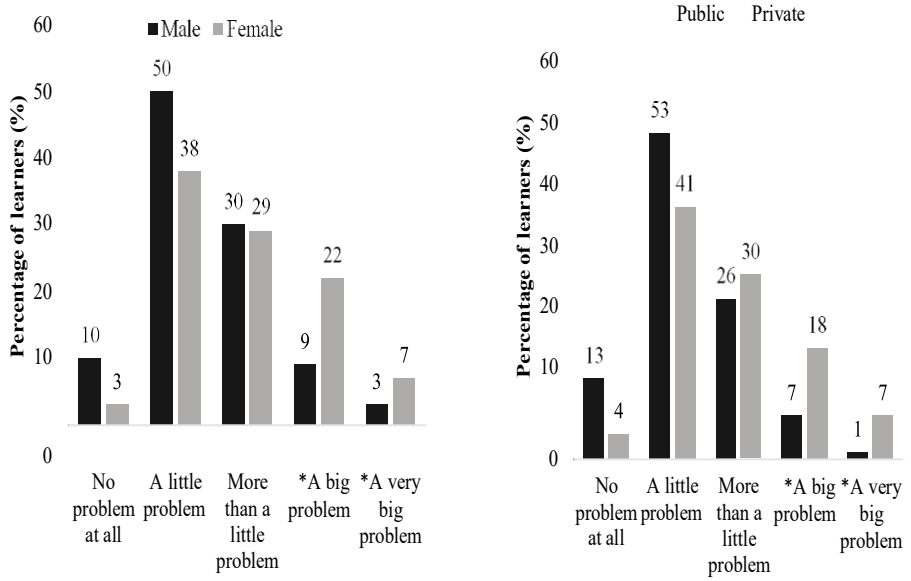


Figure 8. Differences in the number of learners reporting perceived sleepiness problems between the sexes (A.) and between public and private school learners (B.).

4.2.5 Lifestyle habits

4.2.5.1 Prevalence and effects of sports or physical activity

28 % (n=60) learners reported that they had not engaged in organized sport or physical activity and 72 % (n=156) reported that they had engaged in some sort of organized sport or a regularly scheduled physical activity, including competitions in the last week. Participation in sports or physical activity had no significant effect on sleep variables as demonstrated in Appendix M, Table 9a.

4.2.5.2 Frequency and effect of caffeine consumption

53 % of learners reported the consumption of soda with caffeine and 75 % reported the consumption of coffee or tea with caffeine daily (Table 25).

Table 25. A summary of the responses pertaining to the frequency of caffeine consumption obtained from the total sample of students (n=231).

Caffeine product	Never %(n)	Once or twice a day % (n)	Several time every day %(n)	Everyday %(n)	No response % (n)
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi)	44 (101)	32 (75)	7 (15)	14 (33)	3 (7)
Frequency of consumption coffee or tea with caffeine =229	24 (56)	35 (80)	12 (27)	28 (66)	1 (2)

4.2.5.3 Correlation between caffeine consumptions and sleep parameters

There was a relationship between caffeine consumption and some sleep parameters. Specifically, the frequency of consumption of coffee/tea and soda had a weak to medium and positive correlation with sleep onset latency as well as to the scale of the sleep-wake problem. Therefore, those learners who consumed coffee/tea or soda with caffeine more frequently were somewhat more likely to reportlonger overall sleep onset latencies and to score higher on the scale of the

sleep-wake problem, indicative of a possible increased likelihood of experiencing difficulties or problems related to sleep. Correlation coefficients obtained from caffeine association and other sleep parameters indicated weak to no associations. Refer to Tables 11a-n in Appendix M for correlation coefficients obtained from caffeine association and other sleep parameters.

Table 26. An overview of the correlation coefficients for the relationship between consumption of caffeine in relation to sleep variables (τb, $p<0.05$). Weak to moderately medium correlation coefficients are indicated by the asterisk.

	Weekday Sleep onset latency	**Sleep-wake problems scale**
Frequency of consumption soda with caffeine	0.16 *	0.06
Frequency of consumption coffee or tea with caffeine	0.1	0.17 *

4.2.5.4 Use of electrical devices in relation to sleep variables

The most frequently used electrical device before bedtime was a smartphone with only 2.3 % stating they never use it before bedtime and 70 % (n=154) reporting "always" using smartphones before bedtimes. The second most used device before bedtime was laptops (Table 27). 85 % (n=170) of respondents reported never using a videogame before bedtime, making it the least used device before bedtime (Table 27).

Table 27. The frequency of Electronic Devices (EDs) usage before bedtime.

	Never % (n)	**Sometimes % (n)**	**Usually % (n)**	**Always % (n)**	**Total number of respondents using a device before bedtime % (n)**
Smartphone/ Cellphone	2.3 (5)	6.4 (14)	21 (46)	70 (154)	97 (214)
Laptop	27 (56)	37 (77)	20 (41)	17 (36)	74 (154)
Tablet	79 (161)	6.8 (14)	9.3 (19)	5.4 (11)	22 (44)
Television	62 (127)	22 (46)	9.7 (20)	6.3 (13)	38 (79)
Video games	85 (170)	10 (21)	3 (6)	2 (4)	15 (31)

When combined, over half (56 %; n=118) reported using their smartphones/cell phones for either thirty minutes to an hour or an hour to two hours and 21 % (n=45) reported times of more thantwo hours before bed. Of those learners that used laptops/computers, 31 % (n=51) reported usingit for less than thirty minutes and only 15 % (n=24) reported times of more than two hours. The same applied to tablets and television; most learners that used the devices did so for less than thirty minutes. Interestingly, for those that played video games, over half (59 %; n=45) reported times of more than two hours (Table 28).

Table 28. A summary of reported time spent on using Electronic Devices before bedtime

	0-30min % (n)	**30min-1hr % (n)**	**1-2hrs % (n)**	**More than 2hrs % (n)**
Smartphone/Cell phone	22 (47)	28 (59)	28 (59)	21 (45)
Laptop/Computer	31 (51)	31 (50)	23 (38)	15 (24)
Tablet	61 (49)	17 (14)	14 (11)	8.6 (7)
TV	47 (48)	31 (32)	12 (12)	9.8 (10)
Video games (PlayStation, Xbox, etc.)	28 (21)	7.9 (6)	5.3 (4)	59 (45)

4.2.5.5 The correlation between the frequency of usage and time spent on Electronic Devices before bedtime and sleep parameters

Frequency of usage and time spent on a smartphone before bedtime demonstrated a significant but weak to medium positive correlation to both weekday and weekend bedtimes. Therefore, increased frequency and time spent on smartphone usage before bedtime was likely linked to later bedtimes (Table 29).

Similarly, the frequency of use and time spent on laptops/computers before bedtime demonstrated a weak to medium positive correlation to weekday waketimes and the scale of the sleep-wake problem. Therefore, increased frequency and time spent on laptop/computer usage before bedtime was likely linked to later weekday waketimes and more problems/disturbances associated with sleep (Table 29).

Time spent on tablet usage demonstrated a weak and positive correlation to weekday bedtimes,

indicating that prolonged use of a tablet before bedtime may somewhat be linked to later bedtimes. Time spent on tablet usage also demonstrated a medium and negative correlation to the M/E scale. Therefore, prolonged usage of a tablet before bedtime is somewhat linked to lower scores on the M/E scale and indicative of eveningness (Table 29).

Frequency of use and time spent on video games before bedtime demonstrated a medium and negative correlation to weekend sleep onset latencies as well as a weak and positive correlation to weekend bedtimes. Therefore, frequent usage of video games is somewhat related to shorter sleep onset latencies but later bedtimes on the weekends (Table 29). Please note that only correlation coefficients above 0.15 and medium correlations are demonstrated in Table 29. For other correlation coefficients for the use of EDs before bedtime in relation to other sleep, variables refer to Tables 12 to 16 in Appendix M.

Table 29. Correlation coefficients for the use of Electronic Devices before bedtime in relation to sleep variables (τb, $p<0.05$).

	Weekday Bedtime	**Weekday Waketime**	**Weekend Sleep onset latency**	**Weekend Bedtime**	**Sleep-wake Problems Scale**	**M/E Scale**
Frequency of device usage before bedtime						
Smartphone/Cell phone	0.17			0.17		
Laptop		0.2			0.18	
Video games				0.16		
Time spent on device before bedtime						
Smartphone/Cell phone	0.17			0.24		
Laptop		0.2			0.16	
Tablet	0.18					-0.21
Video games			-0.22			

4.2.6 Grade Point Average Differences in relation to sleep variables

In this section, results are presented on the relationship between academic performance and sleep variables.

With reference to Table 30, mean weekday self-reported waketime showed a medium positive association to reported academic performance (measured by grades): learners who reported the lowest performance were also more likely to report the earliest weekday waketimes. On the weekends, however, the association between academic performance and waketimes was negative and weak meaning that learners who reported the lowest performance were somewhat prone to reporting later waketimes. Learners who reported the lowest performance were also somewhat prone to delaying their bedtime on weekends more: this association between the variables, however, was weak. There was a medium negative association between reported academic performance and mean weekend sleep duration as well as WWD, meaning that learners who reported the lowest performance were also more likely to have a longer sleep duration and more delayed waketimes on the weekends. In the data represented in Table 30, the values with an asterisk represent medium associations.

Table 30. An overview of the relationships between academic performance and self-reported sleep variables for the Grade 12 sample. Weak to moderately medium correlation coefficients are indicated by the asterisk.

Acade-mic Performance	**Weekday *correlation coefficients* (τ_b, p<0.05)**					
	Mean sleep duration	**Mean sleep onset latency**	**Mean reported bedtimes**	**Mean reported waketimes**		
	0.04	-0.07	-0.01	0.24 *		
	Weekend *correlation coefficients* (τ_b, p<0.05)				**WBD**	**WWD**
	-0.15 *	-0.04	-0.08	-0.1	-0.1	-0.18 *

While there were no associations between academic performance in mean scores obtained from the sleepiness, depressed mood, and morningness-eveningness scale, there was a weak positive

association between the sum of the sleep-wake problem scale which means that those learners who reported the highest-grade averages were also somewhat prone to experiencing more problems or disturbances in sleep (Table 31).

Table 31. A summary of the correlation coefficients for the relationship between academic performance and other sleep variables (τb, $p<0.05$).

	Sleepiness scale	**Sleep-wake problems scale**	**Depressed mood scale**	**Morningness Eveningness scale**
Correlation with academic performance	-0.03	0.1	0.07	-0.04

4.3 Phase Two

In this section, firstly, the sample characteristics are outlined. Thereafter, weekday and weekend actigraph data are presented. This is followed by weekday and weekend sleep diary data. Finally, results from actigraph and sleep diaries are analysed together and reported on. The following results should be interpreted in the context of the study's broader limitations. As already mentioned, due to the implementation of a lockdown as a result of the pandemic in South Africa, the sample size in Phase two was limited to 14 and only included students in boarding and thus, the results are largely descriptive.

4.3.1 Sample Characteristics

A total of 14 Grade 11 learners from one school participated in sleep diary and actigraph recording. The sample was from a private school and all the learners were boarders in the Makhanda area. Learners were aged between 15-17 (16±0.6) years.

4.3.2 Sleep Behaviors

4.3.2.1 Actigraph data

As shown in Table 32, based on the actigraph recording data, weekday bedtimes did not differ significantly from weekend bedtimes ($p=0.09$, $z=1.7$). However, waketime on the weekends was

significantly later than that recorded for weekday waketimes ($p<0.01$, $z=3.1$; Table 32). As a result, total sleep time was significantly longer on the weekends, relative to the weekdays. ($p<0.01$, $z=3.0$; Table 32). However, there were no significant differences in weekday and weekend sleep onset latencies ($p=0.69$, $z=0.4$; Table 32).

Another important parameter recorded by actigraphs was Wake After Sleep Onset (WASO), which measures the time of nocturnal awakenings or wakefulness that occurs after one has fallen asleep. WASO, during the weekends, did not differ from that recorded during the weekdays ($p=0.09$, $z=1.7$, Table 32. There were also significantly more nocturnal awakenings occurring on weekends relative to weeknights ($p=0.04$, $z=2.1$, Table 32). Sleep efficiency, which refers to the percentage of time spent asleep while in bed was higher on weekdays but also not significantly different to weekends as indicated in Table 32 ($p=0.08$, $z=1.8$).

Table 32. An overview of actigraph recorded data of sleep variables on weekdays and weekends. Plain font: mean and standard deviation, *italic font: median and) quartile ranges 1 and 3*. Significant differences are denoted by the use of an asterisk*

Actigraph recording			
	Weekday Mean (±s.dev) ***Median (Q1-Q3)***	**Weekend Mean (±s.dev)** ***Median (Q1-Q3)***	***P-value***
Bedtime	10:51 p.m. (±00:25) *10:51 p.m. (10:41 p.m.-11:02 p.m.)*	11:06 p.m. (±00:29) *11:00 p.m. (10:54 p.m.- 11:28 p.m.)*	0.09 (z=1.7)
Waketime	06:36 a.m. (±00:21) *06:33 a.m. (06:20 a.m.- 06:49 a.m.)*	07:51 a.m. (±00:43) *07:51 a.m. (07:35 a.m.- 08:07 a.m.)*	<0.01 (z=3.1) *
Total Sleep Time (hr:mins)	07:11 (±00:26) *07:06 (06:54-07:35)*	08:07 (±00:52) *08:16 (07:22-08:40)*	<0.01 (z=3.0) *
Total Time in Bed (hr:mins)	08:25 (±02:01) *08:01 (07:30 - 08:33)*	09:00 (±01:40) *08:20 (08:14 -09:10)*	
Sleep onset latency (minutes)	6 (±13) *1 (0-4)*	5 (±10) *1 (0-9)*	0.69 (0.4)
#Nocturnal Arousals	8 (±5) *7 (4-11)*	12 (±8) *11 (6- 16)*	0.04 (2.1) *

WASO (minutes)	32 (±16) *36 (17- 41)*	40 (±24) *47 (24-52)*	0.09 (z=1.7)
Sleep efficiency (%)	90 (±6) *91 (87- 96)*	85 (±12) *89 (81-93)*	0.08 (z=1.8)

4.3.2.2 Sleep diary data

Based on the sleep diary recordings, weekend bedtimes were significantly later than weekday bedtimes (p=0.03, z=2.2; Table 33). Similarly, self-reported waketimes on the weekend were significantly later than self-reported weekday waketimes (p<0.01, z=3.06; Table 33). This resulted in the self-reported sleep durations being significantly longer on the weekends, relative to weekdays (p=0.03,z=2.2; Table 33). There were no significant differences in sleep-reported weekday and weekend sleep onset latencies (p=0.78, z=0.3; Table 32). Learners also reported the occurrence of nocturnal awakenings once on weekdays and weekends as indicated in Table 33.

Table 33. A summary of sleep diary self-recordings of sleep variables on weekdays and the weekends. Plain font: mean and standard deviation, *italic font: median and quartile ranges 1 and 3.* Significant differences are denoted by the use of an asterisk*

Sleep Diary recordings			
	Weekday Mean (±s.dev) ***Median (Q1-Q3)***	**Weekend Mean (±s.dev)** ***Median (Q1-Q3)***	***P-value***
Bedtime	10:56 p.m. (±00:34) *10:53 p.m. (10:43 p.m.- 11:05 p.m.)*	11:18 p.m. (±00:22) *11:15 p.m. (11:10 p.m.-11:34 p.m.)*	0.03 (z=2.2) *
Waketime	06:35 a.m. (±00:19) *06:36 a.m. (06:21 a.m.-06:41 a.m.)*	07:46 a.m. (±00:28) *07:48 a.m. (07:23 a.m.-08:05 a.m.)*	<0.01 (z=3.06) *
Sleep duration (hr:mins)	07:40 (±00:37) *07:32 (07:22-07:55)*	08:23 (±00:48) *08:24 (07:59- 08:51)*	0.03 (z=2.2) *
Sleep onset latency (minutes)	14 (±7) *13 (8-16)*	13 (±8) *13 (7-17)*	0.78 (z=0.3)
#Nocturnal awakenings	1(±0) *0.7 (0.4-1)*	1 (±1) *1 (0.5- 1)*	0.1 (z=1)

4.3.2.3 Comparison of Actigraphs and sleep diaries in relation to sleep variables

The following section describes data obtained from the actigraphs and sleep diaries. It highlights differences in weekday and weekend sleep variables between the two instruments as indicated in Table 34. Variables to be considered are bedtimes, waketimes, sleep onset latency, total sleep duration, total sleep time, and nocturnal awakenings.

Bedtimes, waketimes, sleep duration, total sleep time, and sleep onset latency, for both weekdays and weekends, did not differ significantly between the sleep diary and actigraph responses (Table 34). However, the number of nocturnal awakenings recorded by the actigraphs was significantly higher on weekdays and weekends relative to sleep diary recordings (Table 34).

Table 34. A comparison of weekday and weekend sleep variables between actigraph recorded values and sleep diary values. Plain font: mean and standard deviation, *italic font: median and quartile range 1 and 3*. Significant differences are denoted by the use of an asterisk*

	Weekdays			**Weekends**		
	Actigraphy	**Sleep diary**	***P-value***	**Actigraphy**	**Sleep diary**	***P-value***
Bedtime	11:51 p.m. (±00:25) *11:51 p.m. (10:41 p.m-11:02 p.m.)*	10:56 p.m. (±00:34) *10:53 p.m. (10:43 p.m.-11:05 p.m.)*	0.67 (z=0.4)	11:06 p.m. (±00:29) *11:00 p.m. (11:54 p.m.-11:28 p.m.)*	11:18 p.m. (±00:22) *11:15 p.m. (11:10 p.m.-11:34 p.m.)*	0.3 (z=1.0)
Waketime	06:36 a.m. (±00:21) *06:33 a.m. (06:20 a.m.-06:49 a.m.)*	06:35 a.m. (±00:19) *06:36 a.m. (06:21 a.m.-06:41 a.m.)*	0.9 (z=0.1)	07:51 a.m. (±00:43) *07:51 a.m. (07:35 a.m.-08:07 a.m.)*	07:46 a.m. (±00:28) *07:48 a.m. (07:23 a.m.- 08:05 a.m.)*	0.6 (z=0.5)
Total Sleep Time/ Self Reported Sleep Duration (hr:mins)	07:10 (±00:26) *07:06* *(06:54-07:35)*	07:40 (±00:37) *07:32* *(07:22-07:55)*	0.18 (z=1.3)	08:07 (±00:52) *08:16* *(07:22-08:40)*	08:23 (±00:48) *08:24* *(07:59-08:51)*	0.3 (z=1.1)
Sleep onset latency (minutes)	6 (±13) *1 (0-4)*	14 (±7) *13 (8-16)*	0.12 (z=1.6)	5 (±10) *1 (0- 9)*	13 (±8) *13 (7-17)*	0.1 (z=1.9)
#Nocturnal arousals/ #Nocturnal Awakenings	8 (±5) *7 (4-11)*	1(±0) *0.7 (0.35-1)*	<0.01 (z=3.1) *	12 (±8) *11 (6-16)*	1 (±1) *1(0.5-1)*	<0.01 (z=3.1) *

CHAPTER V
DISCUSSION

This chapter aims to discuss the overall findings with regards to adolescent sleep-wake behaviors in a sample of Grade 12s across both private and public schools (Phase one) and a smaller cohort of Grade 11s from a private school situated in Makhanda in South Africa (Phase two). Following this, the overall results obtained from Phases one and two will be integrated and discussed further.

5.1 Phase one

The aim of Phase one was to explore and characterize the self-reported sleep-wake habits of a sample of Grade12 adolescents from local private and public high schools using data from the School Sleep Habits Survey (SSHS). Below, the overall findings in relation to weekday and weekend sleep durations, bedtimes, waketimes, delay in weekend bed, and wake times are outlined and discussed. Thereafter, other variables obtained from the survey, namely sleepiness problem, sleep-wake problems, depressed mood, and morningness/eveningness scales are also expanded upon, while the effects of demographic factors, such as sex, public or private schooling, and day scholar or boarder status are discussed.

In summary, the first part of the study found that the overall self-reported sleep duration on weekdays and weekends was shorter than the recommended 8-10 hours (American Academy of Pediatrics, 2016), for adolescents. But importantly this was evident in the majority (i.e., 87%) of the sample on weekdays and on weekends, only 30% of the sample reported less than 8 hours of sleep. Findings also suggested that, on the weekends, all learners had later bed and wake times in comparison to weekdays. Learners in this cohort reported experiencing relatively low levels of daytime sleepiness, and a trend towards a high prevalence of depressive symptoms. These findings are discussed in more detail in the subsequent paragraphs.

5.1.1 Overall self-reported sleep behaviors on weekdays and weekends

5.1.1.1 Self-Reported Sleep durations

Despite the recommended range with a minimum of 8 and a maximum of 10 hours of sleep for the maintenance of optimal health and functioning, as well as to sustain daytime alertness (American Academy of Pediatrics, 2016), the Grade 12 learners in this sample reported a weekday sleep duration that is less than 8 hours. This is of concern as less than 8 hours of sleep is defined as insufficient sleep in this age group by the National Sleep Foundation and other researchers in the field (Mary *et al*., 1980; Carskadon and Acebo 2002; Reid *et al*., 2002; Yang *et al*., 2005; Wolfson *et al*., 2007; Lund, Reider, Whiting, and Prichard, 2010; Hirshkowitz *et al*., 2015; American Academy of Pediatrics, 2016; Fuligni *et al*., 2017; Short *et al*., 2018). The majority (87%; n=202) of the sample reported getting less than 8 hours of sleep on weeknights. Only 13% (n=29) reported getting 8 or more hours of sleep during weeknights. The self-reported weekday sleep duration in this sample is less than reported ranges in other parts of the world such as 07hrs18mins-08hrs36mins as reported in some Asian countries (Chung and Cheung, 2008; Huang *et al*., 2010; Ouyung *et al*., 2009; Shochat *et al*., 2010); 07hrs04mins-08hrs:15mins reported in the US (Wolfson and Carskadon, 1998; Knutson and Lauderdale, 2009; Malone *et al*., 2016), 07hrs:30mins reported in Europe (Lazaratou *et al*., 2005) and 08hrs06mins reported in Australia (Gamble *et al*., 2014), but more than the 05hrs24mins-06hrs18mins reported in other Asian countries (Ohida *et al*., 2004; Yang *et al*., 2005).

In contrast, the majority (70%; n=162) reported getting 8 or more hours of sleep during the weekend. It is worth noting that even on the weekend, self-reported sleep duration was still below 8 hours but closer to the recommended sleep hours for this demographic (Hirshkowitz *et al*., 2015; American Academy of Pediatrics., 2016; Fuligni *et al*., 2017; Short, *et al*, 2018). Studies in other parts of the world such as Asia, America, and Australia have also reported weekend sleep durations longer than 8 hours and ranging between 08hrs07mins to 11hrs (see: Chung and Cheung, 2008; Gau and Song, 1995; Huang *et al*., 2010; Gamble *et al*., 2014; and Lauderdale, 2009; Malone *et al*., 2016; Ohida *et al*., 2004; Ouyung *et al*., 2009; Wolfson and Carskadon, 1998; Yang *et al*., 2005).

Some studies did not report on specific weekday/weekend sleep variables but gave overall sleep durations with weekdays and weekends combined. This included 07hrs42mins in Iran (Ghanizadeh *et al*., 2008); 07hrs29mins in Greece (Lazaratou *et al*., 2005); 06hrs20mins in Japan (Tagaya,

Uchiyama, Ohida, Kamei, Shibui, Ozaki,and Takahashi., 2004); 07hrs21mins in Australia (Bei, Allen, Nicholas, Dudgeon, Murray, and Trinder, 2014) and in South Africa, Reid *et al*. (2002) reported an overall sleep duration of just over 07hrs. Based on the self-reported sleep durations, it seems adolescents in this sample experience shorter sleep durations both on weekdays and on the weekends in comparison to adolescents in other countries. An important finding and recommendation for future research in this area are to ensure that sleep is tracked or reported for both weekdays and weekends, given the differences that may be observed between these two times. Multiple reasons could account for these observations all of which will be explored in sections to follow below.

5.1.1.2 Reported bedtimes

In this study, on weeknights, the most prevalent reasons self-reported for bedtimes were "I feel sleepy" and "I finish my homework". This, therefore, means that on weeknights, in this sample the late bedtime may have been influenced predominantly by bioregulatory pressures (Crowley *et al*., 2007) and psychosocial pressures, specifically academic demands, which, during the final year of school, may have had an impact on sleep-wake behaviour. This given that it is the last year of high school and academic achievement is essential for acceptance into a university or college or the labor market. In line with other research findings, as adolescents grow older, they become more independent, there is less parental control over bedtimes, and even with boarders, as students' progress through the grades, there is more leniency and freedom with regards to bedtimes (Yang *et al*., 2005; Crowley *et al*., 2007; Gradisar *et al*., 2011). Therefore, Grade 12s are more likely to set their bedtimes, with the reason being that they are expected to need more time to study and do homework and it is quite possible that they may have had no other time in the day to do it, this is usually at the expense of adequate sleep (Yang *et al*., 2005; Crowley *et al*., 2007; Gradisar*et al*., 2011).

On the weekend, self-reported bedtime in this sample was significantly later than that reported during the weekdays. Weekend bedtime appeared to be influenced predominantly by psychosocial pressures, specifically socializing (in person or over an electronic device). This is a common observation, given that adolescence is also accompanied by more socializing and use of EDs usually at their discretion (Carskadon, 1990a; Ohayon, Roberts, Zulley, Smirne, and Priest, 2000; Dahl and Lewin 2002; Loessl, Valerius, Kopasz, Hornyak, Riemann, and Voderholzer, 2008). Adolescents are a population group that is invested in their social lives and building relationships

with peers (Dahl, 2004; Curtis, 2015) and that is no different in this sample. This, therefore, curtails sleep time.

The difference between weekday and weekend bedtime, referred to as the Weekend Bedtime Delay (WBD) was an hour-long. This WBD is similar to that of Gamble *et al*. (2014) who reported that Australian adolescent bedtime was also an hour later on weekends. Interestingly, the WBD reported in this study was approximately an hour less than results obtained from a meta-analysis of 41 surveys of worldwide adolescent sleep patterns and problems conducted by Gradisar *et al*. (2011) who concluded that generally, weekend bedtimes are two or more hours later on weekends, when compared to weekday bedtimes. Several studies in various countries also report WDB of two or more hours and include findings from Poland (Szymczak *et al*., 1993); Finland (Saarenpää-heikkilä *et al*., 1995); Italy (Giannotti *et al*., 1997); North America (Wolfson and Carskadon, 1998), China (Cheung *et al*., 1999; Gau and Soong., 2003), and Taiwan (Huang *et al*., 2010). A possible explanation for this is that adolescents in this cohort are most likely not delaying their weekend bedtimes as much as other adolescents in other countries because, during the week, they sleep less than other adolescents, so they get more tired as a result of having accumulated greater sleep debt. In addition to this, over half of the sample consisted of adolescents who lived in boarding houses or hostels and so were likely to have institutionally and socially aligned times that did not change too much on the weekends in relation to the weekdays, while students in other studies were not boarders (Szymczak *et al*., 1993; Saarenpää-heikkilä *et al*., 1995; Giannotti *et al*., 1997; Wolfson and Carskadon, 1998; Cheung *et al*., 1999; Gau and Soong., 2003; Huang *et al*., 2010). An alternative explanation might be that the South African sample may have had an earlier chronotype than adolescents in other parts of the world such as Poland, (Szymczak et al., 1993); Finland (Saarenpää- heikkilä et al., 1995); Italy (Giannotti et al., 1997); North America (Wolfson and Carskadon, 1998), China (Cheung et al., 1999; Gau and Soong., 2003), and Taiwan (Huang et al., 2010) given that weekend sleep timing is typically more reflective of chronotype than week timing.

5.1.1.3 Self-Reported Waketimes

The self-reported weekday waketimes from this study were in accordance with other studies that also reported weekday waketimes of 06:00-07:30 a.m. in high school students (Gau and Soong, 1995; Lee *et al*., 1999; Van den Bulck, 2004; Crowley *et al*., 2007; Ghanizadeh *et al*., 2008; Gamble *et al*., 2014). In a longitudinal study carried out for 2.5 years by Crowley, Van Reen,

LeBourgeois, Acebo, Tarokh, Seifer, and Carskadon (2014) weekday waketime was between 06:20 and 06:30 a.m during the ages of 15-17 years. In the present study, on weekdays, many of the learners (61%) reported waking up because of an alarm, which can be interpreted as waking up at a specific time through the use of an alarm to get ready for school. School start times have been identified as the major contributing factor not only for early waketimes but also to short and ill-timed sleep in adolescents (Yang *et al*., 2005; Knutson and Lauderdale, 2009; Crowley *et al*., 2018). Typically, school start times tend to begin earlier for higher grades (Crowley *et al*., 2007; Wolfson *et al*., 2007). Since school start times were between 07:15-07:30 a.m. for the Grade 12s in this study, on average, learners reported leaving home/hostel at 07:06 a.m. for school. These early start times are in direct opposition to the natural tendency to want to sleep later due to the circadian phase delay that tends to occur during late adolescence (Carskadon *et al*., 1998b; Reid *et al*., 2002; Wolfson *et al*., 2007; Bartel *et al*., 2015). The fact that these adolescents don't wake up spontaneously and that a large portion of this sample needed an alarm to do so on weekdays provides some evidence for the learners waking up prematurely and is most likely as a result of the late weekday bedtimes and early waketimes (Lee*et al*., 1999; Reid *et al*., 2002; Yang *et al*., 2005; National Sleep Foundation, 2006).

On the weekends, self-reported waketimes were significantly later when compared to weekdays, with the difference between the two, referred to as the Weekend Waketime Delay (WWD) being almost two hours long. This is longer than the 34-39 minutes as reported by Andrade *et al*., (1993) among Brazilian adolescents. It is, however, similar to the two hours reported by Gamble *et al*. (2014), but shorter than findings from other countries such as Korea and Spain who reported longer WWDs of 3-3.5 hours in older adolescents (Yang *et al*., 2005; Mateo *et al*., 2012). The current findings, therefore, points to evidence of weekend oversleep, a phenomenon that is commonly observed in the adolescent population and is widely reported in the literature (Saarenpaa-Heikkila et al., 1995; Carskadon et al., 1998a; Laberge et al., 2001). Weekend oversleep in this cohort can be interpreted as a means of compensating for the sleep debt that occurs as a result of short sleep durations obtained during the week which is indicated by the increase in sleep duration on the weekends and this is contributed to by a combination of late bedtimes and early waketimes during the week (Carskadon et al., 1998a; Yang et al., 2005) all of which were observed in this cohort.

5.1.1.4 Other sleep-related variables

Overall, with regards to other sleep variables, 65% of this study sample perceived themselves to

be good quality sleepers. A large proportion of the learners (75%) perceived themselves as getting too little sleep and just 1.0% perceived themselves as getting too much sleep. Less than half (40%) reported no occurrences of nocturnal awakenings. This finding was consistent in South African adolescents as reported by Reid *et al*. (2002). Half of the study sample reported waking up at least once during the night while some (8.7%) of the sample reported having no idea how often they awaken during their sleep. Reporting no occurrences of nocturnal awakenings was associated with good quality sleep while nocturnal awakenings of more than three times were associated with poor quality sleep. Poor quality sleep was also associated with getting too little sleep. Munezawa *et al*. (2011) proposed that this association may occur as a result of long onset sleep onset latencies or perhaps as a result of nocturnal awakenings followed by troubles going back to sleep. It may be possible to attribute the association of poor-quality sleep and getting too little sleep to the occurrence of nocturnal awakenings. Interestingly, among those who considered themselves as good sleepers, 72% also reported that they obtained too little sleep, which may be attributable to the impact of late bedtimes, early wake times, nocturnal awakenings reported from within the group.

