Sleep, Problematic Smartphone Use and Mental Toughness: Exploring the Effectiveness of a School-based Sleep Promotion Intervention

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Abstract

Background and Aims: Sleep is a protective factor against mental and physical ill-health. However, evidence suggests that a minority of adolescents meet the established sleep duration recommendations. In addition, evidence suggests that, among adolescents, problematic smartphone use has contributed to a decline in sleep quality and duration. Research suggests that the psychological construct of mental toughness is associated with sleep quality. As such, this project had several aims. First, to determine whether a school-based sleep promotion intervention could increase sleep duration, sleep quality and mental toughness among school-age adolescents. Second, to determine whether the intervention could reduce problematic smartphone use.

Methods: A school-based sleep promotion intervention was adapted from two evidence-based interventions (Barber & Cucalon, 2017; Brown et al., 2006). Adaptations were informed by the Theory of Planned Behaviour (Ajzen, 1985). A quasi-experimental, pre-test-post-test design with a wait-list control was employed. Thirty-six middle-adolescent female participants completed validated measures of sleep quality, sleep hygiene, problematic smartphone use and mental toughness. Objective sleep data were collected using the Xiaomi Mi-Band 4.

Results: There was a statistically significant improvement in sleep quality post-intervention with a medium-to-large effect size. This effect was sustained at follow-up. Although there was a post-intervention increase in objective sleep duration, this change did not reach statistical significance (p = .051). There was tentative evidence that the improvements in sleep quality may have been driven by improved sleep stability and reduced physiological, cognitive and emotional arousal. There was tentative evidence that the intervention reduced objectively measured screen time, and that this effect was maintained at follow-up. No statistically significant changes in mental toughness or subjective problematic smartphone use were detected. An exit survey indicated that participants found the intervention engaging, acceptable, appropriate and feasible.

Conclusions: This theory-informed, school-based sleep promotion intervention improves subjective sleep quality among a cohort of middle-adolescent females in Ireland. Further research is needed to determine the robustness of the effect of the intervention on sleep duration and screen time. School-based sleep promotion interventions do not appear to be an effective means of increasing mental toughness.

Declaration

This thesis is entirely my own work and has not been submitted for other awards at this or at any other academic establishment. Where use has been made of the work of others, it has been acknowledged.

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List of Acronyms

ANCOVA:	Analysis of Covariance.
ANOVA:	Analysis of Variance.
APA:	American Psychological Association.
ASHS:	Adolescent Sleep Hygiene Scale.
BPS:	British Psychological Society.
CDC:	Centres for Disease Control.
CI:	Confidence Interval.
CMS:	Composite Scale of Morningness.
CONSORT:	Consolidated Standards of Reporting Trials.
DCYA:	Department of Children and Youth Affairs.
DES:	Department of Education and Skills.
DHHS:	Department of Health and Human Services.
DoHLGH:	Department of Housing, Local Government and Heritage.
DSM-5:	Diagnostic and Statistical Manual, Fifth Edition.
ERIC:	Education Resources Information Centre.
ESS:	Epworth Sleepiness Scale.
GDPR:	General Data Protection Regulations.
HSE:	Health Service Executive.
ICSD-3:	International Classification of Sleep Disorders, Third Edition.
ISI:	Insomnia Severity Index.
KSAPS:	Smartphone Addiction Proneness Scale, Korean Version.
LED:	Light Emitting Diode.
M:	Mean.
MEDLINE:	Medical Literature Analysis and Retrieval System Online.
MIREC:	Mary Immaculate Research Ethics Committee.
MPAI:	Mobile Phone Addiction Index.
MPPUS:	Mobile Phone Problematic Use Scale.
MT:	Mental Toughness.
MTI:	Mental Toughness Index.

MTQ-48:	Mental Toughness Questionnaire, 48.
MTQ-4Cs:	Mental Toughness Questionnaire, 4Cs.
NEPS:	National Educational Psychological Service.
NREM:	Non-Rapid Eye Movement.
PDSS:	Paediatric Daytime Sleepiness Scale.
PRISMA:	Preferred Reporting Items for Systematic Reviews and Meta-Analyses.
PSI:	Psychological Society of Ireland.
PSS:	Perceived Stress Scale.
PSQI:	Pittsburgh Sleep Quality Index.
PSG:	Polysomnography.
PSU:	Problematic Smartphone Use.
RCSQ:	Richards-Campbell Sleep Questionnaire.
REM:	Rapid Eye Movement.
RSA:	Road Safety Authority.
SAPS:	Smartphone Addiction Proneness Scale.
SARS-CoV-2:	Severe Acute Respiratory Syndrome Coronavirus 2.
SAS:	Smartphone Addiction Scale.
SAS-SV:	Smartphone Addiction Scale, Short Version.
SBSPI:	School-Based Sleep Promotion Intervention.
SD:	Standard Deviation.
SPHE:	Social, Personal and Health Education.
SPSS:	Statistical Package for the Social Sciences.
TPB:	Theory of Planned Behaviour.
UK:	United Kingdom.
US:	United States.
WoE:	Weight of Evidence.

PREAMBLE

CHAPTER ONE: INTRODUCTION

CHAPTER TWO: LITERATURE REVIEW

CHAPTER THREE: EMPIRICAL PAPER

REFERENCES AND APPENDICES

“The best bridge between despair and hope is a good night’s sleep”

(Rubenstein, 1952, p. 220).

Chapter One: Introduction

Thesis Introduction

Thesis Rationale

Four well-replicated empirical findings formed the rationale for this thesis. First, evidence indicates that the majority of adolescents sleep insufficiently (Gariepy et al., 2020; Peltzer & Pengpid, 2016; Wheaton et al., 2018) and are disproportionally affected by sleep insufficiency compared to other age groups (Jiang et al., 2015). Second, half a century of experimental research indicates that sleep insufficiency causes mental and physical ill-health (Aldabal & Bahammam, 2011; Fang et al., 2019) and impairs cognition (Wickens et al., 2015). Third, individuals frequently have poor subjective judgement of the extent of their sleep insufficiency (American Academy of Sleep Medicine, 2014; Pilcher & Walters, 1997). Fourth, to date, school-based sleep promotion efforts have shown limited effectiveness (Blunden et al., 2012; Chung et al., 2017; Dietrich et al., 2016). Therefore, in light of the prevalence, gravity and poor awareness of adolescent sleep insufficiency, this study sought to develop an effective school-based sleep promotion intervention.

Sleep-related Research in Educational and Child Psychology

The front-line treatment for insomnia, the most prevalent sleep disorder, is cognitive behavioural therapy (National Institutes of Health, 2005; Wilson et al., 2010). This is a recent paradigm shift, however, because several decades ago, insomnia was largely considered a condition requiring pharmacotherapy (Morin, et al., 2006). While this thesis is more concerned with sleep insufficiency rather than sleep disorders, this paradigm shift reflects the growing acknowledgement that sleep health falls within the remit of psychology.

Little has been written about educational and child psychologists’ role in sleep promotion. In a critical review of sleep promotion interventions for adolescents, Rydzkowski et al. (2015) argue that educational psychologists in the United Kingdom (UK) are ideally placed to contribute to sleep promotion efforts in schools. Similarly, Bryant (2017), a practising educational psychologist in the UK, argues:

> By the time that a young person is attending secondary school, it appears that professionals' awareness of the importance of sleep has disappeared and the discourse has shifted towards "behaviour", "responsibility" and "consequences". These discourses all have their own merit in certain contexts. However, it is my view that the question "How is your sleep?" promotes another much-needed discourse that fits within the wider social, emotional and mental health needs framework (p. 73).

However, despite the assertion that educational and child psychologists are well-placed to contribute to sleep promotion efforts, just one empirical study (Furlong et al., 2019) has explored the perspectives of educational psychologists from the UK on the issue. Furlong et al.'s study had several important findings. First, the majority of psychologists (84%) frequently encounter children with sleeping difficulties during casework. Second, the majority of psychologists believe that the promotion of sleep health is (84%) and should be (90%) part of the educational psychologists' role. To date, no research examining these issues in the Irish context is available.

In light of the evidence cited above, this thesis aims to progress school-based sleep promotion within educational and child psychology research and practice, particularly in Ireland, where the topic has received little attention.