38% of adolescents in this study sample reported taking daytime naps on the weekdays and 13% on the weekends. These figures combined were comparable to over 40% as reported by Malone *et al*. (2016) among 15-18-year-old adolescents in a USA sample, but less than the 77% prevalence reported by Reid *et al*. (2002) in another sample of South African adolescents. It is worth noting however that Reid *et al*. (2002) sampled adolescents in various age groups and grades while this study sample consisted of only Grade 12s, who may have had more academic and extracurricular activities such as sporting commitments and increased social activities in addition to having classes after lunchtime, than the younger cohort in Reid *et al*. (2002). Therefore, older adolescents may most likely have less time to nap during the week due to more commitments. Another important consideration is that the questionnaire used by Reid *et al*. (2002) focused on just the previous day/night and therefore may only represent sleep behaviour within just that limited period whereas this study obtained data over a prolonged period.

Daytime napping is not uncommon in adolescents. Afterall, adolescents have been reported to take regular naps, more so as they grow older (Gau and Soong, 1995; Manni *et al*., 1997; Wolfson and Carskadon, 1998; Reid *et al*., 2002; Sadeh, *et al*., 2003; Wolfson *et al*., 2003a; Fredriksen *et al*.,

2004; Lazaratou *et al*., 2005). This has been suggested as a means of compensating for reduced sleep durations at night (Reid *et al*., 2002), which, based upon the observations of the weekday sleep-wake behavior may explain why over half of the sample reported needing to nap. Based on the two-process model of sleep (Borbély, 1982), which describes the interactions of the homeostatic sleep drive and the circadian clock, if adolescents are not getting enough sleep, their sleep pressure remains high even at the start of the day and as a result, adolescents may nap to combat daytime sleepiness.

However, napping during the day may also have contributed to the late bedtimes reported by adolescents in this group, given that prolonged daytime napping can interfere with sleep onset at night (Jakubowski, Hall, Lee, and Matthews, 2017). In this cohort, more of the adolescents reported napping on weekdays relative to the weekend, which may be explained by the fact that they slept longer on weekend nights than weekday nights. This in turn means that oversleep on the weekend results in less sleep pressure and a reduced need to nap on the weekends. It may also be that weekend waketime was less constrained which means adolescents can extend their sleep time as discussed by Jakubowski *et al*. (2017). Another likely possibility may be due to learners in these schools participating in sport-related activities on the weekends, particularly on Saturdays, which may affect the chance to nap. However, in this particular study, learners were not asked about the specific days in which they engage in sport.

The majority (74%) of Grade 12 learners reported having a somewhat little problem with daytime sleepiness while just less than 20% considered themselves as having a somewhat big problem with sleepiness during the day. In other adolescent samples, poor sleep quality has been identified as being one possible cause of daytime sleepiness (Dewald *et al*., 2010). From the results obtained in this particular study, there was no association between perceived daytime sleepiness and perceived sleep quality. However, reduced sleep duration has also been identified as being one possible cause of daytime sleepiness (Dewald *et al*., 2010). In this study sample, learners may be feeling sleepy during the day because they are getting too little sleep during the night. Perhaps then this shows the limitations of self-assessment of sleepiness because it can be affected by a host of different elements of sleep and perhaps this warrants further investigation.

Therefore, with regards to addressing the first objective of this study which was to characterize the sleep-wake behaviour of learners in this context and then to report on and make comparisons

between weekdays and weekend sleep-wake behaviour, the following findings were noted. Based on self-reports, Grade 12 learners in this sample obtained insufficient sleep on weeknights, which is a result of a combination of late bedtimes and early waketimes. Ill-timed sleep in this cohort, on weeknights, was influenced predominantly by an increase in sleep pressure i.e., "feeling sleepy" as well as academic demands as indicated by the response "I finish my homework". While early weekday waketimes were largely influenced by school start times. On the weekend, Grade 12 learners reported obtaining borderline sufficient/insufficient sleep durations because they could sleep later, despite going to bed later during weekend nights. It appears therefore that weekend oversleep in this cohort occurs as a result of sleep debt that accumulates during the week due to late bedtimes, early waketimes, and consequently insufficient sleep. Furthermore, the weekend bedtime delay in this cohort was relatively small which may point to the fact that adolescents in this sample were suffering from sleep loss and high sleep pressure, due, possibly, to insufficient sleep, the majority of the sample reported experiencing some level of daytime sleepiness. Therefore, perhaps in attempts to combat daytime sleepiness and as a means of compensating for insufficient sleep durations during the week over half of the adolescents reported daytime napping. Interestingly, although over half of the learners reported being good quality sleepers, the majority also perceived themselves as getting too little sleep and experiencing varying degrees of nocturnal awakenings.

5.1.2 Personal and other characteristics in relation to sleep variables

The second objective of this study was to explore the impact of certain demographic factors (such as learner sex, whether they attended public or private schools, and whether they were boarders or day scholars) on sleep-wake behaviour. This is important given that the sample consisted of boys and girls, boarders and day scholars as well as public and private school learners.

5.1.2.1 Self-reported sex differences in sleep-wake patterns

With regard to sex differences, on weekdays, female learners who woke up later were also more likely to report problems/disturbances in sleep and more prevalent depressive mood symptoms. Males were more likely to lean towards a morning preference.

There were no significant sex differences in weekday and weekend self-reported sleep duration, sleep onset latency, and bedtimes. This finding was consistent with other research that also reported

no sex differences in sleep duration (Lee *et al*., 1999; Lazaratou *et al*., 2005; Yang *et al*., 2005), in weekend bedtimes (Lee *et al*., 1999; Yang *et al*., 2005) and sleep onset latency (Carskadon *et al*., 1998a). While there were no sex differences for weekend waketimes, there were significant differences in weekday waketimes between the sexes with females reportedly waking up significantly later than male learners. This may be accounted for by the fact that the males reported leaving home/hostel 15 minutes earlier than females. This is in contrast to other survey studies who reported that high school female learners usually have earlier weekday waketimes (Carskadon 1990a; Gau and Soong, 1995; Link and Ancoli-Israel, 1995; Saarenpää-Heikkilä *et al*., 1995; Carskadon *et al*., 1998a; Wolfson and Carskadon, 1998; Lee *et al*., 1999; Van den Bulck, 2004; Yang *et al*., 2005; Loessl *et al*., 2008) and also to other studies that reported no sex differences in waketimes (Ghanizadeh *et al*., 2008).

In this study, the majority of the females (71%) and a little over half of the males (53%) reported "my alarm clock wakes me up" as the main reason for their weekday waketimes. More of the males (22%) reported "The bell in hostel/boarding school wakes me up" relative to females (3.4%). On the weekends, almost half (42%) of the females and a little over half (55%) of the males reported "I don't know. I just wake up" as their main reason for weekend waketimes. However, more females than males reported waking up because of an alarm while more males reported waking up because of the bell in hostel/boarding school. The sex differences in the drivers for weekday and weekend waketimes are interesting to note because while males were almost evenly distributed between being boarders or day scholars, most of the females in the study sample (69%) were boarders yet more males reported waking up because of the bell in hostel/boarding house. Although it is not clear why more females rely on an alarm clock for waking up more than males, a possible explanation may be that females in this cohort wake up after the hostel/boarding school bell rings through the use of an alarm since findings demonstrated later weekday waketimes among females. Also, the fact that more females were boarders relative to males may account for why the males reported leaving earlier to go to school as more would have had to commute. This means that female students spend less time commuting to school relative to their male counterparts, which is supported by the observation that 70% of female learners reported walking to school relative to males (58%). This observation might also be due to the fact that school start times and days are structured in much the same way across the different schools in this particular study sample.

In this study, females scored significantly higher on the scale of the sleep-wake problem, indicating a higher likelihood of experiencing problems/disturbances in sleep. This is in line with previous studies that found that female adolescents are more likely to experience sleep problems (Manni *et al*., 1997; Ohida *et al*., 2004; Fischer *et al*., 2008). This was an unexpected finding in this study since females had later weekday waketimes and no other reported differences in sleep parameters when compared to male learners. Females also scored higher on the depressed mood scale indicating more prevalent depressive mood symptoms. This finding supports previous research as sex differences in rates of depressive moods are known to increase with age from around the ages of 13, through to late adolescence and often beyond that (Nolen-Hoeksema, 2002). Females are known to report more depressive symptoms and moods relative to males from early adolescents (Nolen-Hoeksema, 2002; Kuehner, 2003; Hankin, Mermelstein, and Roesch, 2007; El-Sheikh, 2016). In addition, sleep loss has been implicated in mental health challenges among adolescents (Liu and Buysse, 2006; O'Brien and Mindell, 2005; Fitzgerald *et al*., 2011). In this study, the association between being female and depressive mood symptoms may have to do with the fact that over half (68%, n=62) of the females in this sample were also boarders, but these differences in sleep-wake behaviour between boarders and day scholars are discussed in the next section. It is worth noting that in this sample, other factors may be responsible for the sex differences in depressive mood scoring. For example, females may be more concerned about their physical appearance as this contributes to social acceptance and popularity (Nolen-Hoeksema, 2002). While this may be only one of many factors driving the higher reported depressive moods score, this was beyond the scope of this thesis but is an area that may require more attention in future research.

With regards to the morning eveningness scale, it appears that males may be more morning-oriented relative to their female counterparts. Mateo *et al*. (2012) also describe females as more likely to lean towards eveningness with this observation having been reported from early adolescence. This could perhaps also be explained in part by the fact that females reach their peak (in terms of latest circadian phase delay and late chronotype) earlier than males (Roenneberg, Kuehnle, Juda, Kantermann, Allebrandt, Gordijn, and Merrow, 2007). More female learners reported napping on school days and the weekends relative to males; this is typical for evening chronotypes since according to other studies, evening chronotypes tend to experience shorter sleep durations, particularly during weekdays (Giannotti *et al*., 2002). In this cohort, since there were no sex differences in sleep duration, another plausible scenario that could account for higher

napping frequency among females may have to do with the fact that they had easier access to their beds given that more of them were boarders. More females perceived themselves as having a somewhat big problem with daytime sleepiness relative to males, with this finding being consistent with that of Yang *et al*. (2005). Daytime sleepiness is also characteristic of evening chronotypes, more so during weekdays because evening types are more likely to obtain inadequate sleep due to later bedtimes and early school start times (Giannotti *et al*., 2002).

5.1.2.2 Differences in self-reported sleep-wake behavior between boarders and day scholars

There were also some notable differences in sleep habits between boarders and day scholars. Day scholars reported earlier weekday waketimes, but no other differences in weeknight sleep parameters. On the weekend, however, day scholars reported later bed and wake times and as a result, day scholars also had a longer WWD. Despite having earlier weekend bedtimes, boarders reported shorter weekend sleep durations and were also more likely to experience problems/disturbances in sleep.

Weekend bedtime was later for day scholars relative to boarders. It may be that living in hostel/boarding houses limits adolescents from going to sleep too late or selecting their own bedtimes even on the weekends because boarders know that they have to be up at a certain time for breakfast or other activities which may influence their earlier bedtimes at leasr to some extent (Carskadon and Mancuso, 1988a; Carskadon and Mancuso, 1988b). Alternatively, this could be driven by social factors, given that a higher percentage of boarders chose “I finish socializing (In person or over an electronic device)” as their main reason for their weekday bedtimes when compared to day scholars. Boarders would likely have their peers in the same environment to socialize with and thus when they stop socializing, this would perhaps be a social cue to go to bed.

Possibly, due to the need to commute to school on weekdays, day scholars woke up significantly earlier. On weekends, however, day scholars reportedly woke up much later than boarders and consequently had longer weekend sleep durations. This finding is consistent with Owens *et al*. (2010) who reported that day scholars had longer sleep durations on the weekend relative to boarders. This likely reflects greater sleep debt in day scholars, most likely due to the earlier weekday waketimes that is a result of having to leave for school earlier due to the need to commute. However, this also indicates a great weekday-weekend sleep discrepancy for day scholars. In terms of factors that contributed to waketimes, on weekdays, 25% of the boarders reported waking up

because of the bell in hostel/boarding school, and 29% of the boarders reported this during the weekends. Another 29% of the boarders also reported being woken up by an alarm clock on the weekends relative to 8% of day scholars. This indicates that weekend waketimes in boarders are largely determined by the regulatory influences of living in a boarding house/hostel. Breakfast for example would be served at certain times and learners would therefore be expected to be up at those times. Day scholars, on the other hand, would have fewer restrictions on extending their waketimes on weekends.

Boarders scored significantly higher on the scale of the sleep-wake problem than day scholars. This finding is contrary to those of Vignau, Bailly, Duhamel, Vervaecke, Beuscart, and Collinet, (1997)who found that among French adolescents, more day scholars reported sleep problems relative to boarders. Adolescent boarders live in a unique context, where the seniors may have more independence along with hostel responsibilities and are not influenced by family commitments or constraints. Due to the greater independence, they may perhaps be more likely to adopt unhealthyhabits such as lack of sleep (Jacob and Kaushik., 2017). Lastly, more boarders reported napping on school days and the weekend relative to day scholars. There could be many factors this may be the case, including the fact that boarders can return to their rooms rather quickly during the afternoon without commitments – it would be difficult for day scholars to do this. In sum, day scholars probably wake up earlier on weekdays because they must travel a longer distance to get to school. On the weekends, it appears that day scholars have more freedom to select bed and wake times and are thus able to extend sleep time to compensate for early waketimes and short sleep durations reported during weekdays, while the weekend bed and wake times in boarders may be determined by regulatory influences of living in a boarding house/hostel. This, in part, may account for the insufficient amount of sleep among boarders during both the week and on the weekends, which inturn, may account for the higher score on the scale of the sleep-wake problem.

5.1.2.3 Reports of self-reported sleep variables in relation to the public vs private school learners

Public school learners had earlier bedtimes on weekdays but later bedtimes on weekends than private school learners did. Public school learners also had earlier weekday waketimes but later

weekend waketimes and therefore a longer delay in weekend waketime and longer sleep durations on the weekends. Public school learners were also more likely to lean towards morning preference, while private school learners were more likely to experience problems/disturbances in sleep and reported a higher prevalence of depressive mood symptoms.

Public school learners went to bed earlier and woke up significantly earlier on weekdays relative to private school learners. Over half of both public and private school learners reported waking up on weekdays mainly because of an alarm clock and a considerable amount of private school learners also reported waking up mainly because of the bell in the hostel/boarding house. In the interpretation of these results, it is important to take note of the fact that, a majority of the learners (79%) in private schools were also boarders while the majority of the learners (82%) in public schools were day scholars. This would therefore partially account for the differences in bedtimes, waketimes, and consequently reported sleep duration. This is because, as already mentioned, boarders usually live close to or on the school grounds which is why 82% of learners in private schools reported walking to school relative to just 28% of public-school learners. 16% of learners in public schools also reported taking a taxi to school relative to no learners in private schools having to take a taxi. Public school learners were required to commute to school, which results in necessary earlier weekday waketimes. The earlier start during each school day may mean that public school learners may feel sleepier earlier in the evenings, relative to the boarders,which may explain, in part, the earlier weekday bedtimes.

On the weekends, however, public school learners had longer sleep durations because of later waketimes. Public school learners also reported later weekend bedtimes and had longer WBD in comparison to those learners in private schools. Public school learners, therefore, have greater discrepancies in bedtimes and waking times between school and weekend nights. This may occur as a result of public-school learners compensating for the insufficient sleep they have obtained during weekdays as a result of earlier waketimes. Carskadon (1990a) also reported earlier weekday bed and wake times in public schools and attributed the difference of having to commute. While Makhanda is a small town and therefore the distance between school and home may be shorter relative to other cities or rural areas, other studies in bigger South African cities have reported on students travelling to and from school. In Johannesburg for example, de Kadt *et al*. (2014) reported that over a third of 1428 children in their cohort traveled for more than 6 km to school and 60%

attended school in a different suburb to the one they live in. Other studies in Cape Town (Fataar, 2010) and Durban (Hunter, 2010) also reported a lot of time spent on traveling to and from school which requires learners to wake up at earlier times than they would need to if they attended schools nearby.

It is also worth noting that although this study did not inquire about specific socioeconomic parameters, some studies have found associations between SES in relation to sleep in adolescents as in the general adult population (for example, Keyes *et al*., 2015). This is important because school choice in South Africa is influenced and largely determined by social and economic status (Jansen and Amsterdam, 2006; Ndimande, 2016). Taking all of this into account, future research in South Africa should therefore investigate the relationship between private and public schools, socioeconomic status, distance from school, modes of transport, and how these issues intersect with demographic factors to influence adolescent sleep.

Despite what has been discussed above, private school learners scored higher on the sleep-wake problems scale and the depressed mood scale. This might be because more private school learners perceived themselves as having a somewhat big problem with daytime sleepiness and a majority (83%) perceived themselves as getting too little sleep. This may be related to the fact that most private school learners were also boarders and so were more aware of the restrictions on sleep time and their movements more generally as a result of living in hostel. Boarders are also a group with unique constraints, where they are away from family for most of the time at least and have to learn to live without immediate family support and because of the greater independence, they may perhaps be more likely to adopt unhealthy habits such as lack of sleep which are factors that may contribute to depressive symptoms in this particular group (Jacob and Kaushik., 2017). With regards to the morning eveningness scale, public school learners scored significantly higher, indicating a higher morningness preference. This may be influenced, in part, by the earlier weekday wake and bedtimes observed in public school learners.

More private school learners reported sometimes napping on school days and the weekends in comparison to public school learners. None of the public-school learners reported napping during the weekend. This is related to the differences between boarders and day scholars with regards to daytime napping behavior. Keeping in mind that the majority (79%) of private school learners

were also boarders and the majority (82%) of public-school learners were also day scholars. More boarders reported napping on school days and the weekend relative to day scholars, as already mentioned above, the reason for this could be that boarders can return to their rooms rather quickly during the afternoon without commitments – whereas it would be difficult for day scholars to do this. It is also likely that public school learners do not nap during the weekend because they extend their sleep duration on the weekend and so their sleep pressure during weekends may not be as high as private school learners and hence, there is a reduced drive to nap.

5.1.3 The influence of Behavioral or lifestyle factors

This section discusses findings in relation to physical activity, caffeine consumption, use of EDs, and the impact these had on the participant's self-reported sleep.

5.1.3.1 The influence of sport or exercise activities on sleep variables

Although it has been postulated that because insufficient sleep results in tiredness and therefore reduced levels of physical activity, the majority of the adolescents in this study (72%; n=156) reported that they had engaged in some sort of organized sport or a regularly scheduled physical activity, including competitions in the last week. While some studies have associated physical activity with better sleep (Brand *et al*., 2009; Brand *et al*., 2010a), and specifically better sleep quality, shortened sleep onset latency, fewer nocturnal awakenings (Brand *et al*. 2010a), and earlier bedtimes (Bartel *et al*., 2015). Others have reported an association between physical activity and short sleep durations (Suppiah *et al*., 2015). In this sample, however, there were no significant associations with any of the sleep variables. This may be because the survey didn't ask about the timing or duration of physical activity or exercise and thus, the questions around sport and physical activities were limited in this regard. Decreased sleep duration among those adolescents who partake in sports activities has been attributed to early morning training (Sargent *et al*., 2014), in this case, all the schools sampled have established afternoon sports programs.

5.1.3.2 Relationship between caffeine consumption and sleep

53% of the learners reported the consumption of soda with caffeine and 75% reported the consumption of coffee or tea with caffeine daily. Consistent with research from the United States (Orbeta *et al*., 2006), adolescents in this sample were moderate to high caffeine consumers which

is concerning since caffeine has been identified as a risk factor for poor adolescent sleep (Bryant *et al*., 2010; Snel and Lorist, 2011; Bartel *et al*., 2015). In this study, adolescents who consumed coffee/tea or soda with caffeine more frequently were more likely to report longer overall sleep onset latencies, particularly on weekdays. Adolescents in the current study who reportedly drank coffee/tea with caffeine more frequently were also more likely to score higher on the scale of the sleep-wake problem, which may be indicative of a possible increased likelihood of experiencing difficulties or problems related to sleep. These results support the findings of others that have reported long sleep onset latencies and poor sleep quality, among adolescent coffee drinkers (Lee *et al*., 1999; Pollak and Bright, 2003; National Sleep Foundation, 2006; Orbeta *et al*., 2006; Ghanizadeh*et al*., 2008). Longer sleep onset latencies in caffeine consumers may occur because caffeine is a stimulant and its effects last for several hours (Lee *et al*., 1999). This, therefore, results in increased alertness, a decreased ability to sleep (Calamaro *et al*., 2009), and consequently, longer sleep onset latencies.

While the association between caffeine consumption and sleep problems has also been reported by Pollak and Bright (2003), it is not clear if caffeine causes problems or interrupts sleep or if adolescents are taking caffeine as a result of disturbances in sleep (Pollak and Bright, 2003). In short, it is difficult to determine the direction of this effect given that the relationship between caffeine use and sleep loss is bi-directional. In this sample, it is difficult to determine the direction of causality given caffeine can negatively affect sleep, but similarly, the learners could be using caffeine to compensate for being asleep.

5.1.3.3 The use of Electronic Devices (EDs)

In this sample, high frequency of use and longer time spent on EDs before bedtime was associated with later bedtimes, later waketimes, higher scores on the scale of the sleep-wake problem, and lower scores on the morningness-eveningness scale which is indicative of eveningness. Increased time spent on video games on the weekend was also somewhat associated with shorter sleep onset latencies. Associations with delayed sleep-wake schedules in relation to EDs use have also been reported by other researchers (Van den Bulck, 2004; Eggermont and Van den Bulck, 2006; Shochat *et al*., 2010; Arora *et al*., 2014; Gamble *et al*., 2014). In this study, on the weekends many of the adolescent participants chose “I finish socializing (in person or over an electronic device”) as their main reason for their reported weekend bedtime. On weekend nights, adolescents have more time to engage in socializing since they are usually not expected to wake up as early as they would

on school days and may therefore delay their bedtimes.

These findings are not different from trends in other parts of the world: amongst a cohort of American adolescents, 71% use multiple social media sites at a time, and 92% use the internet daily (Lenhart and Page, 2018). In another recent survey, while 95% of adolescents own a smartphone, 85% reported using their smartphones to access social media sites and a little less than half reported being constantly online through their smartphones (Anderson and Jiang, 2018). Other studies have also reported that adolescents who spent a lot of time using the internet on their computers also had later bedtimes both during weekdays and weekends (Cain and Gradisar, 2010; Gamble *et al*., 2014). These EDs are interactive and may cause arousal and that perhaps explains the delayed bedtimes (Cain and Gradisar, 2010; Short *et al*., 2013a; Gamble *et al*., 2014). Studies have also reported later waketimes and shorter sleep durations during weekdays in relation to internet usage (Do, Shin, Bautista, and Foo, 2013). The effects of ED use on sleep may be due to the fact that light from these devices suppresses the release of melatonin, therefore, delaying sleep initiation and thus bedtime (Wood, Rea, Plitnick, and Figueiro, 2013). Video gaming also results in mental arousal or excitation which may further contribute to delayed bedtimes. (Arora *et al*., 2014). In sum, in this cohort, the use of EDs before bedtime may contribute to delays in bedtime which in turn may contribute to the tendency to lean towards eveningness, and consequently, waketime is also delayed.

5.2 Phase two

The main aim of Phase two was to characterize sleep-wake behavior in a sample of Grade 11 female boarders using actigraphy and sleep diaries. Originally, the sleep-wake behaviour of boaders was going to be contrasted with a cohort of Grade 11-day scholars, but prior to the commencement of this part of the study, South Africa went into lockdown due to the COVID-19 pandemic.

5.2.1 Total Sleep Time and Self-Reported Sleep Duration

Findings from sleep diaries and actigraphic data demonstrated that the Grade 11s in this sample were obtaining weekday total sleep times of less than the recommended 8 hours of sleep in adolescents. The total sleep time obtained from this sample was comparable to 07hrs:04mins as

recorded by Malone *et al* (2016) and 07hrs:28mins obtained from USA adolescents (Park, Tsai, Dahl, Irwin, McCreath, Seeman, and Fuligni, 2016). While this was insufficient with regards to recommended sleep hours for this age group, it was slightly more than the mean weekday total sleep time of 6 hours in America (Matthews, Hall and Dahl, 2014); 6hrs:49mins in the Netherlands (Dewald, Meijer, Oort, Kerkhof, and Bögels, 2014) but shorter than the 08hrs - 08hrs:15mins as recorded in the US (Knutson and Lauderdale, 2009) and the 08hrs:12mins recorded by rural Chinese adolescents (Ouyang, Lu, Wang, Yang, Li, Wang, and Zee, 2009). Other studies obtained overall total sleep times of 6hrs:37mins in Italy (Tonetti, Fabbri, Filardi, Martoni, and Natale, 2015); 6hrs:40 mins in Australia, 07hrs:27mins in the USA (Park *et al*., 2016) and 7hrs in another sample of USA adolescents (El-Sheikh, 2016) all of which were also determined through the use of actigraphy.

Total sleep time, as determined through actigraphy was significantly longer on the weekends than on weekdays, which is a similar finding to other studies (see: Dewald *et al*. (2014); Matthews *et al*., 2014). The sleep duration self-reported in sleep diary entries was also longer on the weekend, also comparable to findings by Malone *et al*. (2016). It is worth noting that even on the weekend, total sleep time as recorded by actigraph devices was just slightly 8 more than hours and therefore may be considered borderline insufficient. These results echo the findings of Carskadon *et al*. (1998a) who also used actigraphic data and demonstrated even on the weekends, adolescents were still getting borderline insufficient sleep. However, as with the survey perhaps, we did not measure the impact of insufficient sleep on this cohort, and therefore, future research should consider exploring this.

5.2.2 Bedtimes

Actigrahic recorded bedtimes during the week were slightly later, but not significantly so, when compared to the weekend bedtimes. In line with previous research findings (Gau and Soong, 1995; Wolfson *et al*., 2003a; Crowley *et al*., 2007; Gradisar *et al*., 2011; Dewald *et al*., 2014), weekday bedtimes were just before 11:00 p.m. while weekend bedtimes were not long after 11:00 p.m. These bedtimes were comparable to the bedtimes of 10:59 p.m reported by Wolfson *et al*. (2003a) and 10:56 p.m. obtained by Dewald *et al*. (2014) for weekdays as well as 12:11 a.m. and 12:01 a.m. for weekend actigraph estimates obtained by Wolfson *et al*. (2003a) and Dewald *et al*. (2014) respectively. Bei *et al*. (2014) also sampled Australian adolescents and reported overall average

bedtime of 11:17 p.m. This was most likely a result of the sleep phase delay already described in adolescents. Also, these were Grade 11 boarders and perhaps had fewer restrictions with regards to bedtime since they are also becoming more independent and experiencing an increase in academic workload (Yang *et al*., 2005; Crowley *et al*., 2007; Gradisar *et al*., 2011). However, the WBD was less than that reported by Wolfson *et al*. (2003a) and Galland *et al*. (2018) respectfully.

The bedtime recorded in sleep diaries was significantly different between weekdays and weekends. This WBD is less than the 1 hour reported by Knutson and Lauderdale (2009). In comparison to another study that also used sleep diaries, Ouyang *et al*. (2009) reported bedtimes between 09:30 p.m to 10:30 p.m, which were notably earlier than reported in this sample. This could be attributed to the fact that adolescents in Ouyang *et al*.'s (2009) study were from a rural area and were, therefore, most likely not as exposed to things such as internet use, light,and late-night social activities in comparison to their urban counterparts. An important finding worth considering here is that bedtimes did not differ in actigraphy but did with sleep diaries. This may be attributed to the fact that, on the weekends, learners in this cohort recorded slightly later bedtimes. This may be because, on school nights, bedtimes are more closely tied and also perhaps influenced by being a boarder, house rules with regards to bed or waketimes or even school-start-time schedules. This would make it easier to record weekday bedtimes and therefore provide accurate estimates of weekdays relative to weekend bedtimes as argued by Wolfson et al. (2003a). Overall indicating that the learners in this sample have earlier bedtimes than they think on weekends.

5.2.3 Waketimes

Comparable to data obtained from the survey, the weekend waketimes measured by actigraphs and recorded on sleep diaries were significantly later when compared to weekdays. This finding suggests that weekend oversleep may occur to compensate for sleep loss and the impact of school start times on sleep during the week on both day scholars and boarders. Actigraph and sleep diary weekday waketimes in this sample were earlier than the 07:23 a.m. obtained by Dewald *et al*. (2014). This sample consisted of females, so the earlier waketimes may be related to grooming and dressing up in the mornings as has been hypothesized in other studies (Lin, Chang, Hurng, Wu, Yen, and Chang, 2018). However, it is also quite possible that the earlier waketimes in this sample were due to earlier school start times considering that the start time for this sample was between 07:15 and 07:30 a.m. This is worth noting since school start times have been identified as the major contributing factor for early

waketimes (Yang et al., 2005; Knutson and Lauderdale, 2009; Crowley et al., 2018) and also since the American Academy of Paediatrics (2014) has recommended that school start times for high schools be no earlier than 08:30 a.m. On the weekends, however, Dewald *et al*. (2014) and Knutson and Lauderdale (2009) reported slightly later waketimes and therefore longer WWDs. The female boarders in this sample may not be delaying their weekend bedtimes because being in boarding school limits their ability to do so, they may for example have to wake up at specific times on the weekends due to breakfast times, sporting commitments, hostel rules amongst other things. Other actigraphy studies did not differentiate between week and weekend waketimes, so it is difficult to compare the current study's results to these. Bei *et al*. (2014) and Tonetti *et al*. (2015) for example, reported overall waketimes of 07:20 a.m. and 07:37 a.m.

5.2.4 Nocturnal arousals, awakenings, and WASO

Based on actigraph recordings, participants in this sample experienced about 7 to 16 nocturnal arousals on average each night on weekdays and weekends. There are many reasons for which nocturnal arousals occur so frequently; environmental factors such as noise, lights being on or switched on by others, uncomfortable beds or there may be underlying pathological reasons such as breathing disorders experienced during sleep, or leg movements (Gupta *et al*., 2008). Participants may have also been experiencing bad dreams throughout the night, which may result in nocturnal arousals (Gupta *et al*., 2008). However, it is quite difficult to determine the cause of the nocturnal arousals since this is not a polysomnographic study so it could be that multiple factors mentioned above played a role (Gupta *et al*., 2008). Self-reported nocturnal awakenings, on the sleep diaries, averaged one. Similarly, another study by Yang *et al*. (2005) which was focused on describing age-related changes in sleep found that nocturnal awakenings decreased with school grade which may explain why the number of nocturnal awakenings was so low in this sample. The authors attributed this to the older adolescents having improved sleep efficiency as a result of the insufficient sleep they obtain on most nights (Yang *et al*., 2005).

Wake After Sleep Onset (WASO) is a good indicator of sleep fragmentation (Lovato and Gradisar, 2014), and is defined as the length of time a person may spend awake after sleep onset (Shrivastava, Jung, Saadat, Sirohi, and Crewson, 2014). On weekends, WASO was slightly longer but not significantly different to the weekdays, which indicates a similar prevalence of sleep

fragmentation occurring during weekdays and on weekends in this cohort. Astill *et al*, (2013) used both actigraphy and sleep diaries to assess the effect of stress on adolescent sleep and estimated an overall WASO was 58 minutes, not so different from the WASO obtained in this cohort so perhaps the effect of stress on sleep in this cohort may be the same on weekdays and weekends and this may be related to living in hostel/boarding houses. However, it is important to note that previous research has demonstrated that actiwatches are prone to overestimating WASOin comparison to polysomnography in adolescents (Lee, Chee, Ong, Teo, van Rijn, Lo, and Chee, 2019). Interestingly, it has been suggested that depressed adolescents spend more time lying awake in bed in the dark, which can result in an influx of thoughts about the effects of their sleeplessness (Lovato and Gradisar, 2014). Being awake in this case is said to further contribute to sleep disturbance by reinforcing reflective thoughts (Lovato and Gradisar, 2014).

Overall, boarders in this sample appear to be getting insufficient sleep, both on the weekdays and weekends, likely as a result of early waketimes on weekdays. In light of these findings, it is important to keep in mind that boarders may have different lifestyle routines when compared to day scholars since they work, socialize, and sleep in a school setting most of the time (Martin *et al*., 2014). Life in a boarding school/hostel is different in the sense that it is more regulated and daily routines follow specific schedules. Adolescents in boarding school have specific waketimes, they have their meals at set times, and participation in recreational activities is largely regulated. Boarders also usually have time set aside for homework or other academic-related activities, they need to follow certain standards to keep their dorms clean/tidy and sometimes can only access the computer or cell phone at given times, all of which depends on age and grade among other things (Lee and Barth, 2009). These differences in lifestyle routines may therefore contribute to the sleep durations both on weekdays and weekends among boarders. It would be important for future research to determine the impact of these short sleep durations on adolescent boarders.

5.3 Overall implications of findings

Adolescents in this cohort like many around the world have weekday sleep durations that are shorter than the recommended 8-10 hours, as determined through the use of the School Sleep Health Survey, as well as actigraphy, and sleep diaries (for a small subset). Thus, it is evident across the different elements of the study that older adolescents (Grade 11 and Grade 12 learners) are not obtaining sufficient sleep during the week, which likely results in sleep debt and a subsequent weekend oversleep to compensate. On the weekend, even though sleep durations were longer, they were still on the lower end of the recommendations. Overall, these rather short, reported sleep durations are aligned with previous research since the sample consisted of Grade 11-12 learners and therefore older adolescents. This is because both weekday and weekend sleep durations have been found to decrease with increases in Grade and age (Strauch and Meier, 1988; Gau and Soong, 1995; Carskadon *et al*., 1998a; Wolfson and Carskadon, 1998; Laberge *et al*., 2001; Giannotti and Cortesi, 2002; Reid *et al*., 2002; Iglowstein *et al*., 2003; Roenneberg *et al*., 2004; Jenni and O'Connor, 2005; Yang *et al*., 2005; Crowley *et al*., 2007; Loessl *et al*., 2008; Gamble *et al*., 2014).This is partly explained by increasingly later bedtimes and earlier waketimes in older adolescents moreso, during the week which results in shortened weekday sleep durations and consequently, weekend oversleep (Anders *et al*., 1978; Wolfson and Carskadon, 1998; Giannotti *et al*., 2002; Campbell *et al*., 2007; Gradisar *et al*., 2011). While these findings are likely the result of many interacting factors that are common to school-going adolescents in other countries, this study also offers unique insights into part of the South African context and emphasizes the importance of learner background or context to fully appreciate the unique challenges they face and consider the implications of personal or contextual characteristics on, amongst other things, their sleep.

In this study, sleep timing was delayed as a result of the bioregulatory and psychosocial factors discussed. Specifically, delayed bedtime was reported to be a result of academic pressures, bedtime autonomy especially among day scholars, and extended screen time prior to bed as reflected in reported usage of smartphones before bedtime. Consistent with findings from other studies, on weekdays, sleep occurred at or just before or at 11:00 p.m. (see, for example, Wolfson *et al*., 2003a; Wolfson *et al*., 2003b; Galland *et al*., 2018). On the weekend, sleep was delayed by nine minutes to an hour this is much shorter in comparison to what other studies have reported (e.g., Szymczak

et al., 1993; Saarenpää-heikkilä *et al*., 1995; Giannotti *et al*., 1997; Wolfson and Carskadon, 1998; Cheung *et al*., 1999; Gau and Soong., 2003; Huang *et al*., 2010). This, therefore, indicates that adolescents in this cohort perhaps have a higher sleep pressure which drives them to have shorter weekend bedtime delays or alternatively, since this sample consisted of older adolescents, on the verge of adulthood, they may perhaps be less-evening oriented.

As is the case with other countries, weekday waketimes were determined by societal pressures, specifically, school start times as indicated in the Perfect Storm Model in Figure 3, and adolescents in this sample had weekday waketimes between 06:20 a.m. -06:36 a.m. Actigraph and sleep diary recorded waketimes were obtained from boarders which were slightly later than obtained from the survey. As has already been mentioned in this and other studies in the field, the early school start times reported in this study may be in direct opposition to the phase delay that adolescents, particularly those in the later stage of adolescence, undergo (Reid *et al*., 2002; Wolfson *et al*., 2007; Gradisar *et al*., 2011). On the weekends, waketime was delayed by 01hr:10mins to 01hr:40mins across the various measures, shorter than findings from other countries such as Korea and Spain (Yang *et al*., 2005; Mateo *et al*., 2012) which is likely indicative of sleep debt in this cohort.

Late bed and early wake times were also influenced by other personal characteristics whether learners were boarders or day scholars, attended a public or private school as well sex, all of which were related. Lifestyle factors such as the consumption of caffeine and usage of electrical devices elicited some effect on sleep. The interaction of several factors, although not explored statistically in this study, supports the theoretical model of the "Perfect Storm of insufficient and inappropriately-timed sleep" (Carskadon, 2011; Crowley *et al*., 2018). Thus, it is evident that the students, across the different schools that were sampled in Makhanda, are getting insufficient sleep and this is evident in the fact that sleep duration in this cohort (as reported in various phases of this study) is shorter than the average recommended and shorter than the average reported need.

While not necessarily the focus of this study, it is important to discuss the potential impact of this short sleep. Insufficient sleep in adolescents' results in daytime sleepiness or decreased alertness (Gau and Soong, 1995; Wolfson and Carskadon, 1998; Fallone *et al*., 2002; O'Brien and Mindell, 2005; Gibson *et al*., 2006; National Sleep Foundation, 2006; Chung and Cheung, 2008). In this

study, sleepiness and depressed mood were not measured in detail, however, there was evidence for some degree of reported daytime sleepiness and depressive mood symptoms in parts of this sample which could be linked to the suboptimal sleep.

Sleepiness has also been found to be strongly associated with poor academic performance (Dewald *et al*., 2010). This is because it impairs cognitive functioning by reducing levels of alertness and compromising the functioning of certain brain areas such as the prefrontal cortex responsible for executive functions (Dewald *et al*., 2010; Beebe, 2011). In addition, sleepiness has been implicated in school absenteeism (Meijer *et al*., 2010) and is linked to lack of motivation and concentration, which are quite important contributors to academic performance (Owens and Adolescent Sleep Working Group., 2014). In this cohort, learners who reported the earliest weekday waketimes and greater irregularity between a week and weekend waketimes were also more likely to report the poorest academic performance. Therefore, it is possible that the academic performance of these learners may have been affected by the early waketimes and that hence, there was a need to prolong sleep and delay waketimes on the weekend. The inability to perform well academically may very well lead to dropping out of school or a failure to qualify for enrolment in a university or college (Beebe, 2011) which is a priority for this cohort of learners at the end of their school careers. It can, therefore, be deduced that optimal adolescent functioning during the day is likely compromised by poor sleep which is the result of late bedtimes and early waketimes which results in insufficient sleep (Hansen, Janssen, Schiff, Zee, and Dubocovich, 2005).

5.4 Recommendations

Due to the interaction of several factors that contribute to the insufficient and ill-timed sleep faced by adolescents in this study, the challenge cannot be addressed by one intervention and would therefore require a systemic, multifaceted approach.

The first step towards addressing the concerns around adolescent sleep relates to education and raising awareness around sleep loss and its effects on this group, this can be achieved through the implementation of sleep hygiene education programs. These programs may incorporate some motivational components in which adolescents would be taught about healthy sleep habits (Irish, Kline, Gunn, Buysse, and Hall, 2015; Otsuka, Kaneita, Itani, and Tokiya, 2020). These are widely available and are an inexpensive form of intervention. Furthermore, adherence to such programs

has been reported to be high in some studies (Irish *et al*., 2015) and others have reported increases in sleep duration and quality as well as sleep hygiene (de Sousa, Araújo, and De Azevedo, 2007; Cain, Gradisar, and Moseley, 2011; Kira, Maddison, Hull, Blunden, and Olds, 2014, Wolfson, Harkins, Johnson, and Marco, 2015). For young adolescents, a contextually and culturally sensitive version of the Sleep Smart Educational Program, for example, could be implemented to improve sleep health and hygiene practices (Wolfson *et al*., 2015).

For older adolescents, motivational interview-based sleep education programs may be implemented, this program included raising awareness on sleep health, role plays, behavioral experiments, and discussions (Moseley and Gradisar, 2009; Cain *et al*., 2011). This can be made possible provided that such programs are to be contextualized in the South African setting and made relevant to South African adolescents. Given the lack of existing knowledge on adolescent sleep problems in the South African context, sleep hygiene education programs could be included in the school curriculum, as part of Life Orientation for instance where material on the importance of physical activity and diet are discussed already. This would however require the training of teachers. Such programs may also be translated to other South African languages for better understanding if need be. Raising awareness and education in this regard is necessary given that adolescents in this sample demonstrate irregular week and weekend sleep-wake behavior, late bedtimes, frequent and prolonged screen time before bedtime, and high caffeine consumption, all of which point to a need for sleep hygiene training.

It is worth noting, however, that even as such programs have been found to improve sleep knowledge, they don't solely result in long-term improvements in sleep-wake habits (Cassoff, Knäuper, Michaelsen, and Gruber, 2013; Irish *et al*., 2015; Otsuka *et al*., 2020). Therefore, it may also be useful to consider improving sleep on an individual level, in this way, resistance to change in sleep behavior can be addressed on an individual basis. Where possible, the internet may be used to deliver personalized sleep hygiene methods (Cassoff *et al*., 2013). In this study, for example, the use of EDs was suggested as playing a contributory role in later bedtimes. Keeping this in mind, adolescents may be encouraged to avoid or limit the use of these devices before bedtimes based on individual frequency and duration of screen time before bedtime (Malone, 2011). Further exploration of ED use before bedtime may be important for intervention purposes. Perhaps work towards interventions aimed at the reduction of ED use for the treatment and prevention of sleep

problems among adolescents who are heavy users of EDs may be useful (Gamble *et al*., 2014). Caffeine consumption in this study was also suggested as a risk factor to obtaining sufficient sleep and as such adolescents are encouraged to avoid caffeine intake 4 hours before bedtime (Calamaro *et al*., 2009; Bryant *et al*., 2010).

Overall, literature has demonstrated that, when school start times are very early, adolescents are required to have impractical and unrealistically early bedtimes, and this, therefore, results in insufficient sleep duration (Allen, 1992; Wahlstrom *et al*., 1997; Wolfson *et al*., 2007; Owens *et al*., 2010; Bartel *et al*., 2015; Bowers and Moyer, 2017). Considering that adolescents in this study reported relatively late bed and early wake times and insufficient sleep, it may be worthwhile exploring delayed school start times. The American Academy of Pediatrics (2014) recommends that school start times for high schools be no earlier than 08:30 in order to accommodate the biological tendency for later bedtimes during adolescents. This would be beneficial for adolescents with regards to sleep, health, and academic outcomes (Minges and Redecker, 2016). Future studies could therefore look at the feasibility and possible constraints of delaying school start times in the South African context specifically, and whether this is viable given that studies have demonstrated its benefits in other contexts. Considerations would have to be given to the context of the schools, the learners, their families as well as transport systems. Part of this process may include interviews with all relevant stakeholders such as parents, the school boards, school principals, other stuff such as teachers and coaches who may have concerns and whose lives will be affected by this change (Wahlstrom, 1999, Wolfson *et al*., 2007).

Some structural and administrative concerns would have to be taken into consideration. For example, the delaying start times will affect the staff, transportation/commuting challenges, extracurricular activities, and safety concerns. With respect to the school staff, late dismissal would mean less time available for teachers to provide extra help to learners after school or to supervise extracurricular activities therefore potentially also having a negative impact on extracurricular activities. With regards to transportation/commuting challenges, it may be beneficial for staff and learners to travel at non- peak hours as there would be less traffic, however, for those that use public transportation it is also quite possible that they may find it difficult to get to school at non-peak hours as they may be fewer taxis or buses. Late school dismissal times also mean possibly having to walk home late which raises a safety concern for teachers and learners.

Interventions, therefore, could range from education and raising awareness around sleep loss and its effects on this group, to possible changes in boarding houses, in this case, for example, boarders actigraph recorded sleep duration was below 8 hours even on the weekend, it may be worthwhile to have boarding houses further delay morning obligations on the weekends, therefore, allowing for longer sleep durations. These changes may be followed by encouraging or requesting that local school districts put some thought into delaying school start times and may eventually be translated into changes in national policy on school start times or curriculum in the long term. Furthermore, thus far, since the study has been conducted in the Makhanda area, there has been continued engagement with schools on this issue of adolescent sleep, and that this has resulted in some meaningful changes including some teachers stopping early morning training; a delay in school start times at one or two schools (driven by COVID and other factors) as well as a heightened awareness among staff and learners about this issue through regular workshops and presentations.

5.5 Limitations of this study

There were limitations to this study, which need to be acknowledged. For both Phases, the generalizability of findings is restricted due to the data having been collected in one town and only among those schools that were willing to participate. Findings obtained from this study therefore cannot be generalized to adolescent groups in other schools that are in other provinces or bigger centres or townships or rural areas, where the population sample, schools, traveling distances, and extracurricular activities may be very different. Furthermore, the findings of this study are limited to older adolescents and not to other grades. Also, due to the cross-sectional design of part of this study, it cannot be used to infer causality on the various factors that may influence sleep as well as on the long-term effects of insufficient sleep.

Additionally, this study did not directly inquire about subjective and/or objective measures of SES the links between SES and sleep and the large economic disparities that exist in South Africa. The study also did not assess the home environment and its impact on sleep, which given the previously mentioned point around the impact of SES-related factors would be important to consider. However, given the sampling strategy and that the sample was limited to Makhanda, and did not include samples from other geographical locations and with various SES backgrounds, it would have been difficult to assess the effects of these aforementioned factors.

In addition to the above, the survey did not ask about the timing or intensity of physical activity or exercise. These are worth considering because other research findings have reported on the effects of training or exercise on sleep (see, for example, Driver *et al*., 2000; Brand *et al*. 2009, 2010a; Suppiah *et al*., 2015). With regards to the effect of caffeine consumption, this study did not inquire about the timing of caffeine consumption, which may be an important factor for the consideration of its effect on sleep. Furthermore, although sleep surveys/questionnaires offer an inexpensive means of obtaining sleep data, they are not without some limitations. These include that they do not always yield accurate responses regarding adolescent sleep-wake behaviours. Participants are also more likely to report their most recent instead of their usual behaviors and giving socially desirable responses.

Furthermore, despite actigraphy providing a more objective assessment of sleep, it is often unable to distinguish between periods of short naps and low levels of physical movement (Galland *et al*., 2018). It also doesn't measure factors such as perceived sleep quality. Finally, the sample size of Phase two was limited to 14 boarders as a result of the implementation of a state of disaster in South Africa as a result of the COVID pandemic. Despite this, the use of actigraphy offered a useful, relatively objective snapshot into the sleep-wake behaviour of boarders which was fairly homogenous and regular.

5.6 Future research implications

Below are a few recommendations on how these sleep challenges faced by adolescents may be addressed. This study was focused mainly on older adolescents because based on the literature, they have been identified as a group that is more prone to experiencing inadequate sleep, future studies in South African adolescents could focus on larger adolescent populations with a wider age span. Future research should therefore include the collection of data over extended periodsacross various geographical areas within South Africa and including various age groups to gather more and accurate information on the sleep-wake behaviour of adolescents in different parts of South Africa.

Future studies could also consider focusing on the effect of early school start times in the South African context and if need be, into school policy changes that complement later school start times. This could be accompanied by additional scheduling changes and practices such as limiting early

sports training from occurring before school begins because later school start times are beneficial in other contexts. Additionally, the research could also look into finding the optimal or realistic ranges of sleep durations for the South African context with the considerationof learners who have to commute extended distances using public transportation or walking to school. It would also be interesting to consider the sleep-wake behaviour of adolescents living in and attending schools in rural areas because factors influencing sleep may be different for adolescents based on their context. Future research in South Africa should therefore investigate the relationship between private and public schools, socioeconomic status, distance from school, modes of transport, and how these issues intersect with demographic factors to influence adolescentsleep. There is also still a need to explore other measures or interventions that may improve the sleep behaviour of adolescents in the South African context specifically with or without changes in school start times. Lastly, the impact of the COVID-19 pandemic and the systemic challenges it has presented to school-going children and adolescents needs to be elucidated. For completeness' sake, a brief synopsis of this is offered, considering that this thesis was completed nearly a year after the pandemic began.

5.7 Further possible implications of the COVID pandemic on adolescent sleep

In addition to all the systemic challenges to sleep in this group, in recent times, these challenges may be accentuated by COVID and the associated effects on the school system. South Africa is currently under alert level 1 lockdown due to the Corona Virus (COVID-19) Pandemic. Alert level 5 lockdown was implemented on 26 March 2020, as a means to contain the spread of the virus. This social distancing has resulted in changing lifestyles and as one would expect, in sleep-wake behaviour. The lockdown period in other countries such as Italy and China have been found to increase psychological distress, anxiety, and depression (Bao, Sun, Meng, Shi, and Lu, 2020; Fu, Wang, Zou, Guo, Lu, Yan, and Mao, 2020; Marelli, Castelnuovo, Somma, Castronovo, Mombelli, Bottoni, D, and Ferini-Strambi, 2020) which can all have a negative impact on sleep (Brooks, Webster, Smith, Woodland, Wessely, Greenberg, and Rubin, 2020).

As mentioned, the global pandemic has resulted in the restriction of physical human contact, which has resulted in many adolescent daily activities such as school attendance, extracurricular activities, and socializing with friends occurring online (Becker and Gregory, 2020). Social distancing has

likely affected adolescents particularly because adolescence is a period known for the prioritization of socializing and autonomy (Becker and Gregory, 2020). It is expected that these changes may have a negative impact on sleep; this is likely to be the case for adolescents since they are experiencing developmental changes that are influencing sleep-wake behaviour (Becker and Gregory, 2020).

On a positive note, however, Roy, Tiwari, Kanchan, and Bajpai (2020) report increased sleep duration in adolescents during the lockdown in India. Nonetheless, since this is a particularly stressful time for many reasons (including but not limited to the loss of family members or friends, financial difficulties for many families, and concerns about prospects and opportunities, all of which may contribute negatively to adolescent sleep) parents, health professionals and school administrators need to be aware of these impacts and how they may influence learner wellbeing going forward (Guessoum, Lachal, Radjack, Carretier, Minassian, Benoit, and Moro 2020; Roy *et al*., 2020). These sleep disturbances may be related to the high prevalence of symptoms of depression and anxiety reported by adolescents as per survey findings reported during lockdown among Chinese adolescents (Zhou, Zhang, Wang, Guo, Wang, Chen, and Chen, 2020). Other reasons suggested for changes in sleep and psychosocial wellbeing have been the added stress of having to adapt to unprecedented changes in the academic year (Wang, Pan, Wan, Tan, Xu, Ho, and Ho, 2020). In a recent study in China, the delay of academics due to COVID-19 has been associated with anxiety (Wang *et al*., 2010). Furthermore, sleep routines may be disrupted by reduced exposure to sunlight and increased opportunity for daytime napping (Becker and Gregory, 2020). In addition, increased usage of EDs due to online learning, social media use, and entertainment, especially before bedtime may delay the production of melatonin, leading to even later bedtimes (Becker and Gregory, 2020; Wang *et al*., 2020) as has already been highlighted in previous sections. While social media platforms may serve as useful means to interact with peers and keep up to date with information, it is important to keep in mind that literature has established a negative association between social media use and sleep in adolescents (e.g. Espinoza and Juvonen, 2011; Woods and Scott, 2016).

This would be worth investigating in the South African context, particularly because in this cohort, the use of EDs before bedtime was associated with sleep parameters such as later bedtimes, and higher scores on the scale of the sleep-wake problem. This was, however, a finding not unique to

this cohort (see, for example, Van den Bulck, 2004; Eggermont and Van den Bulck, 2006; Shochat *et al*., 2010;Arora *et al*., 2014; Gamble *et al*., 2014). Also, interestingly, in this cohort, weekend bedtimes were determined by the time in which respondents finished socializing in person or over an electronic device. This, therefore, raises questions about the extent to which adolescents may further delay bedtimes due to usage of EDs now that early school start times were no longer a major determining factor for weekday waketimes because of the lockdown in many parts of the world.

Overall, future research is needed to investigate the impact of COVID-19 and lockdown / remote learning and social distancing on adolescent sleep. For example, if adolescents are currently going to bed at much later times, what effect will this have when schools are reopened full time and early start times return (Becker and Gregory, 2020)?. An alternative question for future researchers would be whether or not lockdown has allowed adolescents to develop sleep-wake habits that are aligned to their endogenous biological clocks, considering that their circadian rhythms are delayed (Altena, Baglioni, Espie, Ellis, Gavriloff, Holzinger, and Riemann, 2020; Arora and Grey, 2020). It may also be interesting for future studies to look into the effects of COVID-19 on the sleep of adolescents with pre-existing psychopathologies and neurodevelopmental conditions since they may be more susceptible to sleep disturbances (Becker and Gregory, 2020). These findings are interesting to note since adolescents suffering from mental health issues use school routines as coping mechanisms (Lee, 2020). Importantly, this further illustrates the need to further investigate the impact of contextual factors on adolescent sleep, which may lead to effective interventions and planning strategies for this vulnerable population group. Another factor worth considering is how uncertainty during the COVID-19 pandemic may have affected those in public schools more than in private schools and so it would be important to understand this impact more broadly on learner development, wellbeing, and preparedness.

CHAPTER VI
CONCLUSION

Both phases of this study aimed to provide a detailed overview of the sleep-wake behaviour of a sample of late adolescents from public and private schools in Makhanda, South Africa. Evidence indicates that adolescents should be obtaining at least 8 hours of sleep for optimal functioning. However, findings from this study support that of previous research that point to school-going adolescents in this context being a group that obtain insufficient sleep on weekdays. Because of this, adolescents in this cohort presumably accumulate sleep debt, which results in longer weekend sleep duration. Adolescents in this cohort also did not delay their weekend bed and wake times as much as adolescents in other countries, most likely because this cohort consisted of many boarders. This, therefore, emphasizes the importance of considering the influence of personal and contextual characteristics in adolescent sleep. This study also illustrated the effect of some contextual characteristics on sleep. More specifically, according to survey and actigraphy and sleep diary data, boarders not only obtained insufficient sleep on weekdays but, to a lesser extent, on the weekends too. Insufficient weekend sleep duration in boarders may be attributed to the earlier weekend waketimes due to regulated sleep-wake behaviour as a consequence of living in a hostel/boarding house. Furthermore, the differences in sleep-wake behaviour between public and private school learners in this cohort were related to the fact that a majority of the boarders were also private school learners, and subsequently, a majority of public-school learners were also day scholars. Public school learners, therefore, had earlier weekday waketimes because they would have had to commute to school seeing as they were day scholars. Due to this earlier weekday waketime, public school learners also would have had to go to bed earlier to obtain the same weekdaysleep duration as private school learners. Lastly, public school learners also had a greater week and weekend sleep delay, with weekends being characterized by much later waketimes and consequently longer sleep durations to compensate for the sleep debt that presumably accumulates during the week.

The study found that some of the factors that contribute to insufficient sleep in this population group are the use of EDs before bedtime, caffeine consumption, and early school start times. Extrinsic factors, like these, can, to some extent, be modified and should perhaps be focused on in the consideration of interventions. Overall, the findings of this study support that systemic factors that contribute to the "Perfect Storm of insufficient and inappropriately-timed sleep" (Crowley *et al*., 2018) and have contributed in a small way, to ongoing global research on sleep in adolescence and the debates around the feasibility of implementing various interventions. An example of such interventions could be, later school start times, as means to raise awareness on the issues faced by adolescents in relation to their sleep and to eventually find context-specific solutions to improve the situation. Insufficient sleep in adolescents, including learners from the current cohort, may have a negative impact on health, well-being, and performance, in and out of school. Therefore, these findings highlight some concerns regarding the overall well-being of adolescents in the South African schooling system. Thus, efforts to promote healthy lifestyles and optimum performance in adolescents must consider adolescent sleep needs. The first step in achieving this purpose would be through encouraging more research in the South African context and investing more resources in finding the necessary solutions to combat these challenges in a contextualized manner. Growth in local knowledge, at the national, provincial, and school level, may then be used to educate adolescents, parents, educators, health practitioners, and policymakers to better design school systems to be more learner-centred, particularly when it comes to the provision of opportunities for learners to obtain adequate quality sleep.

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Appendix A: Original version of the SHSS

Bradley Hospital

School Sleep Habits Survey

INSTRUCTIONS

Please answer the questions on the following pages as accurately and honestly as you can. There are no right or wrong answers.

- When you mark a response, please be sure to mark it neatly.
- Darken the bubbles as completely as possible using a pencil.
- Avoid stray marks and treat forms gently.
- Do not spend too much time on any one answer. Your first impression is usually best.
- Answer each question in the order that it appears. Do not go back and check your answers.
- Place an X beside any item that YOU DO NOT UNDERSTAND or that DOES NOT APPLY TO YOU or for which you CANNOT GIVE A TRUTHFUL ANSWER.
- Be sure to complete BOTH SIDES of every page.

1. Today's Date:

Month	Day	Year
○ Jan		
○ Feb		
○ Mar	0 0	0 0
○ April	1 1	1 1
○ May	2 2	2 2
○ June	3 3	3 3
○ July	4 4	4 4
○ Aug	5 5	5 5
○ Sept	6 6	6 6
○ Oct	7 7	7 7
○ Nov	8 8	8 8
○ Dec	9 9	9 9

2. Birth Date:

Month	Day	Year
○ Jan		
○ Feb		
○ Mar	0 0	0 0
○ April	1 1	1 1
○ May	2 2	2 2
○ June	3 3	3 3
○ July	4 4	4 4
○ Aug	5 5	5 5
○ Sept	6 6	6 6
○ Oct	7 7	7 7
○ Nov	8 8	8 8
○ Dec	9 9	9 9

3. What time is it now? _____ ○ A.M. ○ P.M.

4. What is your sex?
○ Male
○ Female

5. What is your height? _____ feet _____ inches

6. What is your weight? _____ pounds

7. What is your age in years?
○ 9 ○ 10 ○ 11 ○ 12 ○ 13 ○ 14 ○ 15 ○ 16 ○ 17 ○ 18 ○ 19

8. What grade are you in?
○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ 11 ○ 12

FOR OFFICE USE ONLY

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

9. **What best describes your racial/ethnic background?**
   - ○ White/Caucasian
   - ○ Black/African American
   - ○ Hispanic/Latino
   - ○ Asian/Asian American
   - ○ Native American/Amerindian
   - ○ Multiracial (please specify) _____
   - ○ Other (please specify) _____

10. **In the last two weeks, have you slept in the same bed?**
   - ○ Every night
   - ○ Almost every night
   - ○ A few nights
   - ○ Not at all

11. **Who lives in your home other than you? Please indicate yes or no for every category below:**

	Yes	No
Mother/step-mother	○	○
Father/step-father	○	○
Older brother(s)/sister(s)	○	○
Younger brother(s)/sister(s)	○	○
Other family member(s)	○	○

12. **Does your mother work outside of the home?**
   - ○ Yes
   - ○ No

   If yes, mark each label that best describes her work:
   - ○ Day shift
   - ○ Evening shift
   - ○ Night shift (graveyard)
   - ○ Changing shifts
   - ○ Full time
   - ○ Part time
   - ○ One job
   - ○ More than one job

13. **Does your father work outside of the home?**
   - ○ Yes
   - ○ No

   If yes, mark each label that best describes his work:
   - ○ Day shift
   - ○ Evening shift
   - ○ Night shift (graveyard)
   - ○ Changing shifts
   - ○ Full time
   - ○ Part time
   - ○ One job
   - ○ More than one job

14. **Are your grades in school mostly?:**
   - ○ A's
   - ○ A's and B's
   - ○ B's
   - ○ B's and C's
   - ○ C's
   - ○ C's and D's
   - ○ D's
   - ○ D's and F's

15. **What is the highest grade in school you expect to complete? (mark one)**
   - ○ May not finish high school
   - ○ Will finish high school
   - ○ Will get a college degree
   - ○ Will get a degree beyond college

16. **Do you have any disabilities or chronic illnesses (for example, asthma, diabetes, deafness, loss of the use of a limb, etc.)?**
   - ○ Yes
   - ○ No

   If yes, please specify: _____

17. **Compared to other people your age, would you say that your health is:**
   - ○ Poor
   - ○ Fair
   - ○ Good
   - ○ Excellent

18. **Do you have attention deficit hyperactivity disorder (ADHD) or a learning disability?**
   - ○ Yes
   - ○ No

19. **Do you take Ritalin or some other medication to help with concentration or a learning problem?**
   - ○ Yes
   - ○ No

20. **Do you have an individualized education program or receive special help for difficulties with school work?**
   - ○ Yes
   - ○ No

21. **During the last two weeks, how many days did you stay home from school because you were:**

   a. sick? ⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
   b. other? ⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

   Why did you stay home from school?

   _____

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There are no right or wrong answers. Be careful to choose the **one** answer that **best** describes the way your sleep has been in the last two school weeks (unless otherwise instructed).

The next set of questions has to do with your usual schedule on days when you have school.

22. What time do you usually go to bed on school days?

List ONE time, not a range.

_____ ○ A.M. ○ P.M.

23. There are many reasons for doing things at one time or another. What is the main reason you usually go to bed at this time on school days? (mark one)

- ○ My parents have set my bedtime
- ○ I feel sleepy
- ○ I finish my homework
- ○ My TV shows are over
- ○ My brother(s) or sister(s) go to bed
- ○ I finish socializing
- ○ I get home from my job
- ○ Other: _____

24. What time do you usually wake up on school days?

_____ ○ A.M. ○ P.M.

25. What is the main reason you usually wake up at this time on school days? (choose one)

- ○ Noises or my pet wakes me up
- ○ My alarm clock wakes me up
- ○ My parents or other family members wake me up
- ○ I need to go to the bathroom
- ○ I don't know, I just wake up
- ○ Other: _____

26. What time do you usually leave home on school days?

_____ ○ A.M. ○ P.M.

27. How do you usually get to school?

- ○ Walk
- ○ Take the bus
- ○ Get a ride with parent
- ○ Get a ride with friend(s)
- ○ Drive my car

28. Figure out how long you usually sleep on a normal school night and fill it in here. [Do not include time you spend awake in bed. Remember to mark hours and minutes, even if minutes are zero.]