Constructs

There are four key sleep-related constructs in this thesis: sleep insufficiency, sleep hygiene, sleep quality and sleep duration. First, the International Classification of Sleep Disorders, Third Edition (ICSD-3), defines sleep insufficiency as persistent failure “to obtain the amount of sleep required to maintain normal levels of alertness and wakefulness” (American Academy of Sleep Medicine, 2014, p. 183). The ICSD-3 notes two important points about sleep insufficiency which are relevant to this thesis. First, the condition is more prevalent in adolescence compared to other age groups. Second, individuals are frequently unaware of the disparity between the need for sleep and the amount of sleep obtained. The second construct in this thesis, sleep hygiene, refers to lifestyle and modifiable environmental factors that affect sleep parameters (American Academy of Sleep Medicine, 2014). Empirical data consistently show that sleep hygiene is predictive of sleep quality and sleep duration (Brick et al., 2010; Brown et al., 2002; LeBourgeois et al., 2005). The third construct, sleep quality, is best understood by detailing the subscales of the most commonly used measure of sleep quality. The Pittsburgh Sleep Quality Index (Buysse et al., 1989) comprises seven subscales: subjective sleep quality, sleep onset latency (the time it takes to fall asleep), sleep duration, sleep efficiency (the ratio of total sleep time to time in bed), sleep disturbance (e.g., nocturnal awakening or breathing difficulties), use of sleep medication and daytime dysfunction (difficulty sustaining daytime wakefulness). The fourth sleep-related construct, sleep duration, refers to the time between sleep onset and offset minus the duration of nocturnal awakenings (Shrivastava et al., 2014). Sleep duration can be measured subjectively, with validated questionnaires or sleep diaries, or objectively, with polysomnography[1], actigraphy[2] or commercially available sleep tracking devices[3].

Two additional constructs in this thesis include problematic smartphone use and mental toughness. Over the past decade, research has highlighted a relationship between sleep parameters and both problematic smartphone use (Mac Cárthaigh et al., 2020) and mental toughness (Mac Cárthaigh et al., 2019). Although both constructs are briefly defined here, a thorough discussion of taxonomical issues and conceptual overlaps is presented in the following chapter. There are no official diagnostic criteria for the construct of problematic smartphone use. However, Demirci et al. (2014) offer a useful working definition: "overuse of smartphones to the extent that it disturbs the users' daily lives" (p. 227). Mental toughness, as defined by Clough and Strycharczyk (2012), refers to a multi-dimensional personality trait which "…determines, in large part, how people deal effectively with challenge, stressors and pressures, irrespective of the prevailing circumstances" (p. 9).

This thesis explores the above-described constructs in middle-to-late adolescence. Traditionally, middle-to-late adolescence has described those aged between 14 to 19 years (World Health Organization, 2004, 2020a). However, in light of emerging neurological evidence, it has been argued that it is more appropriate to designate the offset of late adolescence in the mid-twenties (Sawyer et al., 2018; Society of Adolescent Medicine, 1995). Therefore, this thesis adopts Sawyer et al.'s offset for late adolescents: 24 years. Middle adolescence is the focus of the empirical paper of this

[1] Polysomnography (PSG) is considered the gold standard of sleep measurement. PSG measures physiological sleep parameters including brain activity (using electroencephalography), eye movement, muscle tension, heart rate fluctuations and respiration (Marino et al. 2013). Typically, those under investigation with PSG spend a night in a sleep laboratory under the supervision of a sleep technician.

[2] Actigraphy uses wrist movements to assess the presence of sleep or wake states. This is achieved with the use of a wrist-mounted device containing an accelerometer (Marino et al. 2013).

[3] Commercial sleep tracking devices use the same technology as research-grade actigraphy (i.e., writs-mounted accelerometers). In addition, some models, such as Xiaomi Mi-Band 4 which was used in the present thesis, also detect sleep or wake states by assessing changes in heart rate using technology known as optical plethysmography.

thesis (Chapter Three). Middle adolescence is the period after the onset of puberty but before individuals have adjusted to rapid developmental changes and before they have been granted adult status in society—roughly corresponding to a chronological age between 14 to 17 years (Yeager et al., 2018).

Thesis Structure

Following this introductory chapter, Chapter Two contains a systematic literature review. Two separate systematic reviews were conducted. The first review examined the relationship between sleep and problematic smartphone use. The second review examined the relationship between sleep and mental toughness. The conclusions of both systematic reviews were then synthesised, which generated research questions for further investigation. These research questions are addressed in Chapter Three, the empirical paper, which explored the effectiveness of a school-based sleep promotion intervention. Chapter Four presents a critical review of the thesis. The critical review outlines epistemological positioning, strengths and limitations of the study, the impact of the COVID-19 pandemic, ethical considerations, implications of the thesis, dissemination and, finally, an impact statement.

Chapter Two: Literature Review

Introduction

Sleep: a Health Imperative

Sheldon (2015) argues that sleep is among "…the most common, important, and potentially remediable health risks in teens" (p. 595). Meta-analytic research shows that obtaining adequate sleep is a protective factor against a range of physical and mental health conditions including mental health difficulties (Baglioni et al., 2016; Kaneita et al., 2009; Zhai et al., 2015), impaired cognition (Lim & Dinges, 2010; Stickgold et al., 2000; Yoo et al., 2007b), poor immune response (Besedovsky et al., 2012; Irwin et al., 1996), weight gain (Cappuccio et al., 2008; Nedeltcheva et al., 2010; Patel & Hu, 2008; Taheri et al., 2004), low fertility (Kloss et al., 2015; Wu et al., 2011), cardiovascular disease (Yin et al., 2017) hypertension (Meng et al., 2013; Palagini et al., 2013), hyperglycaemia (Cappuccio et al., 2010a; Reutrakul et al., 2018) and all-cause mortality (Cappuccio et al., 2010b).

The academic implications of sufficient sleep are also clear. Longitudinal research on the impact of shifting school start times, and thereby lengthening sleep duration, found benefits including improved attendance and enrolment (Wahistrom, 2002) and improved grades (Wheaton et al., 2016). The conclusions of such longitudinal research are also supported by a systematic review of the experimental literature on the impact of delaying school start times (Minges & Redeker, 2016). However, in light of such compelling evidence, it is troubling that there has been a global decline in sleep quality and duration among middle-to-late adolescents.

Declines in Adolescent Sleep Quality and Duration

A systematic review of 218 studies across 20 countries indicates that sleep duration among middle-to-late adolescents (henceforth "adolescents") has consistently declined over the past century (Matricciani et al., 2012). Moreover, there appears to have been an accelerated decline over the past few decades. For instance, a study of changes in American adolescent sleeping patterns from 1991 to 2012 revealed declines in sleep duration across all sociodemographic subgroups (Keyes et al., 2015). The largest decline suffered among this cohort was by fifteen-year-olds, with a drop of nine percent in those reporting a regular sleep duration of greater than seven hours. Perhaps more concerning, however, is the approximate two-fold increase in chronic insomnia symptoms and daytime tiredness among adolescents in Finland between the mid-1990s and the late-2000s (Kronholm et al., 2015). Similarly, a Norwegian study found that sleep-onset latency had significantly increased among adolescents from 1983 to 2005 (Pallesen et al., 2008). The most recent systematic review of insomnia prevalence suggests a rate of 19% for adolescents, compared to 7% among the general population (Jiang et al., 2015).

Sleep and Problematic Smartphone Use

Deterioration in sleep quality and duration over time has been linked to numerous factors including progressive delays in bedtimes (Dollman et al., 2007), parental attitudes (Thorleifsdottir et al., 2002) and part-time employment (Carskadon, 1990). Similarly, evidence suggests that the use of mobile devices such as smartphones has contributed to the decline (Demirci et al., 2015; Lanaj et al., 2014; Schweizer et al., 2017; Twenge et al., 2017). The impact of smartphone use on sleep may, at least in part, be explained by the melatonin-suppressing effects of blue monochromatic light emissions (Heo et al., 2017; Oh et al., 2015), the interactive nature of smartphones (Irving et al., 2016), technology-induced sleep procrastination (Kroese et al., 2014) and emotional arousal due to social media use before sleep (Baglioni et al., 2010; Fardouly et al., 2015; Waters et al., 1993).