_____ hours _____ minutes

29. On school days, after you go to bed at night, about how long does it usually take you to fall asleep?

_____ minutes

The next set of questions has to do with your usual schedule on days when you do not have school, such as on the weekend.

30. What time do you usually go to bed on weekends?

_____ ○ A.M. ○ P.M.

31. There are many reasons for doing things at one time or another. What is the main reason you usually go to bed at this time on weekends? (choose one)

- ○ My parents have set my bedtime
- ○ I feel sleepy
- ○ I finish my homework
- ○ My TV shows are over
- ○ My brother(s) or sister(s) go to bed then
- ○ I finish socializing
- ○ I get home from my job
- ○ Other: _____

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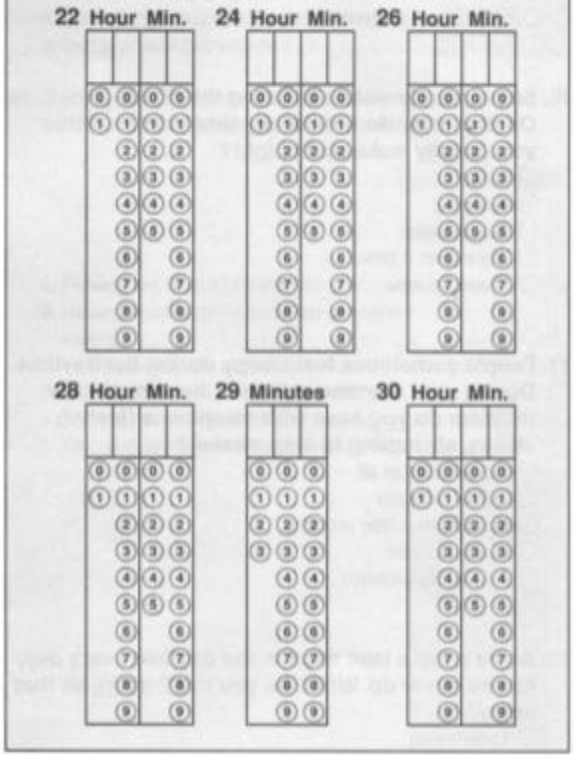

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32. What time do you usually wake up on weekends?

_____ ○ A.M. ○ P.M.

33. What is the main reason you usually wake up at this time on weekends? (choose one)
- ○ Noises or my pet wakes me up
- ○ My alarm clock wakes me up
- ○ My parents wake me up
- ○ I need to go to the bathroom
- ○ I don't know, I just wake up
- ○ Other: _____

34. Figure out how long you usually sleep on a night when you do not have school the next day (such as a weekend night) and fill it in here. [Do not include time you spend awake in bed. Remember to mark hours and minutes, even if minutes are zero.]

_____ hours _____ minutes

35. On weekends, after you go to bed at night, about how long does it usually take you to fall asleep?

_____ minutes

36. Some people wake up during the night. Others never do. How many times do you usually wake up at night?
- ○ Never
- ○ Once
- ○ 2 or 3 times
- ○ More than 3 times
- ○ I have no idea

37. People sometimes feel sleepy during the daytime. During your daytime activities, how much of a problem do you have with sleepiness (feeling sleepy, struggling to stay awake)?
- ○ No problem at all
- ○ A little problem
- ○ More than a little problem
- ○ A big problem
- ○ A very big problem

38. Some people take naps in the daytime every day, others never do. When do you nap? (mark all that apply.)
- ○ I never nap.
- ○ I sometimes nap on school days.
- ○ I sometimes nap on weekends.
- ○ I never nap unless I am sick.

39. Can you figure out how much sleep you need? Fill out below how much sleep you think you would need each night to feel your best every day. [Remember to mark hours and minutes, even if minutes are zero.]

_____ hours _____ minutes

40. In general, do you feel you usually get . . .
- ○ too much sleep?
- ○ enough sleep?
- ○ too little sleep?

41. Do you consider yourself to be . . .
- ○ a good sleeper?
- ○ a poor sleeper?

42. How often do you think that you get enough sleep?
- ○ Always
- ○ Usually
- ○ Sometimes
- ○ Rarely
- ○ Never

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32 Hour Min.

34 Hour Min.

35 Minutes

39 Hour Min.

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Questions 43 to 46 are about things that have happened in the last two weeks.

43. During the last two weeks, have you struggled to stay awake (fought sleep) or fallen asleep in the following situations? (Mark one answer for every item.)

	Both struggled to stay awake and fallen asleep	Fallen asleep	Struggled to stay awake	No
• in a face-to-face conversation with another person?		○	○	○
• traveling in a bus, train, plane or car?		○	○	○
• attending a performance (movie, concert, play)?		○	○	○
• watching television or listening to the radio or stereo?		○	○	○
• reading, studying or doing homework?		○	○	○
• during a test?		○	○	○
• in a class at school?		○	○	○
• while doing work on a computer or typewriter?		○	○	○
• playing video games?		○	○	○
• driving a car?		○	○	○

Do you drive? ○ Yes ○ No

44. During the last two weeks, how often did you . . . (Mark one answer for every item.)

	Every day	Several times every day	Once or twice a day	Never
a. drink soda with caffeine [like Coke, Pepsi; not like root beer, orange soda or Sprite]?		○	○	○
b. drink coffee or tea with caffeine?		○	○	○
c. use tobacco? [cigarettes, cigar, chewing tobacco, etc.]?		○	○	○
d. drink alcohol [beer, wine, liquor]?		○	○	○
e. use drugs [like marijuana, cocaine]? please specify type: _____		○	○	○

45. In the last two weeks, how often have you . . . (Mark one answer for every item.)

	Everyday/night	Several times	Twice	Once	Never
a. felt satisfied with your sleep?		○	○	○	○
b. arrived late to class because you overslept?		○	○	○	○
c. fallen asleep in a morning class?		○	○	○	○
d. fallen asleep in an afternoon class?		○	○	○	○
e. awakened too early in the morning and couldn't get back to sleep?		○	○	○	○
f. stayed up until at least 3 a.m.?		○	○	○	○
g. stayed up all night?		○	○	○	○
h. slept in past noon?		○	○	○	○
i. felt tired, dragged out, or sleepy during the day?		○	○	○	○
j. needed more than one reminder to get up in the morning?		○	○	○	○
k. had an extremely hard time falling asleep?		○	○	○	○
l. had nightmares or bad dreams during the night?		○	○	○	○
m. gone to bed because you just could not stay awake any longer?		○	○	○	○
n. done dangerous things without thinking?		○	○	○	○
o. had a good night's sleep?		○	○	○	○

46. During the last two weeks, how often were you bothered or trouble by the following?

	Much	Somewhat	Not at all
a. Feeling too tired to do things		○	○
b. Having trouble going to sleep or staying asleep		○	○
c. Feeling unhappy, sad, or depressed		○	○
d. Feeling hopeless about the future		○	○
e. Feeling nervous or tense		○	○
f. Worrying too much about things		○	○

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Questions 47 - 56 have to do with how you might organize the timing of various activities if you were free to plan your day according to when you feel your best. Please answer the questions based on your body's "feeling best" times.

47. Imagine: School is cancelled! You can get up whenever you want to. When would you get out of bed? Between:
- ○ 5:00 and 6:30 a.m.
- ○ 6:30 and 7:45 a.m.
- ○ 7:45 and 9:45 a.m.
- ○ 9:45 and 11:00 a.m.
- ○ 11:00 a.m. and noon

48. Is it easy for you to get up in the morning?
- ○ No way!
- ○ Sort of.
- ○ Pretty easy.
- ○ It's a cinch!

49. Gym class is set for 7:00 in the morning. How do you think you'll do?
- ○ My best!
- ○ Okay.
- ○ Worse than usual.
- ○ Awful!

50. The bad news: You have to take a two-hour test. The good news: You can take it when you think you'll do your best. What time is that?
- ○ 8:00 to 10:00 a.m.
- ○ 11:00 a.m. to 1:00 p.m.
- ○ 3:00 p.m. to 5:00 pm.
- ○ 7:00 p.m. to 9:00 p.m.

51. When do you have the most energy to do your favorite things?
- ○ Morning! I am tired in the evening.
- ○ Morning more than evening.
- ○ Evening more than morning.
- ○ Evening! I am tired in the morning.

52. Your parents have decided to let you set your own bed time. What time would you pick? Between:
- ○ 8:00 and 9:00 p.m.
- ○ 9:00 and 10:15 p.m.
- ○ 10:15 p.m. and 12:30 a.m.
- ○ 12:30 and 1:45 a.m.
- ○ 1:45 and 3:00 a.m.

53. How alert are you in the first half hour you're up?
- ○ Out of it.
- ○ A little dazed.
- ○ Okay.
- ○ Ready to take on the world.

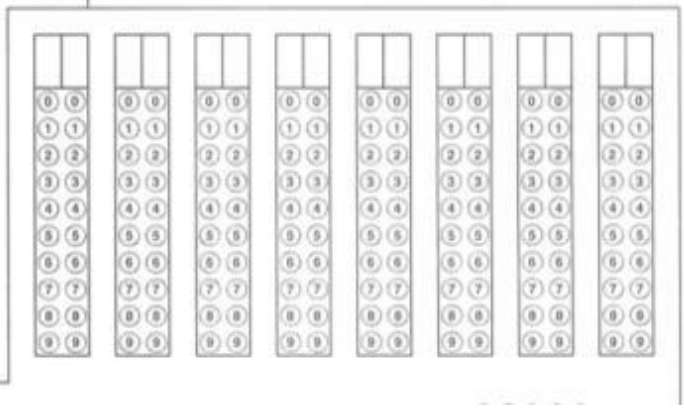
54. When does your body start to tell you it's time for bed (even if you ignore it)? Between:
- ○ 8:00 and 9:00 p.m.
- ○ 9:00 and 10:15 p.m.
- ○ 10:15 p.m. and 12:30 a.m.
- ○ 12:30 and 1:45 a.m.
- ○ 1:45 and 3:00 a.m.

55. Say you had to get up at 6:00 a.m. every morning: What would it be like?
- ○ Awful!
- ○ Not so great.
- ○ Okay (if I have to).
- ○ Fine, no problem!

56. When you wake up in the morning how long does it take for you to be totally "with it"?
- ○ 0 to 10 minutes
- ○ 11 to 20 minutes
- ○ 21 to 40 minutes
- ○ More than 40 minutes

57. Would you say that your growth in height:
- ○ Has not begun to spurt ("spurt" means faster growth than usual)
- ○ Has barely started
- ○ Is definitely underway
- ○ Seems complete
- ○ I don't know

58. Would you say that your other signs of physical maturation:
- ○ Have not yet started to show
- ○ Have barely started to show
- ○ Are definitely underway
- ○ Seem complete
- ○ I don't know



59. During the last week, did you work at a job for pay? (If no, skip to number 60.)
○ Yes ○ No

What kind of job? _____

How many days did you work at the following times?
in the morning before school 0 1 2 3 4 5
in the afternoon after school 0 1 2 3 4 5
in the evening on days that you have school . . 0 1 2 3 4 5
on the weekend 0 1 2

How many hours did you work at your paying job this week?

during the school week: _____ hours

during the weekend: _____ hours

During the last two weeks, have you struggled to stay awake (fought sleep) or fallen asleep at your job?
○ no ○ struggled to stay awake
○ fallen asleep ○ both struggled to stay awake and fallen asleep

If you did not have your job, would you go to bed:
○ earlier than you do. ○ the same as you do.
○ later than you do.

If you did not have your job, would you wake up:
○ earlier than you do. ○ the same as you do.
○ later than you do.

60. During the last week, did you engage in organized sports or a regularly scheduled physical activity? (If no, skip to number 61.)
○ Yes ○ No

What kind of sport? _____

How many days did you practice at the following times?
in the morning before school 0 1 2 3 4 5
in the afternoon after school 0 1 2 3 4 5
in the evening on days that you have school . . 0 1 2 3 4 5
on the weekend 0 1 2

How many hours did you practice this week?

during the school week: _____ hours

during the weekend: _____ hours

During the last two weeks, have you struggled to stay awake (fought sleep) or fallen asleep during practice?
○ no ○ struggled to stay awake
○ fallen asleep ○ both struggled to stay awake and fallen asleep

If you did not have your sports activity, would you go to bed:
○ earlier than you do. ○ the same as you do.
○ later than you do.

If you did not have your sports activity, would you wake up:
○ earlier than you do. ○ the same as you do.
○ later than you do.

61. During the last week, did you participate in organized extracurricular activities? (For example, committees, clubs, volunteer work, musical groups, church groups, etc.) (If no, skip to number 62.)
○ Yes ○ No

What kind of activity? _____

How many days did you participate at the following times?
in the morning before school 0 1 2 3 4 5
in the afternoon after school 0 1 2 3 4 5
in the evening on days that you have school . . 0 1 2 3 4 5
on the weekend 0 1 2

How many hours did you participate this week?

during the school week: _____ hours

during the weekend: _____ hours

During the last two weeks, have you struggled to stay awake (fought sleep) or fallen asleep during this participation?
○ no ○ struggled to stay awake
○ fallen asleep ○ both struggled to stay awake and fallen asleep

If you did not have your organized activity, would you go to bed:
○ earlier than you do. ○ the same as you do.
○ later than you do.

If you did not have your organized activity, would you wake up:
○ earlier than you do. ○ the same as you do.
○ later than you do.

62. During the last week, did you study/do homework?
○ Yes ○ No (If no, skip to number 63.)

How many days did you study at the following times?
in the morning before school 0 1 2 3 4 5
in the afternoon after school 0 1 2 3 4 5
in the evening on days that you have school . . 0 1 2 3 4 5
on the weekend 0 1 2

How many hours did you study this week?

during the school week: _____ hours

during the weekend: _____ hours

During the last two weeks, have you struggled to stay awake (fought sleep) or fallen asleep during studying?
○ no ○ struggled to stay awake
○ fallen asleep ○ both struggled to stay awake and fallen asleep

If you did not have your homework, would you go to bed:
○ earlier than you do. ○ the same as you do.
○ later than you do.

If you did not have your homework, would you wake up:
○ earlier than you do. ○ the same as you do.
○ later than you do.

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Appendix B: Modified SHSS

School Sleep Habits Survey

Instructions:

Please answer the questions on the following pages as accurately and honestly as you can. There are no right or wrong answers.

NB: Participation in this research is completely voluntary; you may choose to withdraw from the research at any time or not answer questions that you do not feel comfortable answering.

- **When you mark a response, please be sure to mark it carefully**
- **Avoid stray marks and treat forms gently**
- **Do not spend too much time on any one answer. Your first impression is usually best.**
- **Answer each question in the order that it appears. Do not go back and check your answers.**
- **Place an X beside any item that you DO NOT UNDERSTAND or that DOES NOT APPLY TO YOU or for which you CANNOT GIVE A TRUTHFUL ANSWER.**
- **Be sure to complete BOTH SIDES of every page**

I voluntarily agree to fill out the survey and I also agree that my data be used for study purposes.
Signature: _____

1. **Age:** _____
2. **Sex:** _____
3. **Height (cm/m):** _____
4. **Weight (kg):** _____
5. **Grade:** _____
6. **Racial/Ethinic background:**
   - ○ White
   - ○ Black/African
   - ○ Colored
   - ○ Indian
   - ○ Other (please specify) _____
7. **In the last two weeks, have you slept in the same bed?**
   - ○ Every night
   - ○ Almost every night
   - ○ A few nights
   - ○ Not at all

8. **Who lives in your home other than you? Please indicate yes or no for every category below:**

	Yes	No
Mother/step mother.....	◯	◯
Father/step father.....	◯	◯
Sibling(s).....	◯	◯
Other family member(s).	◯	◯
Hostel/Boarding school..	◯	◯

9. **Does your mother/guardian work outside of the home?**

◯ Yes
◯ No

If yes, mark each label that best describes her work:

◯ Day shift ◯ Full time
◯ Evening shift ◯ Part time
◯ Night shift ◯ One Job
◯ Changing shift ◯ More than 1 job

10. **Does your father/guardian work outside of the home?**

◯ Yes ◯ No

If yes, mark each label that best describes his work:

◯ Day shift ◯ Full time
◯ Evening shift ◯ Part time
◯ Night shift ◯ One Job
◯ Changing shift ◯ More than 1 job

11. **Are your grades in school <u>mostly?:</u>**

◯ 80-100%
◯ 70-79.99%
◯ 60-69.99%
◯ 50-59.99%
◯ 40-49.99%
◯ 30-39.99%
◯ 20-29.99%

12. **What is the highest grade in school you expect to complete? (<u>mark</u> one)**

◯ May not finish high school
◯ Will finish high school
◯ Will get a university/college degree
◯ Will get a degree beyond university or College

13. **Do you have any disabilities or chronic illnesses (e.g. asthma, diabetes, deafness, loss of the use of a limb, etc.)?**

◯ Yes ◯ No
If yes, please specify: _____

14. **Compared to other people your age, would you say that your health is:**

◯ Poor
◯ Fair

Good

Excellent

15. Do you have attention deficit hyperactivity disorder (ADHD) or a learning disability?

Yes No

16. Do you take Ritalin/Concerta or some other medication to help with concentration or a learning problem?

Yes No

17. Do you take extra lessons or receive special help for difficulties with school work?

Yes No

18. During the last 2 weeks, how many days did you stay home from school because you were:

a. Sick? 0 1 2 3 4 5 6 7 8 9 10
b. Other? 0 1 2 3 4 5 6 7 8 9 10

Why did you stay home from school?

_____

There are no right or wrong answers. Be careful to choose the one answer that best describes the way your sleep has been in the last 2 weeks (unless otherwise instructed).

The next set of questions has to do with your usual schedule on days when you have school.

19. What time do you usually go to bed on school nights ? List ONE time, not a range.

A.M.
_____
P.M.

20. There are many reasons for doing things at one time or another. What is the main reason you usually go to bed at this time on school nights? (mark one)

My parents have set my bedtime

I feel sleepy

I finish my homework

My TV shows are over

My brothers(s) or sister(s) go to bed

I finish socializing ((in person or on social media apps)

I get home from my job

Lights out at hostel/boarding school

Other:

_____

21. What time do you usually wake up on school days? List ONE time, not a range.

A.M.
_____
P.M.

22. What is the main reason you usually wake up at this time on school days? (mark one)

Noises or my pet wakes me up

My alarm clock wakes me up

◯ My parents or other family members wake me up

◯ I need to go to the bathroom

◯ I don't know. I just wake up

◯ The bell in hostel/boarding school

◯ Other:

_____

23. What time do you <u>usually</u> leave home/hostel on school days? List ONE time, not a range.

_____ ◯ A.M. ◯ P.M.

24. How do you usually get to school?

◯ Walk

◯ Get a ride with a friend(s)

◯ Take the school bus

◯ Drive/ride my bicycle

◯ Take a taxi

◯ Get a ride with parent/family member

25. How long do you usually sleep on a normal school night? (Do not include time you spend awake in bed. Remember to mark hours and minutes, even if minutes are zero.)

_____ hours _____ minutes

26. On school days, after you go to bed at night, about how long does it usually take you to fall asleep?

_____ minutes

The next set of questions has to do with your usual schedule on days when you do <u>not</u> have school, such as the weekend

27. What time do you <u>usually</u> go to bed on weekend nights? List ONE time, not a range.

◯ A.M. _____ ◯ P.M.

28. What is the <u>main reason</u> you usually go to bed at this time on weekend nights? (mark one)

◯ My parents have set my bedtime

◯ I feel sleepy

◯ I finish my homework

◯ My TV shows are over

◯ My brothers(s) or sister(s) go to bed

◯ I finish socializing (in person or on social media)

◯ I get home from my job

◯ Lights out at hostel/boarding school

◯ Other:

_____

29. What time do you <u>usually</u> wake up on the weekend? List ONE time, not a range.

◯ A.M. _____ ◯ P.M.

30. What is the main reason you usually wake up at this time on weekends? (mark one)

- ◯ Noises or my pet wakes me up
- ◯ My alarm clock wakes me up
- ◯ My parents or other family members wake me up
- ◯ I need to go to the bathroom
- ◯ I don't know. I just wake up
- ◯ The bell in hostel/boarding school
- ◯ Other: _____

31. How long do you usually sleep on a night when you do not have school the next day (such as a weekend night)? (Do not include time you spend awake in bed. Remember to mark hours and minutes, even if minutes are zero.)

_____ hours _____ minutes

32. On weekends, after you go to bed at night, about how long does it usually take you to fall asleep?

_____ minutes

33. Some people wake up during the night. Others never do. How many times do you usually wake up at night?

- ◯ Never
- ◯ Once
- ◯ 2 or 3 times
- ◯ More than 3 times
- ◯ I have no idea

34. People sometimes feel sleepy during the daytime. During your daytime activities, how much of a problem do you have with sleepiness (feeling sleepy, struggling to stay awake)?

- ◯ No problem at all
- ◯ A little problem
- ◯ More than a little problem
- ◯ A big problem
- ◯ A very big problem

35. Some people take naps in the daytime every day, others never do. When do you nap? (Mark all that apply)

- ◯ I never nap
- ◯ I sometimes nap on school days
- I sometimes nap on weekends.
- ◯ I never nap unless I am sick.

36. Fill out below how much sleep you think you would need each night to feel your best every day. (Remember to mark hours and minutes, even if minutes are zero)

_____ hours _____ minutes

37. In general, do you feel when you usually get up....

- ◯ Too much sleep?
- ◯ enough sleep?
- ◯ too little sleep?

38. Do you consider yourself to be...

a good sleeper?

a poor sleeper?

39. How often do you think that you get enough sleep?

Always

Usually

Sometimes

Rarely

Never

Questions 40 to 42 are about things that have happened in the last 2 weeks.

40. During the last 2 weeks, have you struggled to stay awake (fought sleep) or fallen asleep in the following situations? (Mark <u>one</u> answer for <u>every</u> item.)

4.Both struggled to stay awake and fallen asleep
3. Fallen asleep
2. Struggled to stay awake
1. No

In a face-to-face conversation with another person.....

Travelling in a bus, train, plane, or car.....

Attending a performance (movie, concert, play).....

Watching TV or listening to the radio or music.....

Reading, studying or doing home-work.....

During a test.....

In a class at school.....

While doing work on a computer.....

Playing video games.....

Driving a car.....

Do you drive? Yes

No

41. During the last 2 weeks, how often did you ...<u>(Mark 1 answer for every item.)</u>

4. Every day
3. Several times every day
2. Once or twice a day
1. Never

a. Drink soda with caffeine(E.g. coke; pepsi; not like Orange soda and sprite)?.....

b. Drink coffee or tea with caffeine.....

42. In the last 2 weeks, how often have you... <u>(Mark one answer for every 1 item)</u>

5. Never
4. Once
3. Twice
2. Several times
1. Everyday/night

a. felt satisfied with your sleep?

b. arrived late to class because you overslept?.....

c. fallen asleep in a morning

class?.....

d. fallen asleep in an afternoon class?.....

e. awakened too early in the morning and couldn't get back to sleep?.....

f. stayed up until at least 3 a.m.

g.stayed up all night?.....

h.slept in past noon?.....

i. felt tired, dragged out, or sleepy during the day?.....

j. needed more than 1 reminder to get up in the morning?.....

k. had an extremely hard time falling asleep?.....

l. had nightmares or bad dreams during the night?.....

m. gone to bed because you just could not stay awake any longer?.....

n. done dangerous things without Thinking?.....

o. had a good night's sleep?.....

43. During the last 2 weeks, how often were you bothered or troubled by the following?

	3. Much	2. Somewhat	1. Not at all
a. Feeling too tired to do things.....	◯	◯	◯
b. Having trouble going to sleep or staying asleep.....	◯	◯	◯
c. Feeling unhappy, sad, or depressed..	◯	◯	◯
d. Feeling hopeless about the future.....	◯	◯	◯
e. Feeling nervous or tense.....	◯	◯	◯
f. Worrying too much about things.....	◯	◯	◯

Questions 44 - 53 have to do with how you might organize the timing of various activities if you were free to plan your day according to when you feel your best. <u>Please answer the questions based on your body's "feeling best" times.</u> Circle the answer that is most applicable to you

44. Imagine: School is cancelled! You can get up whenever you want to: When would you get out of bed? Between:

◯ 05:00 and 06:30 a.m.
◯ 06:30 and 07:45 a.m.
◯ 07:45 and 09:45 a.m.
◯ 09:45 and 11:00 a.m.
◯ 11:00 a.m. and noon

45. Is it easy for you to get up in the morning?

◯ No way!
◯ Sort of
◯ Pretty easy
◯ Very easy

46. Physical Education (PE) is set for 7:00 in the morning. How do you think you'll do?

◯ My best!
◯ Okay
◯ Worse than usual
◯ Awful!

47. The bad news: You have to take a 2 hour test. The good news: You can take

it when you think you'll do best. What time is that?

- ◯ 08:00 to 10:00 a.m.
- ◯ 11:00 a.m. to 1:00 p.m.
- ◯ 3:00 p.m. to 5:00 p.m.
- ◯ 7:00 p.m. to 9:00 p.m.

48. When do you have the most energy to do your favorite things?

- ◯ Morning! I am tired in the evening.
- ◯ Morning more than evening
- ◯ Evening more than morning
- ◯ Evening! I am tired in the morning

49. Your parents or hostel master has decided to let you set your own bed time. What time would you pick? Between:

- 8:00 and 9:00 p.m.
- 9:00 and 10:15 p.m.
- 10:15 p.m. and 12:30 a.m.
- 12:30 and 1:45 a.m.
- 1:45 and 3:00 a.m.

50. How alert are you in the first half hour you're up?

- Out of it
- A little dazed
- Okay
- Ready to take on the world

51. When does your body start to tell you it's time for bed (even if you ignore it)? Between:

- 8:00 and 9:00 p.m.
- 9:00 and 10:15 p.m.
- 10:15 p.m. and 12:30 a.m.
- 12:30 and 1:45 a.m.
- 1:45 and 3:00 a.m.

52. Say you had to get up at 6:00 a.m. every morning: What would it be like?

- Awful!
- Not so great.
- Okay (If I have to).
- Fine, no problem!

53. When you wake up in the morning, how long does it take for you to be totally "with it"?

- 0 to 10 minutes
- 11 to 20 minutes
- 21 to 40 minutes
- More than 40 minutes

54. Would you say that your growth in height:

- Has not begun to spurt ("spurt" means faster growth than usual)
- Has barely started
- Is definitely underway
- Seems complete
- I don't know

55. Would you say that your other signs of physical maturation:

- Have not yet started to show
- Have barely started to show
- Are definitely underway
- Seem complete
- I don't know

56. During the last week, did you work at a job for pay? (If no, skip to number 57.)

Yes No

What kind of job?

How many days did you work at the following times?

In the morning before school……..0 1 2 3 4 5
In the afternoon after school……..0 1 2 3 4 5
In the evening on days you have school…..0 1 2 3 4 5
On the weekend……0 1 2

How many hours did you work at your paying job <u>this week?</u>

During the school week: hours
During the weekend: hours

During the last 2 weeks, have you struggled to stay awake (fought sleep) or fallen asleep at your job?

no struggled to stay awake

fallen asleep both struggled to stay awake and fallen asleep

If you did not have your job, would you go to bed:

earlier than you do. the same as you do.

later than you do.

If you did not have your job, would you wake up:

earlier than you do. the same as you do.

later than you do.

57. During the last week, did you engage in organized sports or a regularly scheduled physical activity (If no, skip to number 58.)

Yes No

What kind of sport?

How many days did you practice at the following times?

In the morning before school……..0 1 2 3 4 5
In the afternoon after school……..0 1 2 3 4 5
In the evening on days you have school…..0 1 2 3 4 5
On the weekend……0 1 2

How many hours did you practice <u>this week?</u>

During the school week: hours
During the weekend: hours

During the last 2 weeks, have you struggled to stay awake (fought sleep) or fallen asleep during practice?

no struggled to stay awake

fallen asleep both struggled to stay awake and fallen asleep

If you did not have your organized activity, would you go to bed:

earlier than you do. the same as you do.

later than you do.

If you did not have your organized activity, would you wake up:

earlier than you do. the same as you do.

later than you do.

58. During the last week, did you study/do homework? (If no, skip to number 59.)

Yes No

How many days do you study/do homework at the following times?

In the morning before school……..0 1 2 3 4 5
In the afternoon after school……..0 1 2 3 4 5
In the evening on days you have school…..0 1 2 3 4 5
On the weekend……0 1 2

How many hours did you study/do homework <u>this week?</u>

During the school week: hours
During the weekend: hours

During the last 2 weeks, have you struggled to stay awake (fought sleep) or fallen asleep during studying/homework?

no struggled to stay awake

fallen asleep both struggled to stay awake and fallen asleep

If you did not have to study/do homework, would you go to bed:

earlier than you do. the same as you do.

later than you do.

If you did not have to study/do homework, would you wake up:

earlier than you do. the same as you do.

later than you do.

The following section is meant to assess your use of electrical devices (EDs) before bedtime.

	Smartphone/Mobile Cell phone	**Laptop/ Computer**	**Tablet**	**Television**	**Video games e.g playstation, xbox**
59. Please place an x on the device(s) you have /use					
60. Place an X on the device(s) you have/ use in your room/hostel dorm before bedtime?					
61. What do you usually use device(s) for before bedtime? Place an X next to the appropriate reason	Calling: Texting: Browsing through social media; Browsing the internet: Homework/Assignments: Movies: Other:	Chatting: Browsing through social media: Browsing the internet: Homework /Assignments: Listening to or downloading music: Movies/series Other:	Chatting: Browsing through social media: Browsing the internet: Homework /Assignments: Listening to or downloading music: Movies/series Other:	Watching movies or TV shows: Other:	

62. How often do you use these devices before bedtime? Write: • Never • Sometimes • Usually • Always					
63. How much time do you spend using these devices before bedtime (Hours and minutes) ?					

Appendix C: Final Ethical Clearance Letter

16 August 2019

Natasha Mandondo

Review Reference: 2019-0168-461

Email: g13M4931@campus.ru.ac.za

Dear Natasha Mandondo

Re: Sleep-wake behaviour of South African adolescents

Principal Investigator: Dr Jonathan Davy

Collaborators: Miss Natasha Luleka Mandondo

This letter confirms that the above research proposal has been reviewed and **APPROVED** by the Rhodes University Ethical Standards Committee (RUESC) – Human Ethics (HE) sub-committee.

Approval has been granted for 1 year. An annual progress report will be required in order to renew approval for an additional period. You will receive an email notifying when the annual report is due.

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloguing number allocated.

Sincerely

Prof Joanna Dames

Chair: Human Ethics sub-committee, RUESC- HE

Appendix D: Ethical Clearance from Departmentof Education

Province of the
EASTERN CAPE
EDUCATION

STRATEGIC PLANNING POLICY RESEARCH AND SECRETARIAT SERVICES
Steve Vukile Tshwete Complex • Zone 6 • Zwelitsha • Eastern Cape
Private Bag X0032 • Bhisho • 5605 • REPUBLIC OF SOUTH AFRICA
Tel: +27 (0)40 608 4773/4035/4537 • Fax: +27 (0)40 608 4574 • Website: www.ecdoe.gov.za

Enquiries: B Pamla Email: babalwa.pamla@ecdoe.gov.za Date: 01 August 2019

Ms. Natasha Luleka Mandondo

16 Nixon road

Perridgevale

Port Elizabeth

6001

Dear Ms. Mandondo

PERMISSION TO UNDERTAKE A MASTERS' RESEARCH: SLEEP AWAKE BEHAVIOR OF ADOLESCENTS IN A SAMPLE OF SOUTH AFRICAN HIGH SCHOOL STUDENTS

1. Thank you for your application to conduct research.
2. Your application to conduct the above mentioned research involving Grade 12 adolescents from local private and public high schools in and around Makhanda District of the Eastern Cape Department of Education (ECDoE) is hereby approved based on the following conditions:
   a. there will be no financial implications for the Department;
   b. institutions and respondents must not be identifiable in any way from the results of the investigation;
   c. you seek parents' consent for minors;
   d. it is not going to interrupt educators' time and task;
   e. you present a copy of the written approval letter of the Eastern Cape Department of Education (ECDoE) to the Cluster and District Directors before any research is undertaken at any institutions within that particular district;
   f. you will make all the arrangements concerning your research;
   g. the research may not be conducted during official contact time, provided that an arrangement to do research at the school including getting inside a classroom has been arranged and agreed upon in writing with the Principal and the affected teacher;

h. should you wish to extend the period of research after approval has been granted, an application to do this must be directed to Chief Director: Strategic Management Monitoring and Evaluation;

i. your research will be limited to those institutions for which approval has been granted, should changes be effected written permission must be obtained from the Chief Director: Strategic Management Monitoring and Evaluation;

j. you present the Department with a copy of your final paper/report/dissertation/thesis free of charge in hard copy and electronic format. This must be accompanied by a separate synopsis (maximum 2 - 3 typed pages) of the most important findings and recommendations if it does not already contain a synopsis.

k. you present the findings to the Research Committee and/or Senior Management of the Department when and/or where necessary.

l. you are requested to provide the above to the Chief Director Strategic Management Monitoring and Evaluation upon completion of your research.

m. you comply with all the requirements as completed in the Terms and Conditions to conduct Research in the ECDoE document duly completed by you.

n. you comply with your ethical undertaking (commitmentform).

o. You submit on a six monthly basis, from the date of permission of the research, concise reports to the Chief Director: Strategic Management Monitoring and Evaluation

3. The Department reserves a right to withdraw the permission should there not be compliance to the approval letter and contract signed in the Terms and Conditions to conduct Researchin the ECDoE.

4. The Department will publish the completed Research on its website.

5. The epartment wishes you well in your undertaking. You can contact the Director, Ms. NY should· na on the numbers indicated in the letterhead or email nelisa.kanjana@ecdoe.gov.za uld you need any assistance.

KANJANA

RECTOR: STR

DIRECTOR: STRATEGIC PLANNING POLICY AND RESEARCH

FOR SUPERINTENDENT-GENERAL: EDUCATION

Appendix E: Letter to Parents for Phase one

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

HUMAN KINETICS & ERGONOMICS

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Supervisor: Dr J. Davy•email: j.davy@ru.ac.za •tel: (046)-603-7369

Co-Supervisor: Dr S. Zschernack •email: s.zschernack@ru.ac.za •tel: (046)-603-8472

Researcher: Miss N. Mandondo • email: g13m4931@campus.ru.ac.za

Letter of invitation to participate in a research study on adolescent sleep patterns

Thesis title: The Sleep-wake behavior of adolescents in a sample of South African high school students

My name is Natasha Mandondo and I am a Masters by thesis student in the Human Kinetics and Ergonomics department of Rhodes University.

I am conducting research on adolescent sleep patterns in the Grahamstown/Makhanda area for the partial fulfillment of the Master of Science degree and I would like to extend an invitation to you and your child to participate in this research. Please note that ethical clearance for this study has been granted by the Rhodes University Ethical Review Committee. The main purpose of this research is to give an extensive description and analysis of sleep habits of Grade 12 adolescents.

Why is this study beneficial to you and your child?

Adolescent sleep patterns are increasingly recognized as a global problem, especially, with many adolescents from all over the world reporting disturbed sleep more so among those experiencing increases in age/Grade. This is especially true for Grade 12 learners because they are faced with increased academic, social and other pressures. Based on research, this population group is more prone to experiencing decreased sleep durations and other sleep complaints. This can have many implications such as daytime sleepiness, which is the most obvious and direct effect. Other implications as assessed by research in other parts of the world are poor school achievement or poorer academic performance, decreased school attendance, attention problems, memory problems, reduced concentration levels and increased levels of depression among others.

Your child's participation in the research will be of great importance to assist in contributing to the gap in literature regarding adolescent sleep patterns in the South African context. If we understand the problems that are faced by adolescents then future research or studies can work at finding suitable intervention methods aimed at improving quality of life and improve academic performance. The study may have the following benefits for learners: It may result in increased awareness on one's sleep habits and may prompt thoughts about improvements. Participants may also request to read the paper and its findings upon completion, this information may also be used towards improving sleep hygiene and being more aware of the implications of poor or insufficient sleep. Furthermore, the researcher is more than willing to present findings and to report findings through educational posters.

Instructions to your child:

The survey will be filled in anonymously during class time. The School Sleep Habits Survey (SSHS) will gather information regarding sleep-wake patterns over the past 2 weeks. The questionnaire will include demographics e.g. age, sex, height, weight, grade, ethnicity, school performance, as well as scales to assess daytime sleepiness, sleep-wake behavior problems, depressive mood and chronotype i.e. self-assessed preferred time of day for activities. The survey will also include questions relating to the presence and use of EDs such as cellphones and laptops. The survey has been attached for your information.

The research is for academic purposes only and information will be kept private and confidential. Participation in this research is completely voluntary, and does not involve any reimbursement or payment, you and your child may choose to withdraw from the research at any time or not answer questions that you do not feel comfortable answering. Please also note that coded (anonymous) data will be archived by the Human Kinetics and Ergonomics at Rhodes University in computer format after the project and may be subject to future use for academic purposes.

Statement of Consent

I have read the above information. I feel I understand the study well enough to make a decision about the voluntary and anonymous involvement of my child. I consent to understanding and agreeing to the terms described above. I consent to the use of my child's data for study purposes.

I_____hereby give permission for my child,

_____, to fill in the survey and to voluntarily participate in the study.

Signed: _____

Thank you for your time and participation.

Letter to parents for Phase one (Afrikaans translation)

RHODES UNIVERSITY
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HUMAN KINETICS & ERGONOMICS

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Medebestuurder: Dr S. Zschernack •e-pos: s.zschernack@ru.ac.za •tel: (046)-603-8472

Navoser: Mej. N.L. Mandondo • e-pos: g13m4931@campus.ru.ac.za

Uitnodiging om deel te neem in `n navoorsing studie oor adolesente se slaap petrone

Tesis titel: Slaap wakker gedrag van adolesente in `n groepie van Suid-Afrikaanse hoërskoolstudente

My naam is Natasha Mandondo en ek is ‘n meersters tetis student in Menslike Kinetika en Ergonomie departement van Rhodes Universiteit.

Ek doen ‘n navoorsing studie op adolesente se slaap patrone in die Grahamstown/Makhanda gebied as ‘n gedeeltelike vereiste van my meisters graad in wetenskap en ek wil graag ‘n uitnoodiging uitreik aan jy and jou kind om deel te neem in die navoorsing. Neem asseblief kenis dat etiese klaring vie hierdie studie reeds uitgereik is deur die Universitiet van Rhodes Eteise Hersinnings Commitee. Die hoof doel van hierdie navoorsing is om `n breedvoerige beskrywing en analiseering van slaap gewoontes van graad 12 adolesente.

Hoe gaan jy en jou kind baat vend by merdie studie?

Adolesente se slaap patrone word wereldwyd meer `n probleem, vir al nou dat meer adolesente slaap versteurings raporteer vir al wanner hulle ouer word en raak erger in elke skool graad. Dit is vir al waar in graad 12 leerlinge wat ondervind dat hulle akedemiese en sociale vereistes vermeerder. Gebaseer op navoorsing is hierdie ouderdoms group meer vatbaar vir verkoter slaap periode. Dit kan vele implikasies he soos by voor beeld slaap in die dag, wat die mees opvalende en direkte effek is. Ander implikasies word waargeneem tydens toetse in ander dele van die wêreld soos verswakte skool prestasie of laar punte, `n afname in skool by woning, probleeme met aandag skenk, geheur probleeme, afname in konsentrasie vlakke en verhoogte vlakke van depressie in ander.

Jou kind se deelname in die navoorsing sal baie belangrik wees om by te dra in die gaaping in die beskikbaar litrituur oor adolsente se slaap patrone in die Suid-Afrikaanse konteks. Indien ons verstaan die probleeme waar mee adolesente te doen het dan kan toekomstige navoorsing of studies werk om geskikte oplossings metoodes vund wat gefocus is om depresie symptome to vermunder, lewenskwaliteit te verbeter sovel as akademiese voordering. Die studie mag die volgend voordele het vir leerders: Dit mag `n grooter bewismaaking in mense se slaap patrone tot gevolg het. Deelnemers mag ook aanvrae om die verslag en bevinding te lees na voltooing, hierdie imformasie mag ook gebruik word die verbetering van slaap higiëne en om meer bewis te wees van die implikasies van te min slaap. Verder sal die navoorseer meer as bereidwilig wees om diebefindinge voor te stel en dalk daar aan te werk om `n werkswinkle aan te bied oor slaap higiëne aan te bied in dien nogig.

Instruksies van jou kind

Die vraagstuk sal anoniem ingevul word geduuringde klastyd. Die Skool Slaapgewoontes Studie, sal informasie indien oor slaap wakker patrone oor twee weke. Die vraagstuk sal insluit demogratie by voorbeeld, ouderdom, geslag, lengte, gewig, graad, bevolkings group, skool prestasie, sovel as skale om slaaperigheid in die dag te toets, slaap/wakker gedrags probleme, depressiewe bui en kronetype i.e. Self beproefte verkieste tyd van die dag vir aktiewiteite. Die vraagstuk sal ook insluit vrae met betreking tot die teenwoordigheid en gebruik van elektronise toestelle soos selfoone en skootrekenare.

Die navoorsing is aleenlik vir akademiese doel eindes en informasie sal privaat en konfidential gehou word. Die vraagstuk word hier aangeheg vir jou informasie. Deelname in hierdie navoorsing

is heeltemal vrywillig en het geen betaaling of vergoeding nie, jy en jou kind mag kies om te ontrek van die navoorsing.teen enige tyd of nie. Vrae beantwoord wat julle ongmaklik laat voel nie. Neem asseblief waar dat saamgestelde data sal in die argief gestoor woord by die Menslike Kinetike en Ergonomie departement by die Universiteit van Rhodes un retenaar formaat na die voltooing van die projek en mag in die toekoms gebruik word vir akademiese doel eindes.

……....

Toestemmingsverklaring

Ek het bogenoemde informasie geless. Ek verstaan die studie goed genoeg om `n besluit te maak oor die vrywilige en anonieme betrokkenheid van my kind. Ek gee toestemming dat ek bogenoemde verklaaring verstaan en saamstem. Ek gee toestemming dat my kind se informasie vir studie doel eindes gebruik word. Ek _____ gee hiermee toestemming vir my kind _____ om die vraagstuk vrywiliglik deelteneem in die studie.

Geteken: _____

Dankie vir jou tyd en deelname

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Researcher: Miss N. Mandondo • email: g13m4931@campus.ru.ac.za

Imbalelwano eya kubazali/omele umzali

Incwadi esisimemo kuphando kubantu abatsha neendlela zabo zokulala

Igama lam ngu-Natasha Mandondo, kwaye ndingumfundi we-Masters kwisebe le-Human Kinetics kunye ne-Ergonomics kwiJunivesithi yase-Rhodes.

Ndiqhuba uphando kubantu abatsha neendlela zabo zokulala

Kutheni olu phando lunoncedo kuwe nomntwana wakho?

Iindlela abantu abatsha abalala ngazo ziyakhawuleza ukujongeka njengengxaki kwilizwe jikelele, ngakumbi kubantu abatsha jikelele abaveza izikhalazo zokuphazanyiswa xa belele. Oku kunobangela ukozela emini, iyeyona nto ivamileyo. Ezinye izinto ezichaphazelekayo ngokophando kumanye amazwe kungaqhubi kakuhle ezikolweni, ukungahambi qhoro isikolo, iingxaki kwithuba umntwana akwazi ukuhoya ngalo, iigxaki kukugcina engqondweni nokukhumbula, nokuziva udakumbile ngeyona ndlela. Sifuna nokuthelekisa iimbono zabafundisi-ntsapho, kunye neengxelo ezisuka kubantu abatsha.

Ukuzibandakanya kwenu kolu phando kungabaluleka kakhulu ekuncedeni ukuvala isikhewu kwithala leencwadi ezijongene neendlela abantu abatsha abalala ngazo eMzantsi Afrika. Ukuba singaziqonda iingxaki abantu abatsha abajongene nazo, singasebenzela ukufumana izisombululo ezibafaneleyo ukwehlisa izinga lokuziva udakumbile, siphucule imeko yokuphila, futhi siphucule nomeko yokufunda. Uphando olu lunokubanceda abafundi ngezi ndlela zilandelayo: inokukhuphula ulwazi ngeendlela umntu alala ngazo, ikhuthaze iingcinga zokuziphucula. Abantu abazibandakanyayo banokucela ukufunda ushicilelo neziphumo ukugqitywa kophando. Olu lwazi lunokusetyenziswa ekuphuculeni iindlela zokulala nolwazi lweengxaki ezidibene nokungalali kakuhle.

Umntwana wakho uceliwe ukuba agcwalise i-sleep habits questionnaire

Uphando lwenzelwa imfundo kuphela, kwaye iinkcukacha ziya kugcinwa zingaziwa mntu. Kuqhagamshelwe isicwangciso sokulala ne-survey. Ukuzibandakanya nokuthatha inxaxheba kolu phando akunyanzelwa mntu, kwaye akukho mbuyekezo, wena nomntwana wakho ningakhetha ukukhululeka kuphando nangaliphi ixesha ninongayiphenduli imibuzo eniyiva iyandixhalabisa. Ncedani niqaphele ukuba iinkcukacha ezi-aggegated zobe zigcinwe lisebe le-Human Kinetics ne-Ergonomics kwiJunivesithi yase-Rhodes, ngokwe-computer emveni kophando, kwaye zinokusetyenziswa kwixesha elizayo ezifundweni.

Isibhengezo semvume

Ndizifundile ezi nkcukacha zingentla. Ndiziva ndiluqonda uphando kangangokuba ndingenza isigqibo ngokubandakanye komntwana wami. Ndiyavuma ekuqondeni nasekuvumeleni imiqathango engentla. Ndiyavuma ekusetyenzisweni kweenkcukacha zam nezomntwana wam kolu phando kuphela.

Mna_____Ndiyavuma uba omntwana wam u _____, aphendule imibuzo ye-survey

Sayina: : _____

Enkosi ngexesha lakho nokuthatha inxaxheba.

Appendix F: Letter requesting participation to schools for Phase one

HUMAN KINETICS & ERGONOMICS

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Researcher: Miss N. Mandondo • email: g13m4931@campus.ru.ac.za

High Schools in the Makhanda area are invited to take part in a research study about Grade 12 adolescent sleep patterns.

The study is being conducted by a researcher named Natasha Mandondo who is a Masters student at Rhodes University in the Human Kinetics and Ergonomics department.

Background Information:

The main aim of this study is to give an extensive description and analysis of adolescent sleep-wake habits or patterns.

Procedure:

(If you agree that your school takes part in the study):

- Learners from Grade 12 learners will be asked to anonymously fill in a School Sleep Habits Survey (SSHS).
- All Grade 12 learners willing to participate in the study will be asked to take home a consent letter to their parents/guardians. The letter to the parents/guardians will explain the research study it will ask parents to give permission that their child's data be used.

Voluntary Nature of the Study:

This study is completely voluntary. This study is completely anonymous, and information is to be kept private and confidential. Voluntary consent to the study may also be withdrawn at any later stage.

Risks associated with the study:

- Asking participants questions about their sleep patterns may put them at the psychological risk of experiencing negative affective states such as anxiety, worry about their sleeping habits, and anxiety over the reasons for their inadequate sleep, all of which may also have an impact on their sleep.
- Questioning participants about personal demographic information such as socioeconomic status may make them feel uncomfortable and or embarrassed.
- The effects of the above-mentioned risks have been taken into consideration and in conjunction with the schools, counselors will be asked to assist in this regard following discussions with the relevant stakeholders. Also, based on the guidance provided by schools, we will work with them and the staff to allay fears through workshops and debriefs with relevant professionals.
- The above risks also do not necessarily exceed the risks that participants could encounter in daily life.

Benefits:

Your participation in the research will be of great importance to assist in contribute to the gap in literature regarding adolescent sleep patterns in the South African context. If we understand the problems that are faced by adolescents then future studies can work at finding suitable intervention methods aimed at reducing depressive symptoms, improve quality of life, and improve academic

performance. The study may also have the following benefits for learners: It may result in increased awareness on one's sleep habits and may prompt thoughts about improvements. Participants may also request to read the paper and its findings upon completion, this information may also be used towards improving sleep hygiene and being more aware of the implications of poor or insufficient sleep. The researcher will also commit to inform pupils the results via educational posters

Payment:

This study is completely voluntary; there will be no reimbursement or payment for time.

Privacy and Anonymity:

Any information provided will be kept anonymous. The researcher will not use personal information for any purposes outside of this research project. Also, the researcher will not include individual names or anything else that could serve as identification. Data will be kept secure by password protection and data encryption. Data will be kept for a period of at least 5 years, as required by the university and may be subject to future use for academic purposes. Future use will be limited to analyses of some parts of the data or for comparisons with another population group, however, participants will not be contacted.

Contacts and Questions:

If you have questions now or at a later time, you may contact the researcher, Natasha Mandondo, via natashamandondo@gmail.com, you can also contact my supervisor, Dr. Jonathan Davy via Jonathan.Davy@ru.ac.za or my co-supervisor, Dr. Swanje Zschernack via s.zschernack@ru.ac.za

Statement of Consent

I _____the school principal of _____ high school, have read the above information. I feel I understand the study well enough to make a decision about the involvement of my school and learners. By signing below, I consent to understanding and agreeing to the terms described above and agree that my learners participate in filling in the survey

Signature: _____

Appendix G: Letter to learners for Phase one

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HUMAN KINETICS & ERGONOMICS

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Researcher: Miss N. Mandondo • email: g13m4931@campus.ru.ac.za

Letter of invitation to learners for participation in a research study on adolescent sleep patterns

My name is Natasha Mandondo and I am a Masters by thesis student in the Human Kinetics and Ergonomics department of Rhodes University.

I am conducting research on adolescent sleep patterns in the Grahamstown/Makhanda area for the partial fulfillment of the Master of Science degree at Rhodes University and I would like to extend an invitation to the Grade 12 learners in the school to participate in this research. Please note that ethical clearance for this study has been granted by the Rhodes University Ethical Review Committee. The main aim of this research is to give an extensive description and analysis of Grade 12 adolescent sleep habits

What will the study entail?

The study consists of a School Sleep Habits Survey (SSHS) that will be administered to Grade 12 high school learners in the Grahamstown/Makhanda area. The survey will be filled in anonymously during class time or at times deemed appropriate by the school principal. The School Sleep Habits Survey (SSHS) will gather information regarding sleep-wake patterns over the past

two weeks. The survey has been attached for your information. The survey includes demographics e.g. age, sex, height, weight, grade, ethnicity, school performance, as well as scales to assess daytime sleepiness, sleep-wake behavior problems, depressive mood and chronotype i.e. self-assessed preferred time of day for activities. The survey will also include questions relating to the presence and use of Electronic Devices such as cellphones and laptops.
A letter of consent has been emailed to your parents/guardians. The letter to the parents/guardians explains the research study and requests them to respond should they not want to grant permission that you fill in the survey. The letter to your parents/guardians is also translated into isiXhosa and Afrikaans.

The research is for academic purposes only and information will be kept private and confidential. Participation in this research is completely voluntary; you may choose to withdraw from the research at any time or not answer questions that you do not feel comfortable answering. Please note that coded (anonymous) data will be archived by the Human Kinetics and Ergonomics at Rhodes University in computer format after the project and may be subject to future use for academic purposes. Future use will be limited to analyses of some parts of the data or for comparisons with another population group, however, participants will not be contacted.

Your participation in the research will be of great importance to assist in contribute to the gap in literature regarding adolescent sleep patterns in the South African context. If we understand the problems that are faced by adolescents and especially those of Grade 12s then future research or studies can work at finding suitable intervention methods if need be.

If you are willing to participate in the study, please sign the declaration below. Upon completion, please tear it off and return to the researcher.

……....

I _____ have read the above information. I feel I understand the study well enough to make a decision about my voluntary and anonymous involvement. I understand and agree to the terms described above. I voluntarily agree to fill out the survey and I also agree that my data be used for study purposes.

Signed: _____

Thank you for your time and participation.

Appendix H: Verbal information given to learners for Phase One

My name is Natasha Mandondo and I am a Masters by thesis student in the Human Kinetics and Ergonomics department of Rhodes University.

I am conducting research on adolescent sleep patterns in the Grahamstown/Makhanda area for the partial fulfilment of the Master of Science degree at Rhodes University and I would like to extend an invitation to the Grade 12 learners in the school to participate in this research.

I am going to hand out an eight paged School Sleep Habits Survey (SSHS). I am asking that you please fill it in anonymously and voluntarily during class time or at times deemed appropriate by your principal. The School Sleep Habits Survey (SSHS) will gather information regardingsleep-wake patterns over the past 2 weeks. The questionnaire includes demographics e.g. age, sex,height, weight, grade, ethnicity, school performance, as well as scales to assess daytime sleepiness, sleep-wake behavior problems, depressive mood and chronotype i.e. self-assessed preferred timeof day for activities. The survey will also include questions relating to the presence and use of Electronic Devices such as cellphones and laptops.

Before participation in the study, please take home this letter to your parents/guardians. The letter parents explain the research study, it also asks them to give consent for your participation in the study and only then will you be able to take part in the study.

Please note that this research is for academic purposes only and information will be kept private and confidential. Participation in this research is completely voluntary; you may choose to withdraw from the research at any time or not answer questions that you do not feel comfortable answering. Please also note that coded (anonymous) data will be archived by the Human Kinetics and Ergonomics at Rhodes University in computer format after the project and may be subject to future use for academic purposes. Future use will be limited to analyses of some parts of the data or for comparisons with another population group, however, participants will not be contacted.

Your participation in the research will be of great importance to assist in contributing to the gap in literature regarding adolescent sleep patterns in the South African context. If we understand the problems that are faced by adolescents then we can work at finding suitable intervention methods aimed at reducing depressive symptoms, improve quality of life, and improve academic performance.

Thank you

Appendix I: Final-Consensus-Sleep-Diary-with-instructions

Sleep Diary Instructions (CSD-M)

General Instructions

What is a Sleep Diary?

A sleep diary is designed to gather information about your daily sleep pattern.

How often and when do I fill out the sleep diary? It is necessary for you to complete sleep diary diary every day.

If possible, the sleep diary should be completed within one hour of getting out of bed in the morning.

What should I do if I miss a day?

If you forget to fill in the diary or are unable to finish it, leave the diary blank for that day.

What if something unusual affects my sleep or how I feel in the daytime?

If your sleep or daytime functioning is affected by some unusual event (such as an illness, or an emergency) you may make brief notes on your diary.

What do the words "bed" and "day" mean on the diary?

This diary can be used for people who are awake or asleep at unusual times. In the sleep diary, the word "day" is the time when you choose or are required to be awake. The term "bed" means the place where you usually sleep.

Will answering these questions about my sleep keep me awake?

This is not usually a problem. You should not worry about giving exact times, and you should not watch the clock. Just give your best estimate.

Sleep Diary Item Instructions

Use the guide below to clarify what is being asked for each item of the Sleep Diary.

Date.: Write the date of the morning you are filling out the diary.

1. What time did you get into bed? Write the time that you got into bed. This may not be the time you began "trying" to fall asleep.

2. What time did you try to go to sleep? Record the time that you began "trying" to fall asleep.

3. How long did it take you to fall asleep? Beginning at the time you wrote in question 2, how long did it take you to fall asleep.

4. How many times did you wake up, not counting your final awakening? How many times did you wake up between the time you first fell asleep and your final awakening?

5. In total, how long did these awakenings last? What was the total time you were awake between the time you first fell asleep and your final awakening? For example, if you woke 3 times for 20 minutes, 35 minutes, and 15 minutes, add them all up (20+35+15= 70 min or 1 hr and 10 min).

6a. What time was your final awakening? Record the last time you woke up in the morning.

6b. After your final awakening, how long did you spend in bed trying to sleep? After the last time you woke-up (Item #6a), how many minutes did you spend in bed trying to sleep? For example, if you woke up at 8 am but continued to try and sleep until 9 am, record 1 hour.

6c. Did you wake up earlier than you planned? If you woke up or were awakened earlier than you planned, check yes. If you woke up at your planned time, check no.

6d. If yes, how much earlier? If you answered "yes" to question 6c, write the number of minutes you woke up earlier than you had planned on waking up. For example, if you woke up 15 minutes before. the alarm went off, record 15 minutes here.

7. What time did you get out of bed for the day? What time did you get out of bed with no further attempt at sleeping? This may be different from your final awakening time (e.g. you may have woken up at 6:35 a.m. but did not get out of bed to start your day until 7:20 a.m.)

8. In total, how long did you sleep? This should just be your best estimate, based on when you went to bed and woke up, how long it took you to fall asleep, and how long you were awake. You do not need to calculate this by adding and subtracting; just give your best estimate.

9. How would you rate the quality of your sleep? "Sleep Quality" is your sense of whether your sleep was good or poor.

10. How restful or refreshed did you feel when you woke up for the day? This refers to how you felt after you were done sleeping for the night, during the first few minutes that you were awake.

11a. How many times did you nap or doze? A nap is a time you decided to sleep during the day, whether in bed or not in bed. "Dozing" is a time you may have nodded off for a few minutes, without meaning to, such as while watching TV. Count all the times you napped or dozed at any time from when you first got out of bed in the morning until you got into bed again at night.

11b. In total, how long did you nap or doze? Estimate the total amount of time you spent napping or dozing, in hours and minutes. For instance, if you napped twice, once for 30 minutes and once for 60 minutes, and dozed for 10 minutes, you would answer "1 hour 40 minutes." If you did not nap or doze, write "N/A" (not applicable).

12a. How many drinks containing alcohol did you have? Enter the number of alcoholic drinks you had where 1 drink is defined as one 12 oz beer (can), 5 oz wine, or 1.5 oz liquor (one shot).

12b. What time was your last drink? If you had an alcoholic drink yesterday, enter the time of day in hours and minutes of your last drink. If you did not have a drink, write "N/A" (not applicable).

13a. How many caffeinated drinks (coffee, tea, soda, energy drinks) did you have? Enter the number of caffeinated drinks (coffee, tea, soda, energy drinks) you had where for coffee and tea, one drink = 6-8 oz; while for caffeinated soda one drink = 12 oz.

13b. What time was your last caffeinated drink? If you had a caffeinated drink, enter the time of day in hours and minutes of your last drink. If you did not have a caffeinated drink, write "N/A" (not applicable).