Problematic Smartphone Use: Taxonomical Issues and Conceptual Overlaps

There are important taxonomical considerations in the study of problematic smartphone use (PSU). The construct of PSU is often conceptualised as a type of technology addiction, with the majority of scholars adopting the term “smartphone addiction” (Panova & Carbonell, 2018, p. 252). Technology addiction has been operationally defined as “non-chemical, behavioural addictions which involve human-machine interactions” (Griffiths, 1996, p. 471). Although there has been support for its inclusion in the American Psychiatric Association’s [APA] (2013) Diagnostic and Statistical Manual, Fifth Edition (DSM-5) (Choliz, 2010), to date, there are no official diagnostic criteria for the construct of smartphone addiction. However, a useful working definition, proposed by Demirci et al. (2014), is “overuse of smartphones to the extent that it disturbs the users’ daily lives” (p. 227). Despite the widespread use of the term “smartphone addiction”, as will be detailed in the next paragraph, research indicates that impairments associated with the use of these devices may not rise to the level of addiction. Therefore, several scholars have cautioned against the use of the term “smartphone addiction” to avoid over-pathologizing common behaviours (Billieux et al., 2015; Kardefelt-Winther et al., 2017).

In a comprehensive review of the literature regarding technology addictions, Panova and Carbonell (2018) concluded that, to date, insufficient evidence exists to support the classification of excessive mobile device use as an addictive behaviour. This conclusion was based on several observations. First, reliance within the field on correlational research with non-clinical samples and, second, a lack of *severe* psychological or physiological consequences associated with smartphone use. Similarly, in a review of the validity of the application of the behavioural addiction model to smartphone use, Billieux et al. (2015) concluded that, at present, there is insufficient evidence supporting the classification of excessive smartphone use as an addictive behaviour. Specifically, the authors argue that there is a dearth of research conclusively demonstrating behavioural and neurobiological similarities between excessive smartphone use and behavioural addictions, such as gambling disorder, which have been included in the DSM-5 (APA, 2013). Therefore, in light of this evidence and the general lack of consensus within the field (Montag et al., 2019), the term "problematic smartphone use" (PSU) has been selected for use throughout this systematic review.

The construct of PSU overlaps with internet use disorder, which has been defined as "excessive or poorly controlled preoccupation, urges or behaviours regarding computer use and internet access that lead to impairment or distress" (Shaw & Black, 2008, p. 353). However, internet use disorder has been critiqued for being a poorly defined and heterogeneous construct (Poli, 2017). As a result of these critiques, and despite significant support for the condition's inclusion in diagnostic manuals (Block, 2008; Pies, 2009; Tao et al., 2010), internet use disorder has not been included as an official condition in the DSM-5 (American Psychiatric Association, 2013). Despite the clinical utility of measures of internet use disorder (Bischof-Kastner et al., 2014), these measures may not be suitable for the study of PSU.

Given the ubiquity, versatility and portability of smartphones, current working definitions of internet addiction may not adequately capture behavioural or psychological impairments associated with excessive use of these devices (Haug et al., 2015; Lin et al., 2015; Montag et al., 2019). This speculation has been empirically supported by Kwon et al. (2013) who detected only moderate correlations between scales of PSU and internet use disorder, indicating that the constructs are not identical. Therefore, the construct of PSU ought to be operationalised using valid and reliable scales.

Sleep and Psychological Constructs

In addition to its impact on mental and physical health, sleep quality is also associated with several psychological constructs. For instance, neuroticism has been shown to be the only Big Five personality factor to be consistently predictive of sleep quality (Calkins et al., 2013; Danielsson et al., 2010; Duggan et al., 2014; Gau, 2000). Similarly, associations have been demonstrated between sleep and the psychological constructs of resilience (Farnia et al., 2019; Lee et al., 2015; Liu et al. 2016) and perceived stress (Charles et al., 2011; Schiller et al., 2017; Gerber et al., 2010). In addition, increasing attention has been paid to the relationship between sleep and mental toughness (MT). For instance, research has detected correlations between MT and sleep parameters including sleep efficiency, sleep disturbance, sleep onset latency and sleep quality (Brand et al., 2014a; Brand et al., 2014b; Cooper et al., 2019; Haghighi & Gerber, 2018).

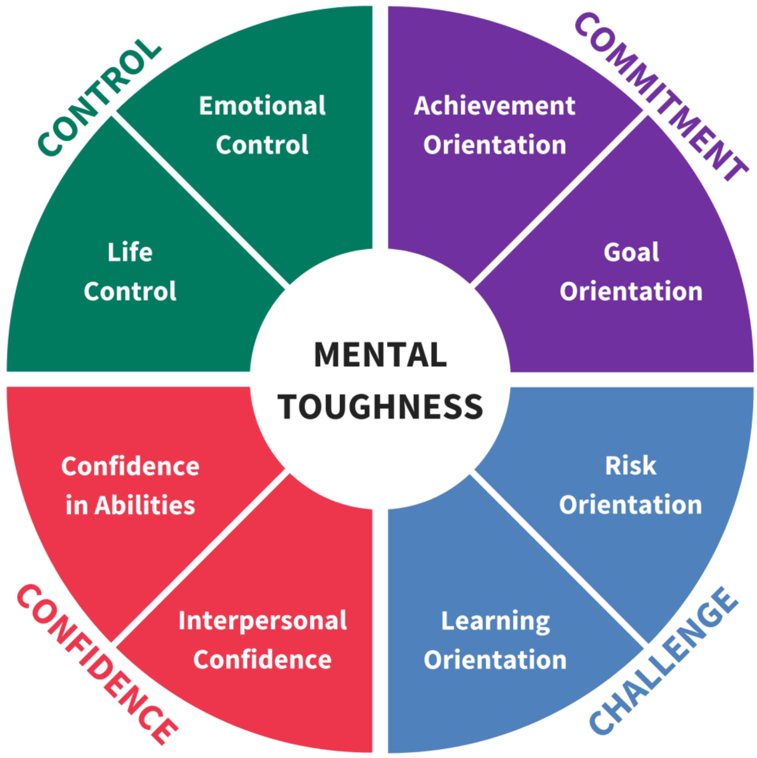
Mental Toughness: Theoretical Roots and Conceptual Overlaps

Conceptually, the construct of MT overlaps with, and has theoretical roots in, the constructs of resilience and hardiness. Resilience, which refers to positive adaption despite adversity (Luthar & Cicchetti, 2000), is positively correlated with indicators of mental wellbeing (Hu, Zhang, & Wang, 2015) and academic persistence (Hartley, 2011). Hardiness, on the other hand, is a characteristic which influences one’s perception of events and response to stressful situations (Gerber et al., 2013). Kobasa (1979) identified three characteristics of hardy individuals. First, these individuals believe they can exert control upon events they experience. Second, they have the ability to feel committed to activities in their daily lives. Third, hardy individuals experience change as an exciting challenge with the potential for personal development. Mental toughness, however, is a broader construct than either resilience or hardiness alone.

Building on Kobasa's (1979) construct of hardiness, Clough et al. (2002) added a fourth factor: the confidence with which one attempts to overcome problems. In addition, Clough et al. further developed the sub-construct of control by distinguishing between life control and emotional control. These revisions led to the 4Cs model of MT, encompassing control, commitment, challenge and confidence (Figure 1). Hence, MT may be understood as a multi-dimensional psychological construct associated with tenacious self-belief, resilience, the ability to cope with stress and the ability to retain focus despite distractions (Crust, 2007). Although MT originates from the field of sports psychology (Clough et al., 2002) and has been influential within health psychology (Gerber et al., 2013), the construct has more recently been studied within education.

Figure 1

The 4Cs Model of Mental Toughness



Note. Figure source: Strycharczyk et al. (2017).

Mental Toughness and Academic Performance

MT is associated with academic performance. In support of this, St Clair-Thompson et al. (2015) found that, among post-primary school students, aspects of MT were related to academic attainment, school attendance, classroom behaviour and peer relations. In addition, MT is associated with fewer concerns regarding the transition to post-primary school (St Clair-Thompson et al., 2017). Similarly, within higher education, significant positive correlations were noted between MT and academic attainment (Crust et al., 2012) and psychological wellbeing (Stamp et al. 2015). All four studies used the Mental Toughness Questionnaire-48 (MTQ-48) (Clough et al., 2002) to assess MT. Several studies have demonstrated the robust psychometric properties of the MTQ-48 (Clough et al., 2002; Perry et al., 2013). Two subscales of the MTQ-48, life control and interpersonal confidence, are significant predictors of academic achievement (Crust et al., 2014). The use of measures of MT comports with the increasing emphasis that has been placed on non-cognitive attributes which lead to academic success (McGeown et al., 2016).

Rationale for a Systematic Review of the Literature

This systematic literature review seeks to, first, clarify the relationship between sleep and PSU and, second, clarify the relationship between sleep and MT. To increase readability, these research questions will be examined with two separate systematic reviews.

Several limitations of the extant literature on the relationship between sleep and PSU have been identified. These limitations include homogeneous samples (Chen et al., 2017; Demirci et al., 2015; Xie et al., 2018), reliance on cross-sectional designs (Demirci et al., 2015; Hughes, & Burke, 2018; Wang et al., 2019) and reliance on self-report measures (Cabré-Riera et al., 2019; Randler et al., 2016). Therefore, this review article seeks to provide an aggregative, critical review of the existing literature on the relationship between sleep and PSU. Previous reviews have explored the relationship between sleep and a range of factors including mobile device access (Cain & Gradisar, 2010; Carter et al., 2016), screen time (Hale & Guan, 2015) and internet use disorder (Alimoradi et al., 2019). However, to date, no such reviews are available on the relationship between sleep and the construct of PSU among adolescents. A comprehensive understanding of the relationship between sleep and PSU will be instructive for the development of effective sleep promotion interventions.

To date, the relationship between sleep and MT has not been systematically reviewed. Although several researchers have posited that a sleep promotion intervention may improve MT (Brand et al., 2014a; Brand et al., 2014b; Brand et al., 2017; Cooper et al., 2019), it remains unclear whether the extant research body supports this claim. In light of this ambiguity, this paper seeks to provide an aggregative, critical review of research on the relationship between sleep and MT. In addition, the paper seeks to provide directions for future research efforts.

Review Questions

1. Is there a relationship between sleep and problematic smartphone use among adolescents?
2. Is there a relationship between sleep and mental toughness among adolescents?

Systematic Review One: Sleep and Problematic Smartphone Use

Search Strategy

A comprehensive search of the peer-reviewed literature was conducted during June 2nd-7th, 2019. The following databases were searched: PsychArticles, PsychInfo, Education Resources Information Centre (ERIC), MEDLINE and Academic Search Complete. The search was conducted using Boolean operators as presented in Table 1. Search filters were applied in line with the exclusion criteria in Table 2.

The search process, following duplicate removal, produced 48 results. Next, the results were screened by title in line with the exclusion criteria, which excluded 36 articles. The abstracts of the remaining 12 articles were screened, all of which met the inclusion criteria. Finally, after full-text evaluation, it was determined that 9 of the 12 articles met the inclusion criteria and would be included in the systematic review. The literature search process is represented in the PRISMA chart in Figure 2, in line with Liberati et al. (2009).

To update the results, the search process was repeated during December 15th-17th, 2020. Following duplicate removal, 72 results remained. After screening by title according to the exclusion criteria and excluding studies which had already been reviewed, 9 articles remained. The abstracts of the remaining 9 articles were screened, which led to the exclusion of 4 articles. Finally, after full-text evaluation of the remaining articles, it was determined that 3 of the 5 remaining studies would be included in the systematic review, as shown in Figure 2.

Table 1

Search Terms for Systematic Review One

		Variables		Target Group
Sleep* OR		problem* smartphone us* OR		adolescen* OR
Circadian		problem* cellphone us* OR		teenage* OR
Rhythms OR		problem* mobile device us* OR		young adult* OR
REM OR		problem* mobile phone us* OR		youth OR
NREM		smartphone addiction OR		young people
		smartphone overuse OR		
		smartphone dependen* OR		
		digital media addiction OR		
	AND	digital media overuse OR	AND	
		digital media dependen* OR		
		cellphone addiction OR		
		cellphone overuse OR		
		cellphone dependen* OR		
		mobile phone addiction OR		
		mobile phone overuse OR		
		mobile phone dependen* OR		
		nomophobia		

Table 2

Inclusion and Exclusion Criteria for Systematic Review One

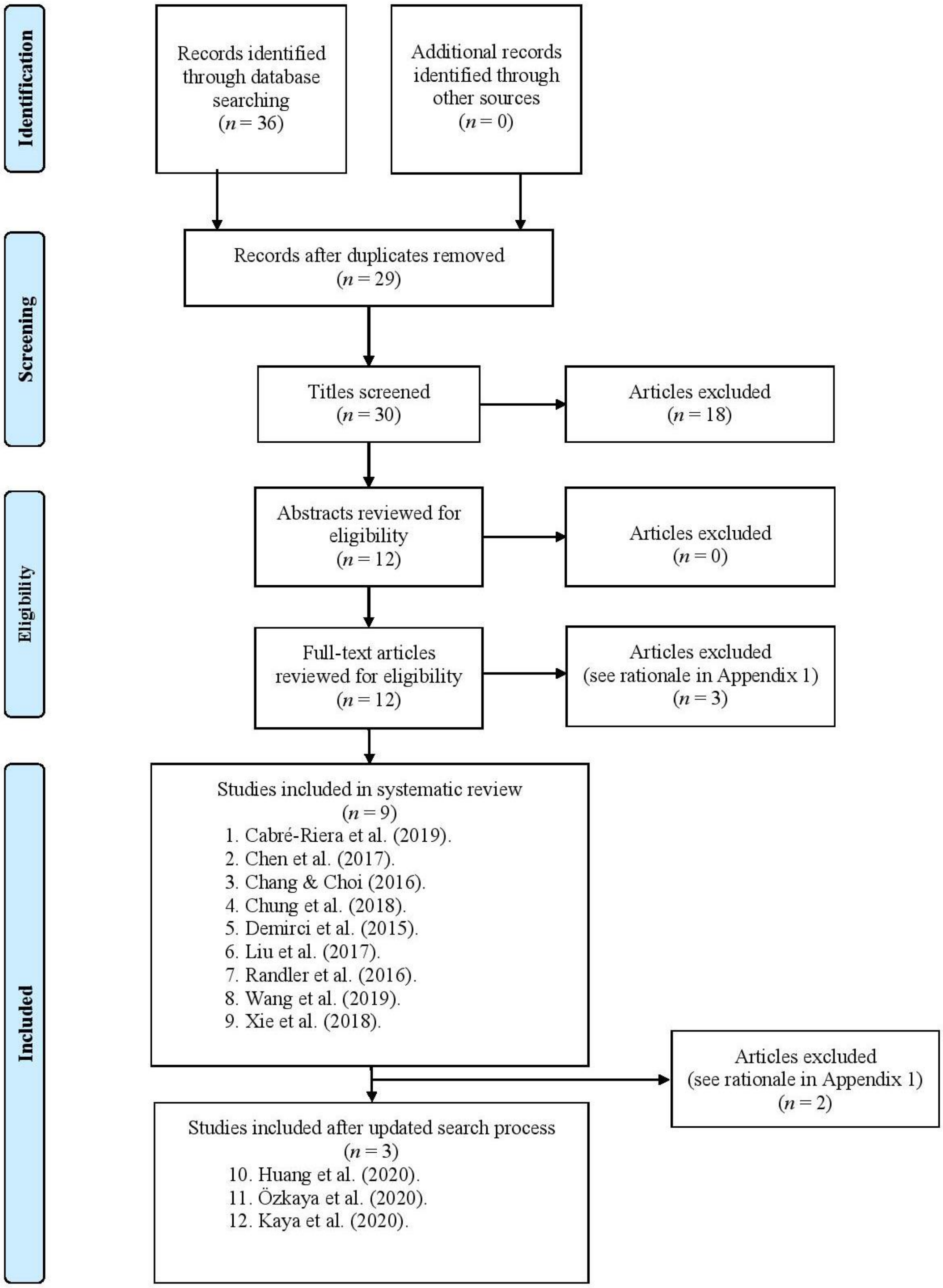
Domain	Inclusion criteria	Exclusion criteria	Rationale
1. Publication year.	Research published after 2007.	Research published before 2007.	The popularity of smartphones has grown enormously since the 2007 launch of Apple Inc.'s iPhone and Google Inc.'s Android operating system (Sarwar & Soomro, 2013). Mobile devices produced before 2007 were much more limited in terms of internet access and functionality (Al-Ismail & Sajeev, 2014). Therefore, in line with the approach selected by several systematic reviews (Al-Ismail & Sajeev, 2014; Belisario, 2015), studies published before 2007 were excluded.
2. Publication type.	Studies published in peer-reviewed academic journals.	Studies not published in peer-reviewed academic journals.	To ensure the academic rigour of the review findings.