14. Did you take any over-the-counter or prescription medication(s) to help you sleep? If so, list medication(s), dose, and time taken: List the medication name, how much and when you took EACH different medication you took tonight to help you sleep. Include medication available over

the counter, prescription medications, and herbals (example: "Sleepwell 50 mg 11 pm"). If every night is the same, write "same" after the first day

15. Comments: If you have anything that you would like to say that is relevant to your sleep feel free to write it here.

Consensus Sleep Diary-M (Please Complete Upon Awakening) **ID/NAME: ____________**

Today's Date	**Sample** 4/5/08							
1. What time did you get into bed?	10:15 p.m.							
2. What time did you try to go to sleep?	11:30 p.m.							
3. How long did it take you to fall asleep?	55 min.							
4. How many times did you wake up, not counting your final awakening?	6 times							
5. In total, how long did these awakenings last?	2 hours 5 min.							
6a. What time was your final awakening?	6:35 a.m.							
6b. After your final awakening, how long did you spend in bed trying to sleep?	45 min.							
6c. Did you wake up earlier than you planned?	☑ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
6d. If yes, how much earlier?	1 hour							
7. What time did you get out of bed for the day?	7:20 a.m.							
8. In total, how long did you sleep?	4 hours 10 min.							
9. How would you rate the quality of your sleep?	☐ Very poor ☑ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good	☐ Very poor ☐ Poor ☐ Fair ☐ Good ☐ Very good
10. How rested or refreshed did you feel when you woke-up for the day?	☐ Not at all rested ☑ Slightly rested ☐ Somewhat rested ☐ Well-rested ☐ Very well-rested	☐ Not at all rested ☐ Slightly rested ☐ Somewhat rested ☐ Well-rested ☐ Very well-rested	☐ Not at all rested ☐ Slightly rested ☐ Somewhat rested ☐ Well-rested ☐ Very well-rested	☐ Not at all rested ☐ Slightly rested ☐ Somewhat rested ☐ Well-rested ☐ Very well-rested	☐ Not at all rested ☐ Slightly rested ☐ Somewhat rested ☐ Well-rested ☐ Very well-rested	☐ Not at all rested ☐ Slightly rested ☐ Somewhat rested ☐ Well-rested ☐ Very well-rested	☐ Not at all rested ☐ Slightly rested ☐ Somewhat rested ☐ Well-rested ☐ Very well-rested	☐ Not at all rested ☐ Slightly rested ☐ Somewhat rested ☐ Well-rested ☐ Very well-rested

Consensus Sleep Diary-M Continued ID/NAME: _____

	Sample							
Today's Date	4/5/10							
11a. How many times did you nap or doze? 11b. In total, how long did you nap or doze?	2 times 1 hour 10 min.							
12a. How many drinks containing alcohol did you have? 12b. What time was your last drink?	3 drinks 9 :20 p.m.							
13a. How many caffeinated drinks (coffee, tea, soda, energy drinks) did you have? 13b. What time was your last drink?	2 drinks 3 :00 p.m.							
14. Did you take any over-the-counter or prescription medication(s) to help you sleep? If so, list medication(s), dose, and time taken	☑ Yes □ No Medication(s): Relaxo-Herb Dose: 50 mg Time(s) taken: 11 pm	□Yes □No Medication(s): Dose: Time(s) taken:	□Yes □No Medication(s): Dose: Time(s) taken:	□Yes □No Medication(s): Dose: Time(s) taken:	□Yes □No Medication(s): Dose: Time(s) taken:	□Yes □No Medication(s): Dose: Time(s) taken:	□Yes □No Medication(s): Dose: Time(s) taken:	□Yes □No Medication(s): Dose: Time(s) taken:
15. Comments (if applicable)	I have a cold							

Nighttime Sleep Diary

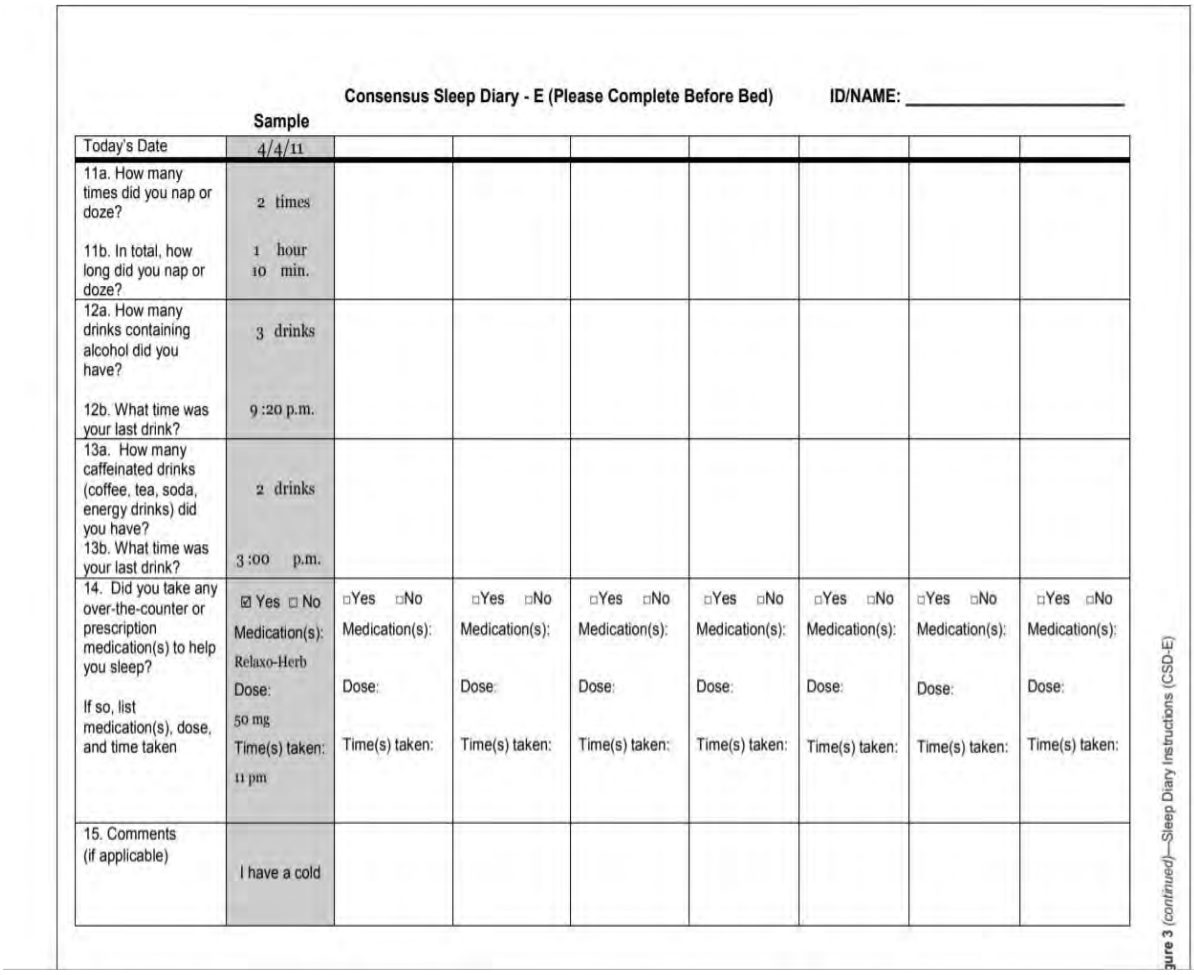
Consensus Sleep Diary - E (Please Complete Upon Awakening) **ID/NAME: ______________________**

Sample

Today's Date	4/5/11							
1. What time did you get into bed?	10:15 p.m.							
2. What time did you try to go to sleep?	11:30 p.m.							
3. How long did it take you to fall asleep?	55 min.							
4. How many times did you wake up, not counting your final awakening?	6 times							
5. In total, how long did these awakenings last?	2 hours 5 min.							
6a. What time was your final awakening?	6:35 a.m.							
6b. After your final awakening, how long did you spend in bed trying to sleep?	45 min.							
6c. Did you wake up earlier than you planned?	☑ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No
6d. If yes, how much earlier?	1 hour							
7. What time did you get out of bed for the day?	7:20 a.m.							
8. In total, how long did you sleep?	4 hours 10 min.							
9. How would you rate the quality of your sleep?	□ Very poor ☑ Poor □ Fair □ Good □ Very good	□ Very poor □ Poor □ Fair □ Good □ Very good	□ Very poor □ Poor □ Fair □ Good □ Very good	□ Very poor □ Poor □ Fair □ Good □ Very good	□ Very poor □ Poor □ Fair □ Good □ Very good	□ Very poor □ Poor □ Fair □ Good □ Very good	□ Very poor □ Poor □ Fair □ Good □ Very good	□ Very poor □ Poor □ Fair □ Good □ Very good
10. How rested or refreshed did you feel when you woke-up for the day?	□ Not at all rested ☑ Slightly rested □ Somewhat rested □ Well-rested □ Very well-rested	□ Not at all rested □ Slightly rested □ Somewhat rested □ Well-rested □ Very well-rested	□ Not at all rested □ Slightly rested □ Somewhat rested □ Well-rested □ Very well-rested	□ Not at all rested □ Slightly rested □ Somewhat rested □ Well-rested □ Very well-rested	□ Not at all rested □ Slightly rested □ Somewhat rested □ Well-rested □ Very well-rested	□ Not at all rested □ Slightly rested □ Somewhat rested □ Well-rested □ Very well-rested	□ Not at all rested □ Slightly rested □ Somewhat rested □ Well-rested □ Very well-rested	□ Not at all rested □ Slightly rested □ Somewhat rested □ Well-rested □ Very well-rested

Figure 3 *(continued)*—Sleep Diary Instructions (CSD-E)

Figure 3 continues on the following page



Consensus Sleep Diary - E (Please Complete Before Bed) **ID/NAME:** _____

	Sample							
Today's Date	4/4/11							
11a. How many times did you nap or doze? 11b. In total, how long did you nap or doze?	2 times 1 hour 10 min.							
12a. How many drinks containing alcohol did you have? 12b. What time was your last drink?	3 drinks 9:20 p.m.							
13a. How many caffeinated drinks (coffee, tea, soda, energy drinks) did you have? 13b. What time was your last drink?	2 drinks 3:00 p.m.							
14. Did you take any over-the-counter or prescription medication(s) to help you sleep? If so, list medication(s), dose, and time taken	☑ Yes ☐ No Medication(s): Relaxo-Herb Dose: 50 mg Time(s) taken: 11 pm	☐Yes ☐No Medication(s): Dose: Time(s) taken:	☐Yes ☐No Medication(s): Dose: Time(s) taken:	☐Yes ☐No Medication(s): Dose: Time(s) taken:	☐Yes ☐No Medication(s): Dose: Time(s) taken:	☐Yes ☐No Medication(s): Dose: Time(s) taken:	☐Yes ☐No Medication(s): Dose: Time(s) taken:	☐Yes ☐No Medication(s): Dose: Time(s) taken:
15. Comments (if applicable)	I have a cold							

gure 3 *(continued)*—Sleep Diary Instructions (CSD-E)

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Consensus Sleep Diary—Carney et al

Appendix J: Letter to Parents for Phase two

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Researcher: Miss N. Mandondo • email: g13m4931@campus.ru.ac.za

Letter of invitation to participate in a research study on adolescent sleep patterns

Thesis title: The Sleep-wake behavior of adolescents in a sample of South African high school students

My name is Natasha Mandondo and I am a Masters by thesis student in the Human Kinetics and Ergonomics department of Rhodes University.

I am conducting research on adolescent sleep patterns in the Grahamstown area for the partial fulfillment of the Master of Science degree and I would like to extend an invitation to you and your child to participate in the second Phase of this research. Please note that ethical clearance for this study has been granted by the Rhodes University Ethical Review Committee. The main purpose of this research is to give an extensive description and analysis of sleep habits of adolescents.

Instructions to your child:

Your child has been asked to voluntarily participate in a week of actigraph recording coupled with daily sleep diary completion. Actigraphs are small, lightweight, and unobtrusive devices which can collect information about activities over time. Use of actigraphy allows us to estimate sleep patterns in a non-invasive manner. The participants will be instructed on the use of actigraphy and on how to go about completing the sleep diaries before they go to sleep and right after they wake up.

Recording at night on the sleep diary will include daytime parameters while recording in the mornings will include information on the previous night sleep. Sleep parameters to be recorded every morning upon awakening will include bedtime, wake-up time, etc. The diary will also include daily recordings of caffeine as well as nap variables

The research is for academic purposes only and information will be kept private and confidential. The survey and sleep diary format have been attached for your information. Participation in this research is completely voluntary, and anonymous and does not involve any reimbursement or payment. Your child may choose to withdraw from the research at any time or not answer questions that you do not feel comfortable answering. Please also note that coded (anonymous) data will be archived by the Human Kinetics and Ergonomics at Rhodes University in computer format after the project and may be subject to future use for academic purposes.

If you would like to give permission for your child to participate in this Phase of the study, please sign the statement of consent below then tear it off and return to researcher with your child

……..

Statement of Consent

I have read the above information. I feel I understand the study well enough to make a decision about the voluntary and anonymous involvement of my child. I consent to understanding and agreeing to the terms described above. I consent to the use of my child's data for study purposes.

I_____hereby give permission for my child,

_____, to participate in actigraph and sleep diary recording

Signed: _____

Thank you for your time and participation.

RHODES UNIVERSITY
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Navoser: Mej. N.L. Mandondo • e-pos: g13m4931@campus.ru.ac.za

Uitnodigingsbrief om deel te neem in 'n navorsingstudie oor adolessente slaappatrone

Proefskrif titel: Die Slaap Wakker gedrag van adolessente van Suid-Afrikaanse hoërskoolleerlinge te beproef.

My naam is Natasha Mandondo en ek is 'n Meestersgraad tesis student in die Menslike Kinetika en Ergonomie en Ergonomie departement van Rhodes Universiteit. Ek doen navorsing oor adolessente slaappatrone in die Grahamstown-area vir die gedeeltelike vervulling van die Meester van Wetenskap graad.Ek wil graag 'n uitnodiging aan jou en jou kind gee om deel te neem in die tweede fase van hierdie navorsing. Neem asseblief kennis dat etiese klaring vir hierdie studie is deur die Rhodes Universiteit Etiese Beoordeling Komitee toegestaan.

Die hoofdoel van hierdie navorsing is om 'n omvattende beskrywing en ontleding van slaapgewoontes van graad 12 adolessente te gee.

Instruksies vir jou kind:

Jou kind het vrywillig gekies om deel te neem in 'n week van actigraph opname, tesame met 'n daaglikse voltooiing van die slaap dagboek. Actigraphies is klein, liggewig, en onopvallende toestelle wat inligting oor aktiwiteite wat tyd-gebaseer is oor 'n lang tyd kan insamel. Gebruik van actigraphy stel ons in staat om slaap patrone te skat in 'n nie-indringende wyse. Die deelnemers het opdrag gekry op die gebruik van actigraphy en ook hoe om oor te gaan met die voltooiing van die slaap dagboeke voordat hulle gaan slaap en reg nadat hulle opwakker.

Opname in die nag op die slaap dagboek sal bedags parameters insluit, terwyl die opname in die oggende sal insluit inligting oor die vorige nag se slaap. Slaap parameters sal elke oggend aangeteken word op ontwaking. Dit sal insluit slaaptyd, opwakker tyd, ens. Die dagboek sal ook daagliks opnames van kafeïen , asook middagslapie veranderlikes.

Die navorsing is vir akademiese doeleindes en inligting sal privaat en vertroulik gehou word. Die opname en slaap dagboek formaat is aangeheg vir u inligting. Deelname aan hierdie navorsing is heeltemal vrywillig en anoniem en betrek geen vergoeding of betaling. Jy en jou kind kan kies om enige tyd te ontrek van die navorsing, of vrae wat jy voel nie gemaklik is,nie te beantwoord. Let asseblief ook dat gesommeerde data sal in die argief deur die Menslike Kinetika en Ergonomie departement by Rhodes Universiteit in rekenaar formaat na die projek gedoen word en mag onderhewig wees aan toekomstige gebruik vir akademiese doeleindes.

As jy wil graag toestemming gee vir jou kind om deel te neem in hierdie fase van die studie, teken asseblief die verklaring van toestemming hieronder, dan skeur dit af en gee dit terug aan die navorser saam met jou kind.

……....

Verklaring van toestemming.

Ek het die bogenoemde inligting gelees. Ek voel ek verstaan die studie goed genoeg om 'n besluit oor die vrywillige en anonieme betrokkenheid van my kind te maak. Ek gee toestemming dat ek begrip het hiermee en stem saam met die terme beskryf hierbo.

Ek gee toestemming vir die gebruik van my kind se data vir studiedoeleindes.

Hiermee gee ek _____toestemming vir my kind, _____om deel te neem in actigraph en slaap dagboek opname.

Geteken: _____

Dankie vir jou tyd en deelname

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HUMAN KINETICS & ERGONOMICS

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Imbalelwano eya kubazali/ omele umzali

Incwadi esisimemo kuphando kubantu abatsha neendlela zabo zokulala

Igama lam ngu-Natasha Mandondo, kwaye ndingumfundi we-Masters kwisebe le-Human Kinetics kunye ne-Ergonomics kwiJunivesithi yase-Rhodes. Ndiqhuba uphando kubantu abatsha neendlela zabo zokulala

Kutheni olu phando lunoncedo kuwe nomntwana wakho?

Iindlela abantu abatsha abalala ngazo ziyakhawuleza ukujongeka njengengxaki kwilizwe jikelele, ngakumbi kubantu abatsha jikelele abaveza izikhalazo zokuphazanyiswa xa belele. Oku kunobangela ukozela emini, iyeyona nto ivamileyo. Ezinye izinto ezichaphazelekayo ngokophando kumanye amazwe kungaqhubi kakuhle ezikolweni, ukungahambi qhoro isikolo, iingxaki kwithuba umntwana akwazi ukuhoya ngalo, iigxaki kukugcina engqondweni

nokukhumbula, nokuziva udakumbile ngeyona ndlela. Sifuna nokuthelekisa iimbono zabazali nabafundisi-ntsapho, kunye neengxelo ezisuka kubantu abatsha.

Ukuzibandakanya kwenu kolu phando kungabaluleka kakhulu ekuncedeni ukuvala isikhewu kwithala leencwadi ezijongene neendlela abantu abatsha abalala ngazo eMzantsi Afrika. Ukuba singaziqonda iingxaki abantu abatsha abajongene nazo, singasebenzela ukufumana izisombululo ezibafaneleyo ukwehlisa izinga lokuziva udakumbile, siphucule imeko yokuphila, futhi siphucule nomeko yokufunda. Uphando olu lunokubanceda abafundi ngezi ndlela zilandelayo: inokukhuphula ulwazi ngeendlela umntu alala ngazo, ikhuthaze iingcinga zokuziphucula. Abantu abazibandakanyayo banokucela ukufunda ushicilelo neziphumo ukugqitywa kophando. Olu lwazi lunokusetyenziswa ekuphuculeni iindlela zokulala nolwazi lweengxaki ezidibene nokungalali kakuhle.

Imiyalelo kumntwana wakho:

Umntwana wakho ukhethe ukuzibandakanya kwiveki ye-actigraph recording edibene nesicwangciso sokulala semihla ngemihla. Ii-Actigraphs ngoomatshini abancinci, abangasindiyo nangaphazamisiyo aqokelela ulwazi ngeenkqubo zamaxesha kwixesha elide. Ukusebenzisa i-actigraph kusinceda sikwazi ukuqikelela iindlela zokulala ngendlela engaphazamisiyo. Abantu abazibandakanyayo bayaliwe ngokusebenzisa i-actigraphy nangendlela yokugqiba izicwangciso zokulala phambi kokuba baye kulala nasemveni bevukile.

Ukubhala ebusuku kwisicwangciso kuya kubandakanya “daytime parameters” ukuze ukubhala kusasa kubandakanye iinkcukacha zokulala ngezolo. “Sleep parameters” emazibhalwe ngentsasa yemihla ngemihla xa kuvukwa mazibandakanye ixesha lokulala, ixesha lokuvuka, ixesha uvukile emveni ulele (imizuzu), iziqendu umana uvuka emveni uye kulala, futhi nesimo sobuthongo silinganiswe sisikali se-Likert (excellent to poor). Ukozela emini makubhalwe mihla ngemihla apho kubhalwa khona ixesha lokulala kwisicwangciso. Isicwangciso siya kuba neenkcukacha zokusela i-caffeine

Uphando lwenzelwa imfundo kuphela, kwaye iinkcukacha ziya kugcinwa zingaziwa mntu. Kuqhagamshelwe isicwangciso sokulala ne-survey. Ukuzibandakanya nokuthatha inxaxheba kolu phando akunyanzelwa mntu, kwaye akukho mbuyekezo, wena nomntwana wakho ningakhetha ukukhululeka kuphando nangaliphi ixesha ninongayiphenduli imibuzo eniyiva iyandixhalabisa.

Ncedani niqaphele ukuba iinkcukacha ezi-aggegated zobe zigcinwe lisebe le-Human Kinetics ne-Ergonomics kwiJunivesithi yase-Rhodes, ngokwe-computer emveni kophando, kwaye zinokusetyenziswa kwixesha elizayo ezifundweni.

Isibhengezo semvume

Ndizifundile ezi nkcukacha zingentla. Ndiziva ndiluqonda uphando kangangokuba ndingenza isigqibo ngokubandakanye komntwana wami. Ndiyavuma ekuqondeni nasekuvumeleni imiqathango engentla. Ndiyavuma ekusetyenzisweni kweenkcukacha zam nezomntwana wam kolu phando kuphela.

Mna_____Ndiyavuma uba omntwana wam u _____, abandakanye kwiveki ye-actigraph recording edibene nesicwangciso sokulala semihla ngemihla.

Sayina: : _____

Enkosi ngexesha lakho nokuthatha inxaxheba.

Appendix K: Letter to learners for Phase two

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Letter of invitation to Grade 11s to participate in a research study on adolescent sleeppatterns

My name is Natasha Mandondo and I am a Masters by thesis student in the Human Kinetics and Ergonomics department of Rhodes University. I am conducting research on adolescent sleep patterns in the Grahamstown area for the partial fulfillment of the Master of Science degree at Rhodes University and I would like to extend an invitation to the Grade 11 learners in the school to participate in the second Phase of this research. This is an invitation for some volunteers to participate in the second Phase of the study. This willconsist of a week of actigraph recording coupled with daily sleep diary completion. Actigraphs are small, lightweight, and unobtrusive devices which can collect information about activities over time. Use of actigraphy allows us to estimate sleep pattern in a non-invasive manner. Volunteers will be instructed on the use of actigraphy and on how to go about completing the sleep diaries before they go to sleep and right after they wake up.

The sleep diary will be filled out daily before you go to bed each night and as soon as you wake in the mornings. Recording at night will include daytime parameters while recording in the mornings

will include information on the previous night sleep. Sleep parameters to be recorded include bedtime, wake-up time, time to sleep onset (minutes), time awake after sleep onset (minutes), number of awakenings after sleep onset, and sleep quality (excellent to poor). Daytime sleepiness will be recorded daily in the bedtime portion of the diary. The diary will also include daily recordings of caffeine, as well as nap variables.

This research is for academic purposes only and information will be kept private and confidential. Participation in this research is completely voluntary; you may choose to withdraw from the research at any time or not answer questions that you do not feel comfortable answering. Please note that coded (anonymous) data will be archived by the Human Kinetics and Ergonomics at Rhodes University in computer format after the project and may be subject to future use for academic purposes. Future use will be limited to analyses of some parts of the data or for comparisons with another population group, however, participants will not be contacted.

Your participation in the research will be of great importance to assist in contribute to the gap in literature regarding adolescent sleep patterns in the South African context. If we understand the problems that are faced by adolescents then future research or studies can work at finding suitable intervention methods aimed at reducing depressive symptoms, improve quality of life, and improve academic performance.

Procedure:

All Grade 11 scholars will be asked to volunteer to take part in the study. Day scholars and boarders will be asked to volunteer separately and then fifteen students from each of the two groups will be selected randomly. If you are willing to take part in the study you will be asked to write down your name on a piece of paper and then fifteen names will be selected randomly for participation. Unfortunately, there are only 15 actigraphs, because of this, participants will be divided into two

groups. Group 1 will participate in the first week and then group 2 will participate in the next week. Group 1 will consist of 50%-day scholars and 50% boarders chosen randomly. The same will apply to group 2.

If you wish to volunteer and participate in this study, please sign the declaration below:

……....

I have read the above information. I feel I understand the study well enough to make a decision about my voluntary and anonymous involvement. I consent to understanding and agreeing to the terms described above. I consent to the use of my data for study purposes. I hereby volunteer to participate in a week of actigraph and sleep diary recording.

Signed:

Thank you for your time and consideration

Appendix L: Verbal Information to learners for Phase Two

My name is Natasha Mandondo and I am a Masters by thesis student in the Human Kinetics and Ergonomics department of Rhodes University.

I am conducting research on adolescent sleep patterns in the Grahamstown area for the partial fulfillment of the Master of Science degree at Rhodes University and I would like to extend an invitation to the Grade 11 learners in the school to participate in the second Phase of this research. I will hand out a letter for you to give to your parents/guardians that participation in the study will only be allowed following the returned signed consent form from your parents/guardians.

This Phase of the study will consist of a week of actigraph recording coupled with daily sleep diary completion. Actigraphs are small, lightweight, and unobtrusive devices which can collect information about activities over. Use of actigraphy allows us to estimate sleep pattern in a non-invasive manner. I will instruct all volunteers on the use of actigraphs and on how to go about completing the sleep diaries before you go to sleep and right after you wake up.

The sleep diary will be filled out daily before you go to bed each night and as soon as you wake in the mornings. Recording at night will include daytime parameters while recording in the mornings will include information on the previous night sleep. Sleep parameters to be recorded include bedtime, wake-up time, time to sleep onset (minutes), time awake after sleep onset (minutes), number of awakenings after sleep onset, and sleep quality (excellent to poor). Daytime sleepiness will be recorded daily in the bedtime portion of the diary. The diary will also include daily recordings of caffeine, as well as nap variables.

This research is for academic purposes only and information will be kept private and confidential. Participation in this research is completely voluntary; you may choose to withdraw from the research at any time or not answer questions that you do not feel comfortable answering. Please note that coded (anonymous) data will be archived by the Human Kinetics and Ergonomics at Rhodes University in computer format after the project and may be subject to future use for academic purposes. Future use will be limited to analyses of some parts of the data or for comparisons with another population group, however, participants will not be contacted.

Procedure:

Day scholars and boarders will volunteer separately and then fifteen students from each of the two groups will be selected randomly. After you have returned the signed consent forms from your parents/guardians and you are willing to take part in the study, you will be asked to please write down your name on a piece of paper and then fifteen names will be selected randomly for participation. One person will pick out the names with their eyes closed. Unfortunately, there are only 15 actigraphs, because of this, participants will be divided into two groups. Group 1 will participate in the first week and then group 2 will participate in the next week. Group 1 will consist of 50%-day scholars and 50% boarders chosen randomly. The same will apply to group 2.

Your participation in the research will be of great importance to assist in contributing to the gap in literature regarding adolescent sleep patterns in the South African context. If we understand the problems that are faced by adolescents then future research or studies can work at finding suitable intervention methods aimed at reducing depressive symptoms, improve quality of life, andimprove academic performance.

Thank you.

Appendix M: Statistical effect tables

Mean reported time for leaving home/hostel on school days

Table 1a. Differences in mean reported time for leaving home/hostel on school days for the sexes.

Variable	Mann-Whitney U Test (w / continuity correction) (Copy of SSHS All schools 3 (version 1))By variable Sex Marked tests are significant at p <,05000								
	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value	Valid N Group 1	Valid N Group 2
Reported time for leaving home/hostel on school days	11739,00	10206,00	4358,000	-2,23666	0,025310	-2,24866	0,024535	121	88

Table 1b. Differences in mean reported time for leaving home/hostel on school days for the type of scholar.

Variable	Mann-Whitney U Test (w / continuity correction) (Copy of SSHS All schools 3 (version 1))By variable Day/Boarder Marked tests are significant at p <,05000								
	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value	Valid N Group 1	Valid N Group 2
Reported time for leaving home/hostel on school days	13345,00	7565,000	3824,000	3,000957	0,002692	3,016173	0,002560	118	86

Table 1c. Differences in mean reported time for leaving home/hostel on school days for the public and private schools.

Variable	Mann-Whitney U Test (w / continuity correction) (Copy of SSHS All schools 3 (version 1)) By variable Public/Private Marked tests are significant at p <,05000								
	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value	Valid N Group 1	Valid N Group 2
Reported time for leaving home/hostel on school days	15167,50	6777,500	4149,500	1,882180	0,059812	1,892285	0,058454	137	72

Weekday vs. Weekend sleep-wake behaviors

Table 2a. Denotes reported differences in weekday and weekend sleep duration

Pair of Variables	Wilcoxon Matched Pairs Test (Copy of SSHS All schools 3 (version 1)) Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Average weekday sleep duration (hours) & Average weekend sleep duration (hours)	206	1930,000	10,19180	0,000000

Table 2b. Denotes reported differences in weekday and weekend sleep onset latency

Pair of Variables	Wilcoxon Matched Pairs Test (Copy of SSHS All schools 3 (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Sleep onset latency on school days (minutes) & Weekend sleep onset latency (minutes)	142	2776,000	4,684824	0,000003

Table 2c. Denotes reported differences in weekday and weekend bedtimes

Pair of Variables	Wilcoxon Matched Pairs Test (Copy of SSHS All schools 3 (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday bed-time & Weekend bed-time	196	2195,500	9,378674	0,000000

Table 2d. Denotes reported differences in weekday and weekend waketimes

Pair of Variables	Wilcoxon Matched Pairs Test (Copy of SSHS All schools 3 (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday wake-time & Weekend wake-time	220	110,0000	12,74341	0,00

Effects of learner sex on sleep-wake behaviour

Table 3a. Effects of sex of learners on sleep variables during the week and weekend.

Variable	Mann-Whitney U Test (w/ continuity correction) (Copy of SSHS All schools 3 (version 1)) By variable Sex Marked tests are significant at p <,05000								
	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value	Valid N Group 1	Valid N Group 2
Weekday bed-time	15162,00	11173,00	5846,000	-0,96982	0,332139	-0,98806	0,323124	136	93
Weekday wake-time	13661,00	12217,00	4750,000	-3,07871	0,002079	-3,10443	0,001907	133	94
Average weekday sleep duration (hours)	15559,50	10546,50	6081,500	0,44057	0,659528	0,44409	0,656977	134	94
Sleep onset latency on school days (minutes)	14775,00	11331,00	5730,000	-1,15750	0,247067	-1,16900	0,242405	134	94
Weekend wake-time	14630,50	11704,50	5450,500	-1,81273	0,069874	-1,82247	0,068385	135	94
Weekend bed-time	15710,50	9940,50	5662,500	1,03745	0,299525	1,05333	0,292191	134	92
Average weekend sleep duration (hours)	15421,50	10456,50	5991,500	0,53141	0,595132	0,54040	0,588923	133	94
Weekend sleep onset latency (minutes)	14536,50	11114,50	5491,500	-1,39156	0,164058	-1,41284	0,157705	134	92

Table 3b. Sex differences in the main reasons given for weekday bedtimes

Statistic	Statistics: Sex(2) x Main reason for bed-time on school days(7) (Copy of SSHS All schools 3)		
	Chi-square	df	p
Pearson Chi-square	3,647376	df=6	p=,72427
M-L Chi-square	4,075532	df=6	p=,66646

Table 3c. Sex differences in the main reasons given for weekend bedtimes

Statistic	Statistics: Sex(2) x Main reason reported for weekend bed-time(7) (Copy of SSHS All schools 3)		
	Chi-square	df	p
Pearson Chi-square	4,194355	df=6	p=,65039
M-L Chi-square	4,587522	df=6	p=,59769

Table 3d. Sex differences in the main reasons given for weekday waketimes

Statistic	Statistics: Sex(2) x Main reason reported for wake-time on school days(6) (Copy of SSHS All schools 3 (version 1))		
	Chi-square	df	p
Pearson Chi-square	14,51119	df=5	p=,01267
M-L Chi-square	15,39564	df=5	p=,00880

Table 3e. Sex differences in the main reasons given for weekend waketimes

Statistic	Statistics: Sex(2) x Main reason reported for weekend wake-time(7) (Copy of SSHS All schools 3 (version 1))		
	Chi-square	df	p
Pearson Chi-square	15,53792	df=6	p=,01646
M-L Chi-square	15,58316	df=6	p=,01618

Table 3f. The distribution of day scholars and boarders within the sexes.

Statistic	Statistics: Sex(2) x Day/Boarder(2) (Copy of SSHS All schools 3 (version 1))		
	Chi-square	df	p
Pearson Chi-square	7,591093	df=1	p=,00587
M-L Chi-square	7,709659	df=1	p=,00549

Differences between boarders and day scholars

Table 4a. Denotes findings between boarders and day scholars in relation to sleep variables

Variable	Mann-Whitney U Test (w/ continuity correction) (Copy of SSHS All schools 3 (version 1)) By variable Day/Boarder Marked tests are significant at p <,05000								
	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value	Valid N Group 1	Valid N Group 2
Weekday bed-time	15343,50	9632,50	5261,500	1,64822	0,099308	1,67888	0,093176	130	93
Weekday wake-time	18185,50	6345,50	2159,500	8,02660	0,000000	8,09184	0,000000	130	91
Average weekday sleep duration (hours)	14822,50	9930,50	5559,500	0,92869	0,353050	0,93620	0,349173	129	93
Sleep onset latency on school days (minutes)	14289,50	10463,50	5774,500	-0,43484	0,663681	-0,43924	0,660490	130	92
Weekend bed-time	12889,50	11420,50	4633,500	-2,69273	0,007087	-2,73245	0,006287	128	92
Weekend wake-time	12120,50	12855,50	3605,500	-5,13411	0,000000	-5,16236	0,000000	130	93
Average weekend sleep duration (hours)	12400,00	12131,00	4015,000	-4,09437	0,000042	-4,16068	0,000032	129	92
Weekend sleep onset latency (minutes)	13791,00	10519,00	5535,000	-0,75693	0,449093	-0,76867	0,442088	128	92

Table 4b. Denotes reported reasons for weekday bedtime by day scholars and boarders

Statistic	Statistics: Day/Boarder(2) x Main reason for bed-time on school days(7) (Copy of SSHS All schools 3 (version 1))		
	Chi-square	df	p
Pearson Chi-square	18,55422	df=6	p=,00499
M-L Chi-square	21,56034	df=6	p=,00145

Table 4c. Denotes reported reasons for weekend bedtime by day scholars and boarders

Statistic	Statistics: Day/Boarder(2) x Main reason reported for weekend bed-time(7) (Copy of SSHS All schools 3 (version 1))		
	Chi-square	df	p
Pearson Chi-square	6,626230	df=6	p=,35680
M-L Chi-square	8,469467	df=6	p=,20569

Table 4d. reported reasons for weekday waketime by day scholars and boarders

Statistic	Statistics: Day/Boarder(2) x Main reason reported for wake-time on school days(6) (Copy of SSHS All schools 3)		
	Chi-square	df	p
Pearson Chi-square	31,69477	df=5	p=,00001
M-L Chi-square	34,41353	df=5	p=,00000

Table 4e. Denotes reported reasons for weekend waketime by day scholars and boarders

Statistic	Statistics: Day/Boarder(2) x Main reason reported for weekend wake-time(7) (Copy of SSHS All schools 3)		
	Chi-square	df	p
Pearson Chi-square	49,02973	df=6	p=,00000
M-L Chi-square	53,75277	df=6	p=,00000

Public and Private school differences

Table 5a. Differences between public and private school learners in relation to sleep variables

Variable	Mann-Whitney U Test (w/ continuity correction) (Copy of SSHS All schools 3 (version 1)) By variable Public/Private Marked tests are significant at p <,05000								
	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value	Valid N Group 1	Valid N Group 2
Weekday bed-time	19201,50	7133,50	4052,500	3,86424	0,000111	3,93693	0,000083	151	78
Weekday wake-time	21958,00	3920,00	1070,000	9,94729	0,000000	10,03038	0,000000	152	75
Average weekday sleep duration (hours)	16887,50	9218,50	5411,500	-0,85236	0,394013	-0,85919	0,390239	151	77
Sleep onset latency on school days (minutes)	16954,50	9151,50	5478,500	-0,71013	0,477627	-0,71718	0,473265	151	77
Weekend bed-time	15791,00	9860,00	4466,000	-2,65622	0,007903	-2,69687	0,007000	150	76
Weekend wake-time	15424,00	10911,00	3796,000	-4,33987	0,000014	-4,36318	0,000013	152	77
Average weekend sleep duration (hours)	14830,50	11047,50	3505,500	-4,84358	0,000001	-4,92547	0,000001	150	77
Weekend sleep onset latency (minutes)	16551,50	9099,50	5226,500	-1,01856	0,308413	-1,03414	0,301074	150	76

Table 5b. Denotes reported reasons for weekday bedtime by public and private school learners

	Statistics: Public/Private(2) x Main reason for bed-time on school days(7) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	9,985970	df=6	p=,12524
M-L Chi-square	10,26185	df=6	p=,11405

Table 5c. Denotes reported reasons for weekend bedtime by public and private school learners

	Statistics: Public/Private(2) x Main reason reported for weekend bed-time(7) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	4,538163	df=6	p=,60425
M-L Chi-square	6,116448	df=6	p=,41027

Table 5d. Denotes prevalent main reasons reported for weekday waketimes distributed between public and private school learners.