3. Research design.	1. Experimental designs. 2. Longitudinal designs. 3. Correlational designs or between-groups designs examining differences between high/low PSU groups or good/poor sleep groups.	Studies not employing an experimental, longitudinal or correlational design.	To ensure that the relationship between sleep and PSU may be explored.
4. Variables.	Studies with at least one variable related to sleep and one related to PSU.	Studies without a variable related to sleep and PSU.	To ensure that the review question is addressed.
5. Target group.	Studies in which the majority of participants are between the ages of 14 and 24 years	Studies in which the majority of participants are not between the ages of 14	This review was primarily concerned with the impact of smartphones on the developing mind. Research suggests that the development of the frontal lobes continues until

	(inclusive).	and 24 years (inclusive).	at least the mid-twenties (Pujol et al., 1993). Hence, this systematic review included participants who met the definition of middle-to-late adolescence, those aged 14-24 years (Sawyer et al., 2018; Society of Adolescent Medicine, 1995).
6. Location.	Any country.	Not applicable.	PSU is a recent phenomenon with a limited research body (Kwon et al., 2013). In addition, PSU appears to present cross-culturally (Lopez-Fernandez, 2017). Hence, studies were not excluded based on location.
7. Scope of research.	Studies which investigated the use of mobile devices (e.g., smartphones and tablets).	Studies which did not investigate the use of mobile devices (e.g., television or personal computers).	Although there is a large body of research examining internet use disorder (Young, 1999), there is a dearth of research on PSU. Given the ubiquity, portability and versatility of these devices, findings from research regarding internet use disorder may not be generalisable to individuals presenting with PSU.

Figure 2

Search Process for Systematic Review One



Method

Mapping the Field and Review Framework

In line with the recommendations of Gough et al. (2017), the twelve studies identified through the literature search process are summarised in Table 3. Summarised data include sample characteristics (including, where available, inclusion and exclusion criteria), study design, variables and main findings. The identified studies were then evaluated using Gough's (2007) Weight of Evidence (WoE) framework. This framework examined three areas of study quality. First, the methodological quality of the studies was evaluated (WoE A: methodological quality). Second, the methodological relevance of the studies' chosen methodology was evaluated (WoE B: relevance of the methodology). Third, the findings and focus of each study were evaluated for relevance to the specific research question of this systematic review (WoE C: relevance to the research question). Finally, to obtain an overall score to assess the strengths of the research evidence, the mean of the scores for WoE A-C was calculated to produce an overall WoE score (WoE D: overall weighting).

Table 3

Summary of Identified Studies in Systematic Review One

Authors	Country	Sample characteristics	Study design	Variables relevant to the review question	Findings relevant to the review question
1. Cabré-Riera et al. (2019).	Spain.	Subjective measures: *N* = 226 (118 females; 108 males). Objective measures: *N* = 110 (gender ratio not reported). Age: 17-18.	Cross-sectional correlational design.	1. PSU: Mobile Phone Problematic Use Scale (Foerster et al., 2015). 2. Sleep quality: Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989). 3. Objective sleep data using ActiGraph	Habitual and frequent problematic smartphone use were associated with reduced sleep quality as measured by the PSQI: Prevalence Ratio 1.55 (95% confidence interval (CI) 1.03–2.33) and 1.67 (95% CI 1.09–2.56), respectively. Increased tablet use was associated with decreased sleep efficiency and increased wake time after sleep onset as measured by actigraphy: β = -1.15 (95% CI -1.99; -

					wGT3X-BT.	.31) and β = 7.00 (95% CI 2.40; 11.60) per increase of 10 minutes per day of use, respectively. 23.2% of participants were classified as problematic mobile phone users (80^{th} percentile). 10.6% of participants were classified as poor or very poor sleepers according to the PSQI (Buysse et al., 1989).
2. Chen et al. (2017).	The People's Republic of China.	*N* = 1441 (691 males; 480 females). Age: 17-26.	Cross-sectional correlational design and a between-groups	1.	PSU: Smartphone Addiction Scale – Short Version (SAS-SV) (Kwon et al., 2013).	Participants in the high PSU group obtained significantly higher scores on the PSQI for both males ($p < .001$) and females ($p = .003$), indicating poorer sleep quality.

			comparison for high/low PSU groups.	2. Sleep quality: Chinese version of the PSQI (Buysse et al., 1989; Liu et al., 1996).	Using the cut-off suggested by Kwon et al. (2013), 29.8% of participants were classified as problematic smartphone users. 35.5% of participants were classified as poor sleepers according to the PSQI.
3. Chang and Choi (2016).	South Korea.	*N* = 300 (160 females; 140 males). Age: 20-40. Inclusion criteria: ownership of a smartphone.	Cross-sectional correlational design and a between-groups comparison for high/low PSU groups.	1. Sleep quality: Korean version of the PSQI (Choi et al., 2012; Buysse et al., 1989). 2. PSU: Smartphone Addiction Proneness Scale	Scores on the PSQI and SAPS were positively correlated for both male (r = .345, p = .001) and female (r = .194, p = .014) participants. Participants in the high PSU group obtained significantly higher scores on the PSQI relative to the general user group

	Exclusion criteria: mental illness, chronic medical conditions, sleep disorders and shift work.	(SAPS) for Adults (Lee et al., 2012).	among males (*p* = .003) and females (*p* = .002), indicating poorer sleep quality. Regression analysis indicated that PSU is predictive of sleep quality among male participants (β = 1.84, *p* = .02). Using the cut-off recommended by Lee et al. (2012), 11.0% and 5.3% of participants were classified as potential problematic smartphone users and problematic smartphone users, respectively. PSQI scores (*M* = 6.45, *SD* = 2.99) exceeded the 5.0 cut-off recommended by Buysse et al. (1989), indicating poor sleep

					quality. However, data regarding the percentage of participants exceeding this value were not provided.
4. Chung et al. (2018).	South Korea.	*N* = 1796 (976 females; 820 males). Age: 7 – 18. Inclusion criterion: ownership of a smartphone.	Cross-sectional correlational design.	1. PSU: Korean Smartphone Addiction Proneness Scale for Youth (K-SAPS) (Kim et al., 2014). 2. Sleepiness: Paediatric Daytime Sleepiness Scale (PDSS) (Drake et al., 2003).	Participants classified as being at risk of PSU according to the K-SAPS were significantly more likely to be in the upper quartile of scores on the PDSS ($p < .001$). According to the K-SAPS, compared to males (15.1%), significantly more females (23.9%) were at risk of PSU ($p < .001$). The overall mean PDSS score was 15.0 ($SD = 6.0$). The mean score in the upper quartile was 20.6 ($SD = 2.8$) and 12.4 ($SD = 4.4$) in the remainder.

5. Demirci et al., (2015).	Turkey.	*N* = 319 (203 females; 116 males). Age: *M* = 20.5, *SD* = 2.5.	Cross-sectional correlational design and a between-groups comparison for high/low PSU groups.	1. PSU: Turkish version of the Smartphone Addiction Scale (SAS) (Demirci et al., 2014; Kwon et al., 2013). 2. Sleep quality: Turkish version of the PSQI (Buysse et al., 1989; Agargun et al., 1996).	Scores in the daytime dysfunction subscale of the PSQI were higher in the high smartphone use group relative to the low smartphone use group ($p = .001$). Scores on the SAS were positively correlated with PSQI global scores ($r = 0.16$, $p = .01$), the subjective sleep quality subscale ($r = .14$, $p = .03$), the sleep disturbance subscale ($r = .15$, $p = .02$) and the daytime dysfunction subscale ($r = .24$, $p < .001$). The mean SAS score was 75.69 (*SD* = 22.46). 39.8% of participants were found

					to present with PSU.
6. Liu et al. (2017).	The People's Republic of China.	*N* = 1196 (634 males; 562 females). Age: 14 – 20.	Cross-sectional mediation moderation analysis.	1. PSU: Mobile Phone Addiction Index (MPAI) (Leung, 2008). 2. Sleep quality: Chinese version of the PSQI (Buysse et al., 1989; Liu et al., 1996).	Scores on the MPAI and PSQI were positively correlated (r = .34, p = .001). Mean scores were 6.31 (SD = 3.26) for the PSQI and 2.32 (SD = 0.75) for the MPAI.
7. Randler et al. (2016).	Germany.	Study 1: *N* = 342 (176 males; 165 females; 1 not indicated) Age: M = 13.4, SD =	Cross-sectional correlational design.	1. PSU: German translation of the SAS-SV (Kwon et al., 2013). 2. PSU: German translation of the K-	Significant negative correlations both between scores on the CMS and SAPS (r = -.35, p < .01) and SAS-SV (r = -.35, p < .01), indicating that evening type chronotype is related to PSU.

	1.8. Study 2: $N = 208$ (146 females; 62 males). Age: $M = 17.1$, $SD = 4.3$.	SAPS (Kim et al., 2014). 3. Chronotype: German version of the Composite Scale of Morningness (CMS) (Randler, 2008; Smith et al., 1989). 4. Sleep duration (no use of a validated scale).	An ANCOVA indicated that chronotype showed a significant effect on SAPS (F (2324) = 15.36, $p < .001$, $\eta^2 = .087$) and SAS-SV (F (2203) = 610.39, $p < .001$, $\eta^2 = .093$). Weekday sleep duration was negatively correlated with scores on the SAPS ($r = -.19$, $p < .001$) and SAS-SV ($r = -.29$, $p < .001$). Multiple regression results indicated that CMS scores were the most significant predictor of scores on the SAPS ($\beta = -.349$, $p < .001$) and the second most significant predictor of scores on the SAS-

					SV (β = -.217, p < .05).
8. Wang et al. (2019).	Taiwan.	N = 409 (409 females; 0 males). Age: 15 – 21. Inclusion criteria: Possession of a smartphone for six or more months and the ability to communicate in Mandarin or Minnan Chinese dialects. Exclusion criteria:	Cross-sectional correlational design.	1. Sleep Quality: Chinese version of the PSQI (Buysse et al., 1989; Tsai et al., 2005). 2. Smartphone addiction (non-validated scale).	Participants classified as having poor sleep quality according to the PSQI had significantly higher PSU scores (p < .01). Mean PSU scores were 12.86 (SD = 3.33) for poor sleepers and 11.44 (SD = 3.21) for good sleepers. Logistic regression indicated a significant association between PSU and scores on the PSQI (odds ratio = .88, CI = .83 – .94, p < .01). 52% of participants were classified as poor sleepers according to the PSQI.

		having children, shift work and mental illness.			
9. Xie et al. (2018).	The People's Republic of China.	*N* = 686 (382 females; 304 males). Age: 11 – 17.	Cross-sectional mediation moderation analysis.	1. Sleep Quality: Chinese version of the PSQI (Buysse et al., 1989; Liu et al., 1996). 2. PSU: Smartphone Addiction Inventory (Lin et al., 2014) and the Mobile Phone Addiction Inventory (Huang et al., 2007).	Significant positive correlations were detected between PSQI scores and all subscales of the PSU measure including use time ($r = .13$, $p < .01$), overuse ($r = .23$, $p < .01$), withdrawal ($r = .31$, $p < .01$), compulsion ($r = .32$, $p < .01$) and disturbance ($r = .25$, $p < .01$). PSU negatively correlated with physical health and sleep quality mediated this relationship.

Studies Identified in Updated Search Process

10. Huang et al. (2020).	The People's Republic of China.	*N* = 439 (381 females; 58 males). Age: 15-24 (*M* = 18.8; *SD* = 1.7). Exclusion criterion: severe physical illness.	Cross-sectional correlational design and a between-groups comparison with good/poor sleepers.	1. Sleep Quality: Chinese version of the PSQI (Buysse et al., 1989; Liu et al., 1996). 2. PSU: Mobile Phone Addiction Index (MPAI) (Leung, 2008).	Chi-square test indicated that poor sleepers were more likely to have higher scores on the MPAI ($p = .007$). Multivariate logistic regression indicated that poor sleep quality was predictive of PSU, as measured by the MPAI (odds ratio: 2.04, CI = 1.01-4.14, $p = .04$).
11. Özkaya et al. (2020).	Turkey.	*N* = 161 (121 females; 40 males). Age: 18-20 (*M* = 19.0; *SD* = 1.7).	Cross-sectional correlational design.	1. Sleep quality: Turkish version of the PSQI (Buysse et al., 1989; Agargun et al., 1996).	Significant positive correlations were detected between scores on the SAS-SV and PSQI ($r = .19$, $p = .01$).

				2. PSU: Turkish version of the SAS-SV (Kwon et al., 2013; Noyan et al., 2015).	
12. Kaya et al. (2020).	Turkey.	*N* = 804 (521 females; 283 males). Age: 17-26 (*M* = 20.9; *SD* = 2.4)	Cross-sectional correlational design.	1. Sleep quality: PSQI (Turkish version) (Buysse et al., 1989; Agargun et al., 1996). 2. PSU: SAS-SV (Turkish version) (Kwon et al., 2013; Noyan et al., 2015).	Multi-variate linear regression analysis indicated that sleep quality was predictive of SAS-SV scores (β = -.099, *p* = .006).

WoE A: Methodological Quality

Risk of bias was assessed with quality checklists. As identified by numerous authors, there is an absence of validated quality appraisal tools specifically designed to evaluate cross-sectional correlational studies (Faragher et al., 2005; Hoffmann et al., 2017; Protogerou & Hagger, 2018). In light of this absence, WoE A (methodological quality) was evaluated with a checklist adapted from the National Heart, Lung and Blood Institute’s Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (items 1-7) (National Institutes of Health, 2014) and Thompson et al.’s (2005) recommendations regarding the quality appraisal of correlational research (items 8-10). Summed points from the checklist indicated the overall methodological quality of the study, with 0 points indicating that none of the quality criteria had been met, and 10 points indicating that all criteria had been met. High-quality studies (≥ 8 points) were assigned a WoE score of 3, acceptable quality studies (4-7 points) a WoE score of 2 and low-quality studies (≤ 3 points) a WoE score of 1. Scores for the quality assessment checklists and the corresponding WoE A scores are presented in Table 4. The completed quality assessment checklist for each study is available in Appendix 2.

Table 4

WoE A Scores for Systematic Review One

	Study	Quality Assessment Score (0 – 10)	WoE A Score (1 – 3)
1	Cabré-Riera et al. (2019).	7	2 (acceptable)
2	Chen et al. (2017).	9	3 (high)
3	Chang & Choi (2016).	7	2 (acceptable)
4	Chung et al. (2018).	9	3 (high)
5	Demirci et al. (2015).	7	2 (acceptable)
6	Liu et al. (2017).	8	3 (high)
7	Randler et al. (2016).	7	2 (acceptable)
8	Wang et al. (2019).	7	2 (acceptable)
9	Xie et al. (2018).	7	2 (acceptable)
10	Huang et al. (2020).	7	2 (acceptable)
11	Özkaya et al. (2020).	6	2 (acceptable)
12	Kaya et al. (2020).	8	3 (high)

Note. Mean quality score (standard deviation) = 7.4 (.86).

WoE B: Methodological Relevance

This review sought to establish the relationship between sleep and PSU. Therefore, to answer the review question, evidence gleaned from certain study designs were more heavily weighted than others, in line with the hierarchy of evidence (Brannen, 2017). Specifically, experimental designs, in which causal relationships may be inferred, were more heavily weighted than cross-sectional correlational designs. The criteria used to determine the methodological relevance to the research question are presented in Table 5. The WoE B score for each study may be found in Table 6.

Table 5.

WoE B Criteria and Rationale for Systematic Review One

Quality	Criteria	WoE B score	Rationale
High	Systematic reviews, meta-analyses, randomised controlled trials or controlled experimental designs.	3	Informed by Brannen (2017).
Acceptable	Uncontrolled experimental designs, quasi-experimental designs, cohort studies, case-control studies or N-of-1 studies.	2	
Low	Qualitative studies, cross-sectional surveys or case reports.	1	

Table 6.

WoE B Scores for Systematic Review One

Authors	WoE B Score
1. Cabré-Riera et al. (2019).	1
2. Chen et al. (2017).	1
3. Chang & Choi (2016).	1
4. Chung et al. (2018).	1
5. Demirci et al. (2015).	1
6. Liu et al. (2017).	1
7. Randler et al. (2016).	1
8. Wang et al. (2019).	1
9. Xie et al. (2018).	1
10. Huang et al. (2020).	1
11. Özkaya et al. (2020).	1
12. Kaya et al. (2020).	1

WoE C: Relevance to the Research Question

WoE C evaluated the relevance of the focus of the study to the current research question: is there a relationship between sleep and PSU among adolescents? With reference to the literature, it was determined that three criteria would contribute to the WoE C scores.