	Statistics: Public/Private(2) x Main reason reported for wake-time on school days(6) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	37,85748	df=5	p=,00000
M-L Chi-square	41,66362	df=5	p=,00000

Table 5e. Denotes prevalent main reasons reported for weekend waketimes distributed between public and private school learners.

	Statistics: Public/Private(2) x Main reason reported for weekend wake-time(7) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	43,26553	df=6	p=,00000
M-L Chi-square	47,25927	df=6	p=,00000

Table 5f. Denotes the distribution of boarders and day scholars between public and private schools

	Statistics: Public/Private(2) x Day/Boarder(2) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	77,63507	df=1	p=0,0000
M-L Chi-square	81,58662	df=1	p=0,0000

Grade Point Average Differences

Table 6a. Denotes the correlation coefficients for relationship between academic performance and average weekday sleep duration.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Reported grades	Average weekday sleep duration (hours)
Reported grades	1,000000	0,035076
Average weekday sleep duration (hours)	0,035076	1,000000

Table 6b. Denotes the correlation coefficients for relationship between academic performance and average weekend sleep duration.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Reported grades	Average weekend sleep duration (hours)
Reported grades	1,000000	-0,153410
Average weekend sleep duration (hours)	-0,153410	1,000000

Table 6c. Denotes the correlation coefficients for relationship between academic performance and average weekday sleep onset latency.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Reported grades	Sleep onset latency on school days (minutes)
Reported grades	1,000000	-0,065205
Sleep onset latency on school days (minutes)	-0,065205	1,000000

Table 6d. Denotes the correlation coefficients for relationship between academic performance and average weekend sleep onset latency.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Reported grades	Weekend sleep onset latency (minutes)
Reported grades	1,000000	-0,044382
Weekend sleep onset latency (minutes)	-0,044382	1,000000

Table 6e. Denotes the correlation coefficients for relationship between academic performance and average weekday bedtime.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Reported grades	Weekday bed-time
Reported grades	1,000000	-0,012011
Weekday bed-time	-0,012011	1,000000

Table 6f. Denotes the correlation coefficients for relationship between academic performance and average weekend bedtime.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Reported grades	Weekend bed-time
Reported grades	1,000000	-0,081484
Weekend bed-time	-0,081484	1,000000

Table 6g. Denotes the correlation coefficients for relationship between academic performance and average weekday waketime.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday wake-time	Reported grades
Weekday wake-time	1,000000	0,240130
Reported grades	0,240130	1,000000

Table 6h. Denotes the correlation coefficients for relationship between academic performance and average weekend waketime.

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	Reported grades	Weekend wake-time
Reported grades	1,000000	-0,144944
Weekend wake-time	-0,144944	1,000000

Table 6i. Denotes the correlation coefficients for relationship between academic performance and average Weekend Bedtime Delay (WBD).

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	WBD	Reported grades
WBD	1,000000	-0,089509
Reported grades	-0,089509	1,000000

Table 6j Denotes the correlation coefficients for relationship between academic performance and average Weekend Waketime Delay (WWD).

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	Reported grades	WWD
Reported grades	1,000000	-0,184872
WWD	-0,184872	1,000000

Table 6k. The correlation coefficients for the relationship between academic performance and the sleepiness scale.

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	Sleepiness scale sum	Reported grades
Sleepiness scale sum	1,000000	-0,025225
Reported grades	-0,025225	1,000000

Table 6l. The correlation coefficients for the relationship between academic performance and the sleep-wake problems scale.

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	Reported grades	Sleep-wake problems sum
Reported grades	1,000000	0,129952
Sleep-wake problems sum	0,129952	1,000000

Table 6m. The correlation coefficients for the relationship between academic performance and the depressed mood scale.

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	Reported grades	Sums from depressed scale
Reported grades	1,000000	0,069204
Sums from depressed scale	0,069204	1,000000

Table 6n. The correlation coefficients for the relationship between academic performance and the morningness eveningness scale.

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	Reported grades	M/E scale sum
Reported grades	1,000000	-0,039565
M/E scale sum	-0,039565	1,000000

Results obtained from the sleepiness, sleep-wake problems, depressive mood and morningeveningness scales.

Table 7a. Denotes differences between the sexes in relation to the sleepiness, sleep-wakeproblems, depressive mood and morning eveningness scales.

	Mann-Whitney U Test (w/ continuity correction) (Copy of SSHS All schools 3 (version 1))By variable Sex Marked tests are significant at p <,05000								
Variable	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value	Valid N Group 1	Valid N Group 2
Sleepiness scale sum	15194,0(	11602,0(	5741,00(	-1,3978	0,16215	-1,4024	0,160784	13	94
Sleep-wake problems sum	14442,5(	12353,5(	4989,50(	-2,9039	0,00368	-2,9067	0,003652	13	94
Sums from depressed scale	13549,0(	13247,0(	4096,00(	-4,6946	0,00000	-4,7210	0,000002	13	94
M/E scale sum	17095,5(	9700,5(	5235,50(	2,41095	0,01591	2,4159(	0,015697	13	94

Table 7b. Denotes differences between day scholars and boarders in relation to the sleepiness, sleep-wake problems, depressive mood and morning eveningness scales.

Variable	Mann-Whitney U Test (w/ continuity correction) (Copy of SSHS All schools 3 (version 1))By variable Day/Boarder Marked tests are significant at p <,05000								
	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value	Valid N Group 1	Valid N Group 2
Sleepiness scale sum	14764,5(	10660,5(	6100,50(	0,15344	0,878052	0,15395	0,877652	13(	95
Sleep-wake problems sum	16549,0(	8876,0(	4316,00(	3,85359	0,000116	3,85731	0,000115	13(	95
Sums from depressed scale	14884,0(	10541,0(	5981,00(	0,40122	0,688258	0,40342	0,686636	13(	95
M/E scale sum	13958,0(	11467,0(	5443,00(	-1,5167(	0,129328	-1,5198(	0,128550	13(	95

Table 7c. Denotes differences between public and private school learners in relation to the sleepiness, sleep-wake problems, depressive mood and morning eveningness scales.

Variable	Mann-Whitney U Test (w/ continuity correction) (Copy of SSHS All schools 3 (version 1)) By variable Public/Private Marked tests are significant at p <,05000								
	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value	Valid N Group 1	Valid N Group 2
Sleepiness scale sum	18107,5(	8688,5(	5528,50(	0,98584	0,324214	0,98906	0,322634	152	79
Sleep-wake problems sum	20214,0(	6582,0(	3422,00(	5,35776	0,000000	5,36292	0,000000	152	79
Sums from depressed scale	18731,0(	8065,0(	4905,00(	2,27988	0,022616	2,29271	0,021865	152	79
M/E scale sum	15882,0(	10914,0(	4254,00(	-3,63099	0,000282	-3,63844	0,000274	152	79

Other sleep variables

- Perceived sleep quality

Table 8a. The association between perceived sleep quality between the sexes

Statistic	Statistics: Sex(2) x Perceived sleep quality(2) (Copy of SSHS All schools 3)		
	Chi-square	df	p
Pearson Chi-square	,5789254	df=1	p=,44673
M-L Chi-square	,5819658	df=1	p=,44554

Table 8b. The association between perceived sleep quality between day scholars and boarders

Statistic	Statistics: Day/Boarder(2) x Perceived sleep quality(2) (Copy of SSHS All schools 3)		
	Chi-square	df	p
Pearson Chi-square	,3943624	df=1	p=,53002
M-L Chi-square	,3929331	df=1	p=,53076

Table 8c. The association between perceived sleep quality between public and private schools

Statistic	Statistics: Public/Private(2) x Perceived sleep quality(2) (Copy of SSHS All schools 3)		
	Chi-square	df	p

Pearson Chi-square	1,836772	df=1	p=,17533
M-L Chi-square	1,811515	df=1	p=,17833

- **Perceived sleep quantity**

Table 8d. The association between perceived sleep quantity between the sexes

	Statistics: Sex(2) x Perceived sleep quantity(3) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	5,40879	df=2	p=,0669
M-L Chi-square	5,60559	df=2	p=,0606

Table 8e. The association between perceived sleep quantity between boarders and day scholars

	Statistics: Day/Boarder(2) x Perceived sleep quantity(3) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	5,744338	df=2	p=,05658
M-L Chi-square	6,431218	df=2	p=,04013

Table 8f. The association between perceived sleep quantity between public and private school learners

	Statistics: Public/Private(2) x Perceived sleep quantity(3) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	9,354375	df=2	p=,00931
M-L Chi-square	9,044832	df=2	p=,01086

- **Nocturnal awakenings**

Table 8g. The association between frequency of nocturnal awakenings between the sexes

	Statistics: Sex(2) x Frequency of nocturnal awakenings(5) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	3,414321	df=4	p=,49102
M-L Chi-square	3,431457	df=4	p=,48838

Table 8h. The association between frequency of nocturnal awakenings between boarders and day scholars

	Statistics: Day/Boarder(2) x Frequency of nocturnal awakenings(5) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p

Pearson Chi-square	5,383423	df=4	p=,25017
M-L Chi-square	5,342076	df=4	p=,25396

Table 8i. The association between frequency of nocturnal awakenings between public and private school learners

	Statistics: Public/Private(2) x Frequency of nocturnal awakenings(5) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	9,084587	df=4	p=,05902
M-L Chi-square	8,814129	df=4	p=,06592

- **Frequency of daytime naps**

Table 8j. The association between frequency of daytime naps between the sexes

	Statistics: Sex(2) x Frequency of daytime naps(5) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	26,62586	df=4	p=,00002
M-L Chi-square	27,62737	df=4	p=,00001

Table 8k. The association between frequency of daytime naps between day scholars and boarders

	Statistics: Day/Boarder(2) x Frequency of daytime naps(5) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	19,43032	df=4	p=,00065
M-L Chi-square	20,01258	df=4	p=,00050

Table 8l. The association between frequency of daytime naps between private and public-school learners

	Statistics: Public/Private(2) x Frequency of daytime naps(5) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	39,52612	df=4	p=,00000
M-L Chi-square	48,40987	df=4	p=,00000

- **Perceived daytime sleepiness problem**

Table 8m. The association between perceived sleepiness problem between the sexes

	Statistics: Sex(2) x Perceived sleepiness problem(5) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	14,14753	df=4	p=,00684
M-L Chi-square	14,34277	df=4	p=,00628

Table 8n. The association between perceived sleepiness problem between boarders and day scholars

	Statistics: Day/Boarder(2) x Perceived sleepiness problem(5) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	4,420717	df=4	p=,35205
M-L Chi-square	4,406318	df=4	p=,35380

Table 8o. The association between perceived sleepiness problem between private and public-school learners

	Statistics: Public/Private(2) x Perceived sleepiness problem(5) (Copy of SSHS All schools 3)		
Statistic	Chi-square	df	p
Pearson Chi-square	16,07932	df=4	p=,00291
M-L Chi-square	17,04855	df=4	p=,00189

Lifestyle habits

Table 9a. The association of sports or physical activity and sleep variables

	Mann-Whitney U Test (wf continuity correction) (Copy of SSHS All schools 3) By variable During the last week, did you engage in organized sports or a regularly scheduled physical activity, including competitions Marked tests are significant at p <,05000								
variable	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value	Valid N Group 1	Valid N Group 2
Weekday bed-time	16984,00	5807,000	4037,000	1,25579	0,209191	1,27894	0,200920	154	59
Weekday wake-time	16886,00	5480,000	3710,000	1,94328	0,051983	1,95870	0,050149	152	59
Reported time for leaving home/hostel on school days	14630,00	4480,000	3049,000	2,03505	0,041847	2,04496	0,040860	142	53
Average weekday sleep duration (hours)	16311,50	6266,500	4376,500	-0,22352	0,823131	-0,22551	0,821580	154	58
Sleep latency on school days (minutes)	15670,50	6907,500	3735,500	-1,83337	0,066749	-1,85284	0,063906	154	58
Weekend bed-time	15973,00	6182,000	4412,000	0,10612	0,915490	0,10779	0,914160	151	59
Weekend wake-time	15885,50	6905,500	3950,500	-1,47068	0,141378	-1,47831	0,139327	154	59
Average weekend sleep duration (hours)	16219,50	6358,500	4129,500	-0,72600	0,467841	-0,73956	0,459566	155	57
Weekend sleep latency (minutes)	15814,00	6552,000	3724,000	-1,57178	0,116003	-1,59744	0,110169	155	56
WRD	15802,00	6989,000	3867,000	-1,67812	0,093325	-1,67988	0,092982	154	59
WBD	15328,00	6617,000	4003,000	-1,07104	0,284151	-1,08267	0,278958	150	59
Sleepiness scale sum	17064,50	6155,500	4385,500	0,53068	0,595644	0,53246	0,594410	156	59
Sleep wake problems sum	16947,00	6273,000	4503,000	0,24200	0,808782	0,24224	0,808591	156	59
Sums from depressed scale	16747,00	6473,000	4501,000	-0,24691	0,804977	-0,24829	0,803912	156	59
M/E scale sum	16914,50	6305,500	4535,500	0,16215	0,871187	0,16249	0,870919	156	59

- **The association of consumption of soda with caffeine and sleep variables**

Table 10a. The association between the consumption of soda with caffeine and weekday bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000 Weekday bed-time	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi;not like Orange soda and Spite)
Weekday bed-time	1,000000	-0,090569
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	-0,090569	1,000000

Table 10b. The association between the consumption of soda with caffeine and weekend bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000 Weekend bed-time	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi;not like Orange soda and Spite)
Weekend bed-time	1,000000	0,074002
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	0,074002	1,000000

Table 10c. The association between the consumption of soda with caffeine and weekday waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000 Weekday wake-time	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)
Weekday wake-time	1,000000	-0,075203
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	-0,075203	1,000000

Table 10d. The association between the consumption of soda with caffeine and weekend waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000 Weekend wake-time	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi;not like Orange soda and Spite)
Weekend wake-time	1,000000	0,119254
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	0,119254	1,000000

Table 10e. The association between the consumption of soda with caffeine and weekday sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekday sleep duration (hours)	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi;not like Orange soda and Spite)
Average weekday sleep duration (hours)	1,000000	0,039047
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	0,039047	1,000000

Table 10f. The association between the consumption of soda with caffeine and weekend sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	Average weekend sleep duration (hours)
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	1,000000	0,101764
Average weekend sleep duration (hours)	0,101764	1,000000

Table 10g. The association between the consumption of soda with caffeine and weekday sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	Sleep onset latency on school days (minutes)
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	1,000000	0,160725
Sleep onset latency on school days (minutes)	0,160725	1,000000

Table 10h. The association between the consumption of soda with caffeine and weekend sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	Weekend sleep onset latency (minutes)
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	1,000000	0,091372
Weekend sleep onset latency (minutes)	0,091372	1,000000

Table 10i. The association between the consumption of soda with caffeine and Weekend Bedtime Delay (WBD)

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000

Variable	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi;not like Orange soda and Spite)	WBD
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	1,000000	0,143197
WBD	0,143197	1,000000

Table 10j. The association between the consumption of soda with caffeine and Weekend Waketime Delay (WWD)

	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	WWD	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi;not like Orange soda and Spite)
WWD	1,000000	0,097116
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	0,097116	1,000000

Table 10k. The association between the consumption of soda with caffeine and the Sleepiness Scale

	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi;not like Orange soda and Spite)	Sleepiness scale sum
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	1,000000	0,095751
Sleepiness scale sum	0,095751	1,000000

Table 10l. The association between the consumption of soda with caffeine and the Sleep-wake Problems Scale

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi;not like Orange soda and Spite)	Sleep-wake problems sum
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	1,00000	0,05581
Sleep-wake problems sum	0,05581	1,00000

Table 10m. The association between the consumption of soda with caffeine and the Depressive Mood Scale

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	Sums from depressed scale
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	1,000000	0,098522
Sums from depressed scale	0,098522	1,000000

Table 10n. The association between the consumption of soda with caffeine and the Morningness Eveningness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption soda with caffeine (E.g. Coke; Pepsi;not like Orange soda and Spite)	M/E scale sum
Frequency of consumption soda with caffeine (E.g. Coke; Pepsi; not like Orange soda and Spite)	1,000000	-0,072496
M/E scale sum	-0,072496	1,000000

- **Association of frequency of consumption of coffee or tea with and sleep variables**

Table 11a. Association of consumption of coffee or tea with caffeine and weekday bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption coffee or tea with caffeine	Weekday bed-time
Frequency of consumption coffee or tea with caffeine	1,000000	-0,061861
Weekday bed-time	-0,061861	1,000000

Table 11b. Association of consumption of coffee or tea with caffeine and weekend bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend bed-time	Frequency of consumption coffee or tea with caffeine
Weekend bed-time	1,000000	-0,046057
Frequency of consumption coffee or tea with caffeine	-0,046057	1,000000

Table 11c. Association of consumption of coffee or tea with caffeine and weekday waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday wake-time	Frequency of consumption coffee or tea with caffeine
Weekday wake-time	1,000000	0,058226
Frequency of consumption coffee or tea with caffeine	0,058226	1,000000

Table 11d. Association of consumption of coffee or tea with caffeine and weekend waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption coffee or tea with caffeine	Weekend wake-time
Frequency of consumption coffee or tea with caffeine	1,000000	0,041914
Weekend wake-time	0,041914	1,000000

Table 11e. Association of consumption of coffee or tea with caffeine and weekday sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption coffee or tea with caffeine	Average weekday sleep duration (hours)
Frequency of consumption coffee or tea with caffeine	1,000000	0,012512
Average weekday sleep duration (hours)	0,012512	1,000000

Table 11f. Association of consumption of coffee or tea with caffeine and weekend sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption coffee or tea with caffeine	Average weekend sleep duration (hours)
Frequency of consumption coffee or tea with caffeine	1,000000	0,013149
Average weekend sleep duration (hours)	0,013149	1,000000

Table 11g. Association of consumption of coffee or tea with caffeine and weekday sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleep onset latency on school days (minutes)	Frequency of consumption coffee or tea with caffeine
Sleep onset latency on school days (minutes)	1,000000	0,134188
Frequency of consumption coffee or tea with caffeine	0,134188	1,000000

Table 11h. Association of consumption of coffee or tea with caffeine and weekend sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption coffee or tea with caffeine	Weekend sleep onset latency (minutes)

Frequency of consumption coffee or tea with caffeine	1,000000	0,126482
Weekend sleep onset latency (minutes)	0,126482	1,000000

Table 11i. Association of consumption of coffee or tea with caffeine and Weekend Bedtime Delay (WBD)

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption coffee or tea with caffeine	WBD
Frequency of consumption coffee or tea with caffeine	1,000000	-0,015597
WBD	-0,015597	1,000000

Table 11j. Association of consumption of coffee or tea with caffeine and Weekend Waketime Delay (WWD)

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	WWD	Frequency of consumption coffee or tea with caffeine
WWD	1,000000	0,002330
Frequency of consumption coffee or tea with caffeine	0,002330	1,000000

Table 11k. Association of consumption of coffee or tea with caffeine and Sleepiness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption coffee or tea with caffeine	Sleepiness scale sum
Frequency of consumption coffee or tea with caffeine	1,000000	0,033483
Sleepiness scale sum	0,033483	1,000000

Table 11l. Association of consumption of coffee or tea with caffeine and Sleep-wake Problems Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption coffee or tea with caffeine	Sleep-wake problems sum
Frequency of consumption coffee or tea with caffeine	1,000000	0,167745
Sleep-wake problems sum	0,167745	1,000000

Table 11m. Association of consumption of coffee or tea with caffeine and Depressed Mood Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption coffee or tea with caffeine	Sums from depressed scale
Frequency of consumption coffee or tea with caffeine	1,000000	0,102784
Sums from depressed scale	0,102784	1,000000

Table 11n. Association of consumption of coffee or tea with caffeine and Morningness Eveningness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of consumption coffee or tea with caffeine	M/E scale sum
Frequency of consumption coffee or tea with caffeine	1,000000	0,018008
M/E scale sum	0,018008	1,000000

- **The association of electrical devices in relation to sleep variables**

Table 12a. Association of the frequency of Smartphone and Cellphone before weekday bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday bed-time	Frequency of use of Smartphone/Cell phone before bedtime
Weekday bed-time	1,000000	0,160862
Frequency of use of Smartphone/Cell phone before bedtime	0,160862	1,000000

Table 12b. Association of the frequency of Smartphone and Cellphone before weekend bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend bed-time	Frequency of use of Smartphone/Cell phone before bedtime
Weekend bed-time	1,000000	0,173873
Frequency of use of Smartphone/Cell phone before bedtime	0,173873	1,000000

Table 12c. Association of the time spent on using Smartphone and Cellphone before weekday bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday bed-time	Time spent on using Smartphone/Cell phone before bedtime
Weekday bed-time	1,000000	0,166223
Time spent on using Smartphone/Cell phone before bedtime	0,166223	1,000000

Table 12d. Association of the time spent on using Smartphone and Cellphone before weekend bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend bed-time	Time spent on using Smartphone/Cell phone before bedtime
Weekend bed-time	1,000000	0,237658
Time spent on using Smartphone/Cell phone before bedtime	0,237658	1,000000

Table 12e. Association of the frequency of Smartphone and Cellphone before weekday waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Smartphone/Cell phone before bedtime	Weekday wake-time
Frequency of use of Smartphone/Cell phone before bedtime	1,000000	0,023094
Weekday wake-time	0,023094	1,000000

Table 12f. Association of the time spent on using Smartphone and Cellphone before weekday waketi me

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday wake-time	Time spent on using Smartphone/Cell phone before bedtime
Weekday wake-time	1,000000	-0,068147
Time spent on using Smartphone/Cell phone before bedtime	-0,068147	1,000000

Table 12g. Association of the frequency of Smartphone and Cellphone before weekend waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend wake-time	Frequency of use of Smartphone/Cell phone before bedtime
Weekend wake-time	1,000000	-0,128184
Frequency of use of Smartphone/Cell phone before bedtime	-0,128184	1,000000

Table 12h. Association of the time spent on using Smartphone and Cellphone before weekend waketi me

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Time spent on using Smartphone/Cell phone before bedtime	Weekend wake-time
Time spent on using Smartphone/Cell phone before bedtime	1,000000	0,051209
Weekend wake-time	0,051209	1,000000

Table 12i. Association of the frequency of Smartphone and Cellphone before weekday sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Smartphone/Cell phone before bedtime	Average weekday sleep duration (hours)
Frequency of use of Smartphone/Cell phone before bedtime	1,000000	-0,112971
Average weekday sleep duration (hours)	-0,112971	1,000000

Table 12j. Association of the time spent on using Smartphone and Cellphone before weekday sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekday sleep duration (hours)	Time spent on using Smartphone/Cell phone before bedtime
Average weekday sleep duration (hours)	1,000000	-0,083168
Time spent on using Smartphone/Cell phone before bedtime	-0,083168	1,000000

Table 12k. Association of the frequency of Smartphone and Cellphone before weekend sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Smartphone/Cell phone before bedtime	Average weekend sleep duration (hours)
Frequency of use of Smartphone/Cell phone before bedtime	1,000000	-0,111495
Average weekend sleep duration (hours)	-0,111495	1,000000

Table 12l. Association of the time spent on using Smartphone and Cellphone before weekend sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekend sleep duration (hours)	Time spent on using Smartphone/Cell phone before bedtime
Average weekend sleep duration (hours)	1,000000	-0,057034
Time spent on using Smartphone/Cell phone before bedtime	-0,057034	1,000000

Table 12m. Association of the frequency of Smartphone and Cellphone before weekday sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Smartphone/Cell phone before bedtime	Sleep onset latency on school days (minutes)
Frequency of use of Smartphone/Cell phone before bedtime	1,000000	-0,012454
Sleep onset latency on school days (minutes)	-0,012454	1,000000

Table 12n. Association of the time spent on using Smartphone and Cellphone before weekday sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleep onset latency on school days (minutes)	Time spent on using Smartphone/Cell phone before bedtime
Sleep onset latency on school days (minutes)	1,000000	-0,018177
Time spent on using Smartphone/Cell phone before bedtime	-0,018177	1,000000

Table 12o. Association of the frequency of Smartphone and Cellphone and weekend sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend sleep onset latency (minutes)	Frequency of use of Smartphone/Cell phone before bedtime
Weekend sleep onset latency (minutes)	1,000000	-0,032614
Frequency of use of Smartphone/Cell phone before bedtime	-0,032614	1,000000

Table 12p. Association of the time spent on using Smartphone and Cellphone and weekend sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Time spent on using Smartphone/Cell phone before bedtime	Weekend sleep onset latency (minutes)
Time spent on using Smartphone/Cell phone before bedtime	1,000000	-0,082120
Weekend sleep onset latency (minutes)	-0,082120	1,000000

Table 12q. Association of the frequency of Smartphone and Cellphone and Weekend Bedtime Weekend Bedtime Delay (WBD).

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	WBD	Frequency of use of Smartphone/Cell phone before bedtime
WBD	1,000000	0,026101
Frequency of use of Smartphone/Cell phone before bedtime	0,026101	1,000000

Table 12r. Association of the time spent on using Smartphone and Cellphone and Weekend Bedtime Delay (WBD)

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
	WBD	Time spent on using Smartphone/Cell phone before bedtime
WBD	1,000000	0,138009
Time spent on using Smartphone/Cell phone before bedtime	0,138009	1,000000

Table 12s. Association of the frequency of Smartphone and Cellphone and Weekend Waketime Delay (WWD).

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Smartphone/Cell phone before bedtime	WWD
Frequency of use of Smartphone/Cell phone before bedtime	1,000000	-0,128894
WWD	-0,128894	1,000000

Table 12t. Association of the time spent on using Smartphone and Cellphone and Weekend Waketime Delay (WWD)

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	WWD	Time spent on using Smartphone/Cell phone before bedtime
WWD	1,000000	0,039584
Time spent on using Smartphone/Cell phone before bedtime	0,039584	1,000000

Table 12u. Association of the frequency of Smartphone and Cellphone and the Sleepiness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Smartphone/Cell phone before bedtime	Sleepiness scale sum
Frequency of use of Smartphone/Cell phone before bedtime	1,000000	0,084256
Sleepiness scale sum	0,084256	1,000000

Table 12v. Association of the time spent on using Smartphone and Cellphone and the Sleepiness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleepiness scale sum	Time spent on using Smartphone/Cell phone before bedtime
Sleepiness scale sum	1,000000	0,102468
Time spent on using Smartphone/Cell phone before bedtime	0,102468	1,000000

Table 12w. Association of the frequency of Smartphone and Cellphone and the Sleep-wake Problems Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Smartphone/Cell phone before bedtime	Sleep-wake problems sum
Frequency of use of Smartphone/Cell phone before bedtime	1,000000	0,062814
Sleep-wake problems sum	0,062814	1,000000

Table 12x. Association of the time spent on using Smartphone and Cellphone and the Sleep-wake Problems Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleep-wake problems sum	Time spent on using Smartphone/Cell phone before bedtime
Sleep-wake problems sum	1,000000	0,053838
Time spent on using Smartphone/Cell phone before bedtime	0,053838	1,000000

Table 12y. Association of the frequency of Smartphone and Cellphone and the Depressed Mood Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Smartphone/Cell phone before bedtime	Sums from depressed scale
Frequency of use of Smartphone/Cell phone before bedtime	1,000000	0,112030
Sums from depressed scale	0,112030	1,000000

Table 12z. Association of the time spent on using Smartphone and Cellphone and the Depressed Mood Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sums from depressed scale	Time spent on using Smartphone/Cell phone before bedtime
Sums from depressed scale	1,000000	0,093950
Time spent on using Smartphone/Cell phone before bedtime	0,093950	1,000000

Table 12zi. Association of the frequency of Smartphone and Cellphone and the Morningness Eveningness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Smartphone/Cell phone before bedtime	M/E scale sum
Frequency of use of Smartphone/Cell phone before bedtime	1,000000	-0,054295
M/E scale sum	-0,054295	1,000000

Table 12zii. Association of the time spent on using Smartphone and Cellphone and the Morningness Eveningness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	M/E scale sum	Time spent on using Smartphone/Cell phone before bedtime
M/E scale sum	1,000000	-0,030670
Time spent on using Smartphone/Cell phone before bedtime	-0,030670	1,000000

Table 13a. Association of the frequency of use of laptop/computer before bedtime and weekday bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of laptop/computer before bedtime	Weekday bed-time
Frequency of use of laptop/computer before bedtime	1,000000	0,051297
Weekday bed-time	0,051297	1,000000

Table 13b. Association between time spent on the use of laptop or computer before bedtime and weekday bedtime.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday bed-time	Time spent on Laptop/computer before bedtime
Weekday bed-time	1,000000	0,117730
Time spent on Laptop/computer before bedtime	0,117730	1,000000

Table 13c. Association of the frequency of use of laptop/computer before bedtime and weekend bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000 Weekend bed-time	Frequency of use of laptop/computer before bedtime
Weekend bed-time	1,000000	0,057086
Frequency of use of laptop/computer before bedtime	0,057086	1,000000

Table 13d. Association between time spent on the use of laptop or computer before bedtime and weekend bedtime.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000 Weekend bed-time	Time spent on Laptop/computer before bedtime
Weekend bed-time	1,000000	0,097677
Time spent on Laptop/computer before bedtime	0,097677	1,000000

Table 13e. Association of the frequency of use of laptop/computer before bedtime and weekday waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000 Weekday wake-time	Frequency of use of laptop/computer before bedtime
Weekday wake-time	1,000000	0,201339
Frequency of use of laptop/computer before bedtime	0,201339	1,000000

Table 13f. Association between time spent on the use of laptop or computer before bedtime and weekday waketime.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000 Time spent on Laptop/computer before bedtime	Weekday wake-time
Time spent on Laptop/computer before bedtime	1,000000	0,201750
Weekday wake-time	0,201750	1,000000

Table 13g. Association of the frequency of use of laptop/computer before bedtime and weekend waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend wake-time	Frequency of use of laptop/computer before bedtime
Weekend wake-time	1,000000	-0,012440
Frequency of use of laptop/computer before bedtime	-0,012440	1,000000

Table 13h. Association between time spent on the use of laptop or computer before bedtime and weekend waketime.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend wake-time	Time spent on Laptop/computer before bedtime
Weekend wake-time	1,000000	0,014798
Time spent on Laptop/computer before bedtime	0,014798	1,000000

Table 13i. Association of the frequency of use of laptop/computer before bedtime and weekday sleep duration.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekday sleep duration (hours)	Frequency of use of laptop/computer before bedtime
Average weekday sleep duration (hours)	1,000000	0,035012
Frequency of use of laptop/computer before bedtime	0,035012	1,000000

Table 13j. Association between time spent on the use of laptop or computer before bedtime and weekday sleep duration.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekday sleep duration (hours)	Time spent on Laptop/computer before bedtime
Average weekday sleep duration (hours)	1,000000	-0,044819
Time spent on Laptop/computer before bedtime	-0,044819	1,000000

Table 13.k Association of the frequency of use of laptop/computer before bedtime and weekend sleep duration.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekend sleep duration (hours)	Frequency of use of laptop/computer before bedtime
Average weekend sleep duration (hours)	1,000000	-0,025100
Frequency of use of laptop/computer before bedtime	-0,025100	1,000000

Table 13l. Association between time spent on the use of laptop or computer before bedtime and weekend sleep duration.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekend sleep duration (hours)	Time spent on Laptop/computer before bedtime
Average weekend sleep duration (hours)	1,000000	-0,006770
Time spent on Laptop/computer before bedtime	-0,006770	1,000000

Table 13m. Association of the frequency of use of laptop/computer before bedtime and weekday sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of laptop/computer before bedtime	Sleep onset latency on school days (minutes)
Frequency of use of laptop/computer before bedtime	1,000000	-0,066184
Sleep onset latency on school days (minutes)	-0,066184	1,000000

Table 13n. Association between time spent on the use of laptop or computer before bedtime and weekday sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleep onset latency on school days (minutes)	Time spent on Laptop/computer before bedtime
Sleep onset latency on school days (minutes)	1,000000	-0,089275
Time spent on Laptop/computer before bedtime	-0,089275	1,000000

Table 13o. Association of the frequency of use of laptop/computer before bedtime and weekend sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend sleep onset latency (minutes)	Frequency of use of laptop/computer before bedtime
Weekend sleep onset latency (minutes)	1,000000	-0,051295
Frequency of use of laptop/computer before bedtime	-0,051295	1,000000

Table 13p. Association between time spent on the use of laptop or computer before bedtime and weekend sleep onset latency.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend sleep onset latency (minutes)	Time spent on Laptop/computer before bedtime
Weekend sleep onset latency (minutes)	1,000000	-0,091747
Time spent on Laptop/computer before bedtime	-0,091747	1,000000

Table 13q. Association of the frequency of use of laptop/computer before bedtime and Weekend Bedtime Delay (WBD).