First, criterion one evaluated the proportion of participants who fell within the age range of interest to this review, 14-24 years (inclusive). The rationale for this choice was to maximise the generalisability of the findings to those within this age range, as there is suggestive evidence that adolescents may be more susceptible to the allure of smartphones compared to other age groups (Mac Cárthaigh, 2020). In support of this, it has been argued that adolescents experience a developmental stage of heightened concern with gaining peer validation (Erikson, 1963). Such validation may be readily obtained through the use of smartphones, particularly by engaging with social media (Mac Cárthaigh, 2020). This developmental stage, known as “identity versus role confusion” (Erikson, 1963), when combined with the increased sensitivity of the adolescent brain to dopaminergic rewards (Steinberg, 2008; Veissière & Stendel, 2018), may make adolescents uniquely vulnerable to PSU.

There is also strong evidence that adolescents experience markedly different sleep schedules compared to other age groups. For instance, these differences include up to a two-hour delay in circadian timing (Carskadon et al., 1993; Crowley et al., 2014), a slower accumulation of homeostatic sleep drive relative to middle childhood (Jenni & Carskadon, 2007), a need for longer sleep duration relative to early and late adulthood (Hirshkowitz et al., 2015) and sharp declines in delta and theta non-rapid eye movement (NREM) sleep beginning in early adolescence (Campbell & Feinberg, 2009). As outlined in the exclusion criteria, studies in which fewer than 50% of participants fell within the 14-24 (inclusive) age range were excluded. Criterion one of WoE C weighted studies which exceeded this percentage as outlined in Table 7.

Second, criterion two considered the use of objective measures of PSU. The inclusion of this criterion was informed by the observation that subjective and objective frequency of smartphone use are poorly correlated (Andrews et al., 2015; Ellis et al., 2019). Moreover, estimates of smartphone usage duration may be affected by distortions of time perception (Lin et al., 2015; McLoughlin, 2012; Rau et al., 2006). For instance, McLoughlin (2012) found that a greater level of technology use may be associated with increased subjective timing (i.e., overestimation of the passage of time).

Finally, criterion three considered the use of objective sleep measures. The inclusion of this criterion was deemed important due to the equivocal validity of subjective measures of sleep (Baker et al., 1999; Lauderdale et al., 2008; Regestein et al., 2004) and the recommendation of numerous studies to employ both objective and subjective measures (Landry et al., 2015; Rowe et al., 2008; Van Den Berg et al., 2008; Voderholzer et al., 2003). The WoE C scores for each study are presented in Table 8.

Table 7.

WoE C Criteria and Rationale for Systematic Review One

Criteria	Weighting	
1. The proportion of participants between the ages of 14 and 24 (inclusive).	3 (high)	All participants between the ages of 14 and 24 (inclusive).
	2 (acceptable)	More than 90% of participants between the ages of 14 and 24 (inclusive).
	1 (low)	Fewer than 75% of participants between the ages of 14 and 24 (inclusive).
2. Variables for PSU.	3 (high)	Two or more objective measures of smartphone use, such as duration and frequency of use.
	2 (acceptable)	One objective measure of smartphone use.
	1 (low)	No objective measures of smartphone use.
3. Variables for sleep.	3 (high)	Both objective and subjective measures of sleep.
	2 (acceptable)	Objective measures of sleep only.
	1 (low)	Subjective measures of sleep only.

Table 8.

WoE C Scores for Systematic Review One

Authors	WoE C Scores			
	WoE C Criterion 1	WoE C Criterion 2	WoE C Criterion 3	WoE C Mean Scores
1. Cabré-Riera et al. (2019).	3	1	3	2.3
2. Chen et al. (2017).	2	1	1	1.3
3. Chang & Choi (2016).	1	1	1	1
4. Chung et al. (2018).	1	1	1	1
5. Demirci et al. (2015).	3	1	1	1.7
6. Liu et al. (2017).	2	1	1	1.3
7. Randler et al. (2016).	2	1	1	1.3
8. Wang et al. (2019).	3	1	1	1.7
9. Xie et al. (2018).	1	1	1	1

10. Huang et al. (2020).	3	1	1	1.7
11. Özkaya et al. (2020).	3	1	1	1.7
12. Kaya et al. (2020).	3	1	1	1.7

WoE D: Overall Weight of Evidence

For each study, the mean score of WoE A-C was calculated to produce WoE D, the overall study weighting. The WoE D scores for each study are presented in the WoE summary table (Table 9). WoE D scores ranged from 1.3 to 1.9. These scores represent a weak-to-moderate overall weight of evidence.

Table 9.

WoE Summary Table for Systematic Review One

Authors	Quality of Methodology (WoE A)	Relevance of the Methodology (WoE B)	Relevance for the Research Question (WoE C)	Overall Weighting (WoE D)
1. Cabré-Riera et al. (2019).	2	1	2.3	1.8
2. Chen et al. (2017).	3	1	1.3	1.8
3. Chang & Choi (2016).	2	1	1	1.3
4. Chung et al. (2018).	3	1	1	1.7
5. Demirci et al. (2015).	2	1	1.7	1.6
6. Liu et al. (2017).	3	1	1.3	1.8
7. Randler et al. (2016).	2	1	1.3	1.4

8. Wang et al. (2019).	2	1	1.7	1.6
9. Xie et al. (2018).	2	1	1	1.3
10. Huang et al. (2020).	2	1	1.7	1.6
11. Özkaya et al. (2020).	2	1	1.7	1.6
12. Kaya et al. (2020).	3	1	1.7	1.9

Results

Participants

This systematic review of the relationship between sleep and PSU among adolescents evaluated twelve studies and included data from 8437 participants. The sample sizes ranged from $N = 110$ (Cabré-Riera et al., 2019) to $N = 1767$ (Chung et al., 2018). The sample size in Cabré-Riera et al. was limited by its inclusion of actigraphy which is more expensive than subjective sleep measures (Martin & Hakim, 2011). No other studies employed objective sleep measures. Gender statistics were reported for all studies except a sub-study of Cabré-Riera et al. The gender ratio of the total sample was approximately equal (53% females). Several studies (Cabré-Riera et al., 2019; Demirci et al., 2015; Huang et al., 2020; Kaya et al., 2020; Özkaya et al., 2020; Wang et al., 2019) exclusively sampled participants who fell within the age range which was of interest to this review, whereas fewer than 75% of participants fell within this range in other studies (Chang & Choi, 2016, Chung et al., 2018; Xie et al., 2018). This discrepancy was, therefore, reflected in the WoE C scores. All but three studies (Chang & Choi, 2016; Chung et al., 2018; Huang et al., 2020; Wang et al., 2019) neglected to provide information regarding participant inclusion and exclusion criteria (e.g., pre-existing sleep disorders).

Research Design

All studies employed a cross-sectional correlational design. However, during the literature search process, one study with an experimental design had been identified (Hughes & Burke, 2018). This study examined the impact of voluntarily restricting smartphone access several hours before bed on PSU. Although thematic analysis indicated that participants experienced improved sleep quality and reduced sleep onset, no dependent variables related to sleep were employed by the authors. Therefore, Hughes et al. did not meet inclusion criterion four, as outlined in Appendix 1 (excluded studies and rationale).

Four studies included a between-groups component to compare high and low PSU groups on subjective measures of sleep (Chang & Choi, 2016; Chen et al., 2017; Demirci et al., 2015; Huang et al., 2020) and two studies conducted mediation-moderation analysis (Liu et al., 2017; Xie et al., 2018). The chosen design of all studies may elucidate the relationship between variables, but it precludes the establishment of causation. Therefore, this design limitation was reflected in the scores for criterion one of WoE B in all studies. Several studies (Cabré-Riera et al., 2019; Huang et al., 2020; Kaya et al., 2020; Özkaya et al., 2020; Xie et al., 2018) did not control for potential confounding variables. Since age has been shown to influence PSU (Gezgin, 2018; Van Deursen et al., 2015), failure to control for such variables was considered in WoE A.

Measures

All but two studies (Chung et al., 2018; Randler et al., 2016) evaluated sleep using the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) or validated translations of this scale. The psychometric properties of the PSQI have been empirically supported (Mollayeva et al., 2016). However, this self-report measure also has significant limitations which are examined in the discussion section of this review paper. Chung et al. employed the Paediatric Daytime Sleepiness Scale (Drake et al., 2003), whereas Randler et al. employed the German version of the Composite Scale of Morningness (CMS) (Randler, 2008; Smith et al., 1989). Just one study complemented subjective sleep scales with objective measures. Cabré-Riera et al. (2019) employed actigraphy, which has demonstrated strong correlations with polysomnography (Sadeh, 2011), on a subset of participants. Therefore, the inclusion of an objective measure of sleep contributed to a higher WoE C score for Cabré-Riera et al.

PSU was assessed using a variety of validated scales. These scales included the Mobile Phone Problematic Use Scale (MPPUS) (Foerster et al., 2015), the Smartphone Addiction Scale, Short Version (SAS-SV) (Kwon et al., 2013), the Smartphone Addiction Proneness Scale for Adults (SAPS) (Lee et al., 2012), the Mobile Phone Addiction Index (MPAI) (Leung, 2008) and a scale adapted from the Smartphone Addiction Inventory (Lin et al., 2014) and the Mobile Phone Addiction Inventory (Huang et al., 2007). Wang et al. (2019), however, employed a non-validated scale, which was considered in the WoE A score for this study. No studies complemented self-report PSU scales with objective data. This limitation was considered in criterion two of WoE C and is examined in the discussion.

Findings

This systematic review aimed to determine the relationship between sleep and PSU among adolescents. WoE D refers to the overall weight of research evidence to answer this research question and is presented in the WoE summary table (Table 9). The overall WoE D score provides weak-to-moderate support for a relationship between sleep and PSU among adolescents. Two studies obtained a low WoE D score of 1.3 (Chang & Choi, 2016; Xie et al., 2018). The highest scoring studies obtained a WoE of 1.8 (Cabré-Riera et al., 2019; Chen et al., 2017; Liu et al., 2017) and 1.9 (Kaya et al., 2020). All studies evaluated in this review indicated that there is a relationship between PSU and sleep. However, studies with higher WoE D scores should be given more weight (Cabré-Riera et al., 2019; Chen et al., 2017; Kaya et al., 2020; Liu et al., 2017) and findings from studies with lower WoE D scores should be interpreted cautiously (Chang & Choi, 2016; Xie et al., 2018).

The correlational nature of all studies precludes the inferral of causation. The strength of the relationship between PSU and sleep varied depending on the study and the measures employed, ranging from weak to moderate. For instance, Demirci et al. (2015) found a weak positive correlation between the daytime dysfunction subscale of the PSQI and the SAS-SV (r = .24, p < .001). However, the SAS-SV correlation with the PSQI global scores was much weaker (r = .16, p = .014). Contrastingly, Liu et al. (2017) found a comparatively stronger correlation between the MPAI and the PSQI (r = .34, p = .001). Liu et al.'s study has a greater weight of evidence due to its relatively higher WoE D score. Randler et al. (2016) was the only study to explore chronotype and found a weak negative correlation between scores on the CMS and the SAS-SV (r = -.35, p < .01) and the SAPS (r = -.35, p < .01). Interestingly, Randler et al. was the only study to employ multiple subjective measures of PSU, which likely improved internal validity and generalisability and reduced method bias (Lerner et al., 2015). The strongest correlation was found by Wang et al. (2019) between the PSQI and PSU (r = .43, p < .01). However, this finding should be interpreted cautiously as Wang et al. employed a non-validated scale of PSU. All studies which employed regression analysis supported the hypothesis that PSU is associated with sleep parameters (Cabré-Riera et al., 2019; Chang & Choi, 2016; Huang et al., 2020; Kaya et al., 2020; Randler et al., 2016; Wang et al., 2019). Interestingly, although Cabré-Riera et al., 2019 was the only study to employ objective measures of sleep and found a relationship between scores on the MPPUS and the PSQI[4], these findings were not supported by analysis using objective, actigraphically-measured sleep. Compared to other studies, Cabré-Riera et

[4] Habitual problematic smartphone use and PSQI prevalence ratio of 1.55 (95% confidence interval 1.03–2.33); frequent problematic smartphone use and PSQI prevalence ratio of 1.67 (95% confidence interval 1.09–2.56).

al.'s study has a higher weight of evidence due to a moderate WoE D score of 1.8.

Several studies compared sleep parameters among participants who scored high and low on measures of PSU (Cabré-Riera et al., 2019; Chang & Choi, 2016; Chen et al., 2017; Chung et al., 2018; Demirci et al., 2015; Huang et al., 2020; Randler et al., 2016; Wang et al., 2019). All such comparisons which employed subjective sleep measures supported the hypothesis that PSU is associated with poor sleep. However, comparisons of occasional, frequent and habitual smartphone users did not yield significant differences in objective measures of sleep in Cabré-Riera et al.

Discussion

This systematic review aimed to, first, integrate and summarise the findings of research on the relationship between sleep and PSU and, second, evaluate the strength of the evidence. In sum, evidence was found for a weak-to-moderate correlation between PSU and subjective sleep, such that higher levels of PSU were associated with poorer sleep outcomes. The overall weight of evidence, as indicated by WoE D scores, was weak-to-moderate (1.3-1.8). As will be discussed, the findings should be interpreted tentatively until more methodologically rigorous studies are available. Notwithstanding these limitations, the findings of this systematic review have important implications for adolescent sleep.

Adolescent Sleep: An Emerging Public Health Concern

On the basis of a consultation with a multi-disciplinary expert panel and a systematic review of 312 peer-reviewed articles, the United States (US) National Sleep Foundation (Hirshkowitz et al., 2015) recommends a sleep duration of 8-10 hours for middle-adolescents (14-17 years) and 7-9 hours for late-adolescents (18-24 years). However, analysis by the Centres for Disease Control (CDC) indicates that fewer than

42% of middle school students and fewer than 28% of high school students obtain the recommended sleep duration (Wheaton et al., 2018). Similarly, among university students surveyed across 26 countries, 39% reported a sleep duration of less than six hours (Peltzer & Pengpid, 2016). Adolescent sleep loss, therefore, is a major public health concern which warrants urgent action.

As discussed throughout this paper, the cause of adolescent sleep loss is manifold. Due to a slower accumulation of homeostatic sleep drive relative to other age groups (Jenni & Carskadon, 2007) and changes in circadian timing (Carskadon et al., 1993; Crowley et al., 2014), sleep onset is delayed among adolescents. However, despite these biological demands, adolescents are generally expected to terminate their sleep cycles in line with other age groups (American Academy of Pediatrics, 2014). The problem of adolescent short sleep duration is compounded by early school start times (Start School Later Non-Profit Organisation, 2021; Watson et al., 2017). Indeed, the CDC reported that fewer than 18% of public middle and high schools had observed the recommendations of the American Academy of Pediatrics (2014) to start school at 8:30 a.m. or later (Wheaton et al., 2015). In addition to these factors, the findings of this systematic review indicate that PSU may also be a contributing factor in adolescent sleep insufficiency.

Causal Mechanisms in the Relationship between Sleep and PSU

Several causal mechanisms in the association between sleep and PSU have been identified. First, it has been demonstrated that blue monochromatic light emissions from smartphone light-emitting diode (LED) displays delay sleep onset through melatonin suppression (Chang et al., 2015; Heo et al., 2017; Oh et al., 2015). For instance, in a double-blind, placebo-controlled study, Heo et al. (2017) found that melatonin onset was significantly delayed among participants who had been exposed to blue monochromatic light from smartphones. Similarly, Chang et al. found that exposure to mobile device LED displays for approximately four hours before bedtime delayed the endogenous circadian melatonin phase by 90 minutes. A second potential causal mechanism in the association between sleep and PSU is smartphone-induced negative emotional arousal. In a review of the empirical literature on the association between sleep and emotions, Baglioni et al. (2010) concluded that negative emotional arousal is a maintaining factor in adolescent sleep difficulties. Similarly, Waters et al. (1993) found that negative emotional arousal contributes to sleep onset and sleep maintenance difficulties among adolescents. Since the majority of adolescents' smartphone screen time is spent on social media use (Joshi et al., 2019), and social media use has been linked to negative emotional arousal (Fardouly et al., 2015; Lin et al., 2016; Woods & Scott, 2016), it is plausible that smartphone use before sleep may interfere with sleep onset and maintenance. A third likely causal mechanism in the relationship between sleep and PSU is bedtime procrastination. This phenomenon is defined as going to bed later than intended despite the absence of external reasons for doing so (Kroese et al., 2014). Bedtime procrastination has been found to mediate the association between self-regulation skills and sleep insufficiency (Kroese et al., 2016). Moreover, Chung et al. (2020) found that, compared to adolescents who scored low on measures of bedtime procrastination, their counterparts with high scores spent 451% more time engaged with their smartphones in the three-hour period before bedtime. In addition, these adolescents reported higher levels of insomnia symptoms and later sleep onset. In light of this compelling evidence, it seems plausible that bedtime procrastination mediates the relationship between PSU and sleep parameters, particularly among adolescents with a predisposition towards self-regulation difficulties