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	WBD	Frequency of use of laptop/computer before bedtime
WBD	1,000000	0,023746
Frequency of use of laptop/computer before bedtime	0,023746	1,000000

Table 13r. Association between time spent on the use of laptop or computer before bedtime and Weekend Bedtime Delay (WBD).

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000

Variable	WBD	Time spent on Laptop/computer before bedtime
WBD	1,000000	0,016065
Time spent on Laptop/computer before bedtime	0,016065	1,000000

Table 13s. Association of the frequency of use of laptop/computer before bedtime and Weekend Waketime Delay (WWD).

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	WWD	Frequency of use of laptop/computer before bedtime
WWD	1,000000	-0,047396
Frequency of use of laptop/computer before bedtime	-0,047396	1,000000

Table 13t. Association between time spent on the use of laptop or computer before bedtime and Weekend Waketime Delay (WWD).

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	WWD	Time spent on Laptop/computer before bedtime
WWD	1,000000	-0,026868
Time spent on Laptop/computer before bedtime	-0,026868	1,000000

Table 13u. Association of the frequency of use of laptop/computer before bedtime and Sleepiness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleepiness scale sum	Frequency of use of laptop/computer before bedtime
Sleepiness scale sum	1,000000	0,003971
Frequency of use of laptop/computer before bedtime	0,003971	1,000000

Table 13v. Association between time spent on the use of laptop or computer before bedtime and Sleepiness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleepiness scale sum	Time spent on Laptop/computer before bedtime
Sleepiness scale sum	1,000000	0,026043
Time spent on Laptop/computer before bedtime	0,026043	1,000000

Table 13w. Association of the frequency of use of laptop/computer before bedtime and Sleep-wake Problems Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of laptop/computer before bedtime	Sleep-wake problems sum
Frequency of use of laptop/computer before bedtime	1,000000	0,180792
Sleep-wake problems sum	0,180792	1,000000

Table 13x. Association between time spent on the use of laptop or computer before bedtime and Sleep-wake Problems Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleep-wake problems sum	Time spent on Laptop/computer before bedtime
Sleep-wake problems sum	1,000000	0,159015
Time spent on Laptop/computer before bedtime	0,159015	1,000000

Table 13y. Association of the frequency of use of laptop/computer before bedtime and Depressed Mood Scale.

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000

Variable	Sums from depressed scale	Frequency of use of laptop/computer before bedtime
Sums from depressed scale	1,000000	0,048520
Frequency of use of laptop/computer before bedtime	0,048520	1,000000

Table 13z. Association between time spent on the use of laptop or computer before bedtime and Depressed Mood Scale.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sums from depressed scale	Time spent on Laptop/computer before bedtime
Sums from depressed scale	1,000000	0,113914
Time spent on Laptop/computer before bedtime	0,113914	1,000000

Table 13zi. Association of the frequency of use of laptop/computer before bedtime andMorningness Eveningness Scale.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	M/E scale sum	Frequency of use of laptop/computer before bedtime
M/E scale sum	1,000000	-0,007290
Frequency of use of laptop/computer before bedtime	-0,007290	1,000000

Table 13zii. Association between time spent on the use of laptop or computer before bedtime and Morningness Eveningness Scale.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	M/E scale sum	Time spent on Laptop/computer before bedtime
M/E scale sum	1,000000	-0,005236
Time spent on Laptop/computer before bedtime	-0,005236	1,000000

Table 14a. Association between the frequency of use of tablet before bedtime and weekday bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday bed-time	Frequency of use of tablet before bedtime
Weekday bed-time	1,000000	0,105793
Frequency of use of tablet before bedtime	0,105793	1,000000

Table 14b. Association between time spent on using a tablet before bedtime and weekday bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday bed-time	Time spent on using tablet before bedtime
Weekday bed-time	1,000000	0,184556
Time spent on using tablet before bedtime	0,184556	1,000000

Table 14c. Association between the frequency of tablet use before bedtime and weekend bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend bed-time	Frequency of use of tablet before bedtime
Weekend bed-time	1,000000	0,006397
Frequency of use of tablet before bedtime	0,006397	1,000000

Table 14d. Association between time spent on using a tablet before bedtime and weekend bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend bed-time	Time spent on using tablet before bedtime
Weekend bed-time	1,000000	0,007177
Time spent on using tablet before bedtime	0,007177	1,000000

Table 14e. Association between the frequency of use of tablet before bedtime and weekday waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday wake-time	Frequency of use of tablet before bedtime
Weekday wake-time	1,000000	0,036778
Frequency of use of tablet before bedtime	0,036778	1,000000

Table 14f. Association between time spent on tablet use before bedtime and weekday waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday wake-time	Time spent on using tablet before bedtime
Weekday wake-time	1,000000	0,111256
Time spent on using tablet before bedtime	0,111256	1,000000

Table 14g. Association between the frequency of use of tablet before bedtime and weekend waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend wake-time	Frequency of use of tablet before bedtime
Weekend wake-time	1,000000	0,079631
Frequency of use of tablet before bedtime	0,079631	1,000000

Table 14h. Association between time spent on tablet use before bedtime and weekend waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend wake-time	Time spent on using tablet before bedtime
Weekend wake-time	1,000000	-0,000708
Time spent on using tablet before bedtime	-0,000708	1,000000

Table 14i. Association between the frequency of use of tablet before bedtime and weekday sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekday sleep duration (hours)	Frequency of use of tablet before bedtime
Average weekday sleep duration (hours)	1,000000	-0,103403
Frequency of use of tablet before bedtime	-0,103403	1,000000

Table 14j. Association between time spent on tablet use before bedtime and weekday sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekday sleep duration (hours)	Time spent on using tablet before bedtime
Average weekday sleep duration (hours)	1,000000	-0,094686
Time spent on using tablet before bedtime	-0,094686	1,000000

Table 14k. Association between the frequency of use of tablet before bedtime and weekend sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekend sleep duration (hours)	Frequency of use of tablet before bedtime
Average weekend sleep duration (hours)	1,000000	-0,059106
Frequency of use of tablet before bedtime	-0,059106	1,000000

Table 14l. Association between time spent on tablet use before bedtime and weekend sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekend sleep duration (hours)	Time spent on using tablet before bedtime
Average weekend sleep duration (hours)	1,000000	-0,121401
Time spent on using tablet before bedtime	-0,121401	1,000000

Table 14m. Association between the frequency of use of tablet before bedtime and weekday sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of tablet before bedtime	Sleep onset latency on school days (minutes)
Frequency of use of tablet before bedtime	1,000000	-0,033027
Sleep onset latency on school days (minutes)	-0,033027	1,000000

Table 14n. Association between time spent on tablet use before bedtime and weekday sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleep onset latency on school days (minutes)	Time spent on using tablet before bedtime
Sleep onset latency on school days (minutes)	1,000000	-0,036101
Time spent on using tablet before bedtime	-0,036101	1,000000

Table 14o. Association between the frequency of use of tablet before bedtime and weekend sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend sleep onset latency (minutes)	Frequency of use of tablet before bedtime
Weekend sleep onset latency (minutes)	1,000000	-0,042705
Frequency of use of tablet before bedtime	-0,042705	1,000000

Table 14p. Association between time spent on tablet use before bedtime and weekend sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend sleep onset latency (minutes)	Time spent on using tablet before bedtime
Weekend sleep onset latency (minutes)	1,000000	-0,080556
Time spent on using tablet before bedtime	-0,080556	1,000000

Table 14q. Association between the frequency of use of tablet before bedtime and Weekend Bedtime Delay (WBD).

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of tablet before bedtime	WBD
Frequency of use of tablet before bedtime	1,000000	-0,064843
WBD	-0,064843	1,000000

Table 14r. Association between time spent on tablet use before bedtime and Weekend BedtimeDelay (WBD)

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	WBD	Time spent on using tablet before bedtime
WBD	1,000000	-0,124098
Time spent on using tablet before bedtime	-0,124098	1,000000

Table 14s. Association between the frequency of use of tablet before bedtime and Weekend Waketime Delay (WWD).

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of tablet before bedtime	WWD
Frequency of use of tablet before bedtime	1,000000	0,059939
WWD	0,059939	1,000000

Table 14t. Association between time spent on tablet use before bedtime and Weekend Waketime Delay (WWD)

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	WWD	Time spent on using tablet before bedtime
WWD	1,000000	-0,030376
Time spent on using tablet before bedtime	-0,030376	1,000000

Table 14u. Association between the frequency of use of tablet before bedtime and Sleepiness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of tablet before bedtime	Sleepiness scale sum
Frequency of use of tablet before bedtime	1,000000	0,091558
Sleepiness scale sum	0,091558	1,000000

Table 14v. Association between time spent on tablet use before bedtime and Sleepiness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleepiness scale sum	Time spent on using tablet before bedtime
Sleepiness scale sum	1,000000	0,141729
Time spent on using tablet before bedtime	0,141729	1,000000

Table 14w. Association between the frequency of use of tablet before bedtime and Sleep-wake Problems Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of tablet before bedtime	Sleep-wake problems sum
Frequency of use of tablet before bedtime	1,000000	-0,069160
Sleep-wake problems sum	-0,069160	1,000000

Table 14x. Association between time spent on tablet use before bedtime and Sleep-wake Problems Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleep-wake problems sum	Time spent on using tablet before bedtime
Sleep-wake problems sum	1,000000	0,051146
Time spent on using tablet before bedtime	0,051146	1,000000

Table 14y. Association between the frequency of use of tablet before bedtime and Depressed Mood Scale

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000

Variable	Frequency of use of tablet before bedtime	Sums from depressed scale
Frequency of use of tablet before bedtime	1,000000	-0,010175
Sums from depressed scale	-0,010175	1,000000

Table 14z. Association between time spent on tablet use before bedtime and Depressed Mood Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sums from depressed scale	Time spent on using tablet before bedtime
Sums from depressed scale	1,000000	0,042582
Time spent on using tablet before bedtime	0,042582	1,000000

Table 14zi. Association between the frequency of use of tablet before bedtime and Morningness Eveningness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of tablet before bedtime	M/E scale sum
Frequency of use of tablet before bedtime	1,000000	-0,131335
M/E scale sum	-0,131335	1,000000

Table 14zii. Association between time spent on tablet use before bedtime and Morningness Eveningness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	M/E scale sum	Time spent on using tablet before bedtime
M/E scale sum	1,000000	-0,207827
Time spent on using tablet before bedtime	-0,207827	1,000000

Table 15a. Association between the frequency of use of television before bedtime and weekday bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of TV before bedtime	Weekday bed-time
Frequency of use of TV before bedtime	1,000000	-0,081695
Weekday bed-time	-0,081695	1,000000

Table 15b. Association between time spent on watching TV before bedtime and weekday bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday bed-time	Time spent on using the TV before bedtime
Weekday bed-time	1,000000	-0,006001
Time spent on using the TV before bedtime	-0,006001	1,000000

Table 15c. Association between the frequency of use of television before bedtime and weekend bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of TV before bedtime	Weekend bed-time
Frequency of use of TV before bedtime	1,000000	0,015659
Weekend bed-time	0,015659	1,000000

Table 15d. Association between time spent on watching TV before bedtime and weekend bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend bed-time	Time spent on using the TV before bedtime
Weekend bed-time	1,000000	-0,040690
Time spent on using the TV before bedtime	-0,040690	1,000000

Table 15e. Association between the frequency of use of television before bedtime and weekday waketime

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000

Variable	Weekday wake-time	Frequency of use of TV before bedtime
Weekday wake-time	1,000000	-0,114675
Frequency of use of TV before bedtime	-0,114675	1,000000

Table 15f. Association between time spent on watching TV before bedtime and weekdaywaketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday wake-time	Time spent on using the TV before bedtime
Weekday wake-time	1,000000	-0,018185
Time spent on using the TV before bedtime	-0,018185	1,000000

Table 15g. Association between the frequency of use of television before bedtime and weekend waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend wake-time	Frequency of use of TV before bedtime
Weekend wake-time	1,000000	0,094552
Frequency of use of TV before bedtime	0,094552	1,000000

Table 15h. Association between time spent on watching TV before bedtime and weekend waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend wake-time	Time spent on using the TV before bedtime
Weekend wake-time	1,000000	0,007450
Time spent on using the TV before bedtime	0,007450	1,000000

Table 15i. Association between the frequency of use of television before bedtime and weekday sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of TV before bedtime	Average weekday sleep duration (hours)
Frequency of use of TV before bedtime	1,000000	0,035610
Average weekday sleep duration (hours)	0,035610	1,000000

Table 15j. Association between time spent on watching TV before bedtime and weekday sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekday sleep duration (hours)	Time spent on using the TV before bedtime
Average weekday sleep duration (hours)	1,000000	0,009364
Time spent on using the TV before bedtime	0,009364	1,000000

Table 15k. Association between the frequency of use of television before bedtime and weekend sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekend sleep duration (hours)	Frequency of use of TV before bedtime
Average weekend sleep duration (hours)	1,000000	0,099932
Frequency of use of TV before bedtime	0,099932	1,000000

Table 15l. Association between time spent on watching TV before bedtime and weekend sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekend sleep duration (hours)	Time spent on using the TV before bedtime
Average weekend sleep duration (hours)	1,000000	-0,013369
Time spent on using the TV before bedtime	-0,013369	1,000000

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able 15m. Association between the frequency of use of television before bedtime and weekday sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleep onset latency on school days (minutes)	Frequency of use of TV before bedtime
Sleep onset latency on school days (minutes)	1,000000	0,121726
Frequency of use of TV before bedtime	0,121726	1,000000

Table 15n. Association between time spent on watching TV before bedtime and weekday sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleep onset latency on school days (minutes)	Time spent on using the TV before bedtime
Sleep onset latency on school days (minutes)	1,000000	0,059185
Time spent on using the TV before bedtime	0,059185	1,000000

Table 15o. Association between the frequency of use of television before bedtime and weekend sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of TV before bedtime	Weekend sleep onset latency (minutes)
Frequency of use of TV before bedtime	1,000000	0,072221
Weekend sleep onset latency (minutes)	0,072221	1,000000

Table 15p. Association between time spent on watching TV before bedtime and weekend sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend sleep onset latency (minutes)	Time spent on using the TV before bedtime
Weekend sleep onset latency (minutes)	1,000000	0,033672
Time spent on using the TV before bedtime	0,033672	1,000000

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Table 15q. Association between the frequency of use of television before bedtime and Weekend Bedtime Delay (WBD)

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000

Variable	WBD	Frequency of use of TV before bedtime
WBD	1,000000	0,071991
Frequency of use of TV before bedtime	0,071991	1,000000

Table 15r. Association between time spent on watching TV before bedtime and Weekend Bedtime Delay (WBD)

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	WBD	Time spent on using the TV before bedtime
WBD	1,000000	-0,028518
Time spent on using the TV before bedtime	-0,028518	1,000000

Table 15s. Association between the frequency of use of television before bedtime and Weekend Waketime Delay (WWD)

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	WWD	Frequency of use of TV before bedtime
WWD	1,000000	0,141373
Frequency of use of TV before bedtime	0,141373	1,000000

Table 15t. Association between time spent on watching TV before bedtime and Weekend Waketime Delay (WWD)

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
Variable	WWD	Time spent on using the TV before bedtime
WWD	1,000000	0,029220
Time spent on using the TV before bedtime	0,029220	1,000000

Table 15u. Association between the frequency of use of television before bedtime and Sleepiness Scale

	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000

Variable	Frequency of use of TV before bedtime	Sleepiness scale sum
Frequency of use of TV before bedtime	1,000000	0,042338
Sleepiness scale sum	0,042338	1,000000

Table 15v. Association between time spent on watching TV before bedtime and Sleepiness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleepiness scale sum	Time spent on using the TV before bedtime
Sleepiness scale sum	1,000000	0,037655
Time spent on using the TV before bedtime	0,037655	1,000000

Table 15w. Association between the frequency of use of television before bedtime and Sleep-wake Problems Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of TV before bedtime	Sleep-wake problems sum
Frequency of use of TV before bedtime	1,000000	-0,067079
Sleep-wake problems sum	-0,067079	1,000000

Table 15x. Association between time spent on watching TV before bedtime and Sleep-wake Problems Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleep-wake problems sum	Time spent on using the TV before bedtime
Sleep-wake problems sum	1,000000	-0,068748
Time spent on using the TV before bedtime	-0,068748	1,000000

Table 15y. Association between the frequency of use of television before bedtime and Depressed Mood Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of TV before bedtime	Sums from depressed scale
Frequency of use of TV before bedtime	1,000000	0,008180
Sums from depressed scale	0,008180	1,000000

Table 15z. Association between time spent on watching TV before bedtime and Depressed Mood Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Sums from depressed scale	Time spent on using the TV before bedtime
Sums from depressed scale	1,000000	0,006569
Time spent on using the TV before bedtime	0,006569	1,000000

Table 15zi. Association between the frequency of use of television before bedtime and Morningness Eveningness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of TV before bedtime	M/E scale sum
Frequency of use of TV before bedtime	1,000000	0,039550
M/E scale sum	0,039550	1,000000

Table 15zii. Association between time spent on watching TV before bedtime and Morningness Eveningness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	M/E scale sum	Time spent on using the TV before bedtime
M/E scale sum	1,000000	-0,009673
Time spent on using the TV before bedtime	-0,009673	1,000000

Table 16a. Association between the frequency of use of video games before bedtime and weekday bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000 Weekday bed-time	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime
Weekday bed-time	1,000000	0,090759
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	0,090759	1,000000

Table 16b. Association between time spent on video games before bedtime and weekday bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000 Weekday bed-time	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
Weekday bed-time	1,00000	0,13721
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	0,13721	1,00000

Table 16c. Association between the frequency of use of video games before bedtime and weekend bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000 Weekend bed-time	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime
Weekend bed-time	1,000000	0,161111
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	0,161111	1,000000

Table 16d. Association between time spent on video games before bedtime and weekend bedtime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000 Weekend bed-time	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
Weekend bed-time	1,000000	0,061618
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	0,061618	1,000000

Table 16e. Association between the frequency of use of video games before bedtime and weekday waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	Weekday wake-time
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	1,000000	-0,042532
Weekday wake-time	-0,042532	1,000000

Table 16f. Association between time spent on video games before bedtime and weekday waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekday wake-time	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
Weekday wake-time	1,000000	0,072035
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	0,072035	1,000000

Table 16g. Association between the frequency of use of video games before bedtime and weekend waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	Weekend wake-time
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	1,000000	0,061968
Weekend wake-time	0,061968	1,000000

Table 16h. Association between time spent on video games before bedtime and weekend waketime

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend wake-time	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
Weekend wake-time	1,000000	-0,036074
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	-0,036074	1,000000

Table 16i. Association between the frequency of use of video games before bedtime and weekday sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	Average weekday sleep duration (hours)
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	1,000000	-0,065840
Average weekday sleep duration (hours)	-0,065840	1,000000

Table 16j. Association between time spent on video games before bedtime and weekday sleep duration.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekday sleep duration (hours)	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
Average weekday sleep duration (hours)	1,000000	-0,074481
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	-0,074481	1,000000

Table 16k. Association between the frequency of use of video games before bedtime and weekend sleep duration

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	Average weekend sleep duration (hours)
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	1,000000	0,005984
Average weekend sleep duration (hours)	0,005984	1,000000

Table 16l. Association between time spent on video games before bedtime and weekend sleep duration.

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Average weekend sleep duration (hours)	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
Average weekend sleep duration (hours)	1,00000	-0,09360
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	-0,09360	1,00000

Table 16m. Association between the frequency of use of video games before bedtime andweekday sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleep onset latency on school days (minutes)	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime

Sleep onset latency on school days (minutes)	1,000000	0,008510
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	0,008510	1,000000

Table 16n. Association between time spent on video games before bedtime and weekday sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
	Sleep onset latency on school days (minutes)	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
Sleep onset latency on school days (minutes)	1,000000	-0,139180
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	-0,139180	1,000000

Table 16o. Association between the frequency of use of video games before bedtime and weekend sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	Weekend sleep onset latency (minutes)
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	1,000000	-0,123310
Weekend sleep onset latency (minutes)	-0,123310	1,000000

Table 16p. Association between time spent on video games before bedtime and weekend sleep onset latency

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Weekend sleep onset latency(minutes)	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
Weekend sleep onset latency (minutes)	1,000000	-0,21378
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	-0,21378	1,000000

Table 16q. Association between the frequency of use of video games before bedtime and Weekend Bedtime Delay (WBD).

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	WBD
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	1,000000	0,095560
WBD	0,095560	1,000000

Table 16r. Association between time spent on video games before bedtime and Weekend

Bedtime Delay (WBD).

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000	
	WBD	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
WBD	1,000000	-0,029062
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	-0,029062	1,000000

Table 16s. Association between the frequency of use of video games before bedtime and Weekend Waketime Delay (WWD).

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	WWD	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime
WWD	1,000000	0,108705
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	0,108705	1,000000

Table 16t. Association between time spent on video games before bedtime and Weekend Waketime Delay (WWD).

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	WWD	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
WWD	1,000000	-0,001786
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	-0,001786	1,000000

Table 16u. Association between the frequency of use of video games before bedtime andSleepiness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	Sleepiness scale sum
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	1,000000	0,027623
Sleepiness scale sum	0,027623	1,000000

Table 16v. Association between time spent on video games before bedtime and Sleepiness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3) MD pairwise deleted Marked correlations are significant at p <,05000 Sleepiness scale sum	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
Sleepiness scale sum	1,000000	0,053889
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	0,053889	1,000000

Table 16w. Association between the frequency of use of video games before bedtime and Sleep-wake Problems Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000 Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	Sleep-wake problems sum
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	1,00000	-0,02418
Sleep-wake problems sum	-0,02418	1,00000

Table 16x. Association between time spent on video games before bedtime and Sleep-wake Problems Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000 Sleep-wake problems sum	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
Sleep-wake problems sum	1,000000	-0,065436
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	-0,065436	1,000000

Table 16y. Association between the frequency of use of video games before bedtime and Depressed Mood Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000 Sums from depressed scale	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime
Sums from depressed scale	1,000000	-0,091969
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	-0,091969	1,000000

Table 16z. Association between time spent on video games before bedtime and Depressed Mood Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000 Sums from depressed scale	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
Sums from depressed scale	1,000000	-0,067226

Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	-0,067226	1,000000

Table 16zi. Association between the frequency of use of video games before bedtime and Morningness Eveningness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	M/E scale sum	Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime
M/E scale sum	1,000000	0,029833
Frequency of use of Video games (PlayStation, Xbox, etc) before bedtime	0,029833	1,000000

Table 16zii. Association between time spent on video games before bedtime and Morningness Eveningness Scale

Variable	Kendall Tau Correlations (Copy of SSHS All schools 3)MD pairwise deleted Marked correlations are significant at p <,05000	
	M/E scale sum	Time spent on using Video games (PlayStation, Xbox, etc) before bedtime
M/E scale sum	1,000000	-0,046304
Time spent on using Video games (PlayStation, Xbox, etc) before bedtime	-0,046304	1,000000

Phase two

Actigraphic data

Table 17a. Actigraph data of weekday and weekend bedtime

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday B.T (ACT) & Weekend B.T (Act)	13	21,00000	1,712199	0,086861

Table 17b. Actigraph data of weekday and weekend waketime

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday W.T (ACT) & Weekend W.T (ACT)	14	3,000000	3,107436	0,001887

Table 17c. Actigraph data of weekday and weekend sleep duration

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday S.D (ACT) & Weekend S.D (ACT)	13	3,000000	2,970140	0,002977

Table 17d. Actigraph data of weekday and weekend sleep onset latency

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1)) Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday S.L (ACT) & Weekend S.L (ACT)	11	28,50000	0,400099	0,689084

Table 17e. Actigraph data of weekday and weekend Nocturnal awakenings

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday N.A (ACT) & Weekend N.A (ACT)	13	15,50000	2,096570	0,036032

Table 17f. Actigraph data of weekday and weekend WASO

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday WASO (ACT) & Weekend WASO (ACT)	9	11,00000	1,362402	0,173072

Table 17g. Actigraph data of weekday and weekend Sleep Efficiency

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday S.E (ACT) & Weekend S.E (ACT)	14	24,50000	1,757741	0,078792

Sleep diary data

Table 18a. Sleep diary recordings of weekday and weekend bedtimes

Pair of Variables	Wilcoxon Matched Pairs Test (Sleep diary data)Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday B.T (SD) & Weekend B.T (SD)	12	11,00000	2,196501	0,028057

Table 18b. Sleep diary recordings of weekday and weekend waketimes

Pair of Variables	Wilcoxon Matched Pairs Test (Sleep diary data) Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday W.T (SD) & Weekend W.T (SD)	12	0,00	3,059412	0,002218

Table 18c. Sleep diary recordings of weekday and weekend sleep duration

Pair of Variables	Wilcoxon Matched Pairs Test (Sleep diary data) Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday S.D (SD) & Weekend S.D (SD)	12	11,00000	2,196501	0,028057

Table 18d. Sleep diary recordings of weekday and weekend sleep onset latency

	Wilcoxon Matched Pairs Test (Sleep diary data) Marked tests are significant at p <,05000			
Pair of Variables	Valid N	T	Z	p-value
Weekday S.L (SD) & Weekend S.L (SD)	11	29,50000	0,311188	0,755658

Table 18e. Sleep diary recordings of weekday and weekend nocturnal awakenings

	Wilcoxon Matched Pairs Test (Sleep diary data) Marked tests are significant at p <,05000			
Pair of Variables	Valid N	T	Z	p-value
#Weekday N.A (SD) & #Weekend N.A (SD)	12	19,00000	1,568929	0,116665

Actigraphic and Sleep diary data

Table 19a. Differences in weekday bedtimes between actigraphs and sleep diaries

	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
Pair of Variables	Valid N	T	Z	p-value
Weekday B.T (ACT) & Weekday B.T (SD)	12	33,50000	0,431455	0,666137

Table 19b. Differences in weekend bedtimes between actigraphs and sleep diaries

	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
Pair of Variables	Valid N	T	Z	p-value
Weekend B.T (Act) & Weekend B.T (SD)	12	26,00000	1,019804	0,307822

Table 19c. Differences in weekday waketimes between actigraphs and sleep diaries

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday W.T (ACT) & Weekday W.T (SD)	11	32,00000	0,088911	0,929153

Table 19d. Differences in weekend waketimes between actigraphs and sleep diaries

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekend W.T (ACT) & Weekend W.T (SD)	11	27,00000	0,533465	0,593712

Table 19e. Differences in weekday sleep onset latencies between actigraphs and sleep diaries

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday S.L (ACT) & Weekday S.L (SD)	12	19,00000	1,568929	0,116665

Table 19f. Differences in weekend sleep onset latencies between actigraphs and sleep diaries

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekend S.L (ACT) & Weekend S.L (SD)	12	15,00000	1,882715	0,059740

Table 19g. Differences in weekday sleep duration between actigraphs and sleep diaries

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday S.D (ACT) & Weekday S.D (SD)	12	22,00000	1,333590	0,182339

Table 19h. Differences in weekend sleep duration between actigraphs and sleep diaries

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekend S.D (ACT) & Weekend S.D (SD)	11	21,00000	1,066930	0,286004

Table 19i. Differences in weekday nocturnal awakenings between actigraphs and sleep diaries

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekday N.A (ACT) & #Weekday N.A (SD)	12	0,00	3,059412	0,002218

Table 19j. Differences in weekend nocturnal awakenings between actigraphs and sleep diaries

Pair of Variables	Wilcoxon Matched Pairs Test (Actigraph data spreadsheet (version 1))Marked tests are significant at p <,05000			
	Valid N	T	Z	p-value
Weekend N.A (ACT) & #Weekend N.A (SD)	12	0,00	3,059412	0,002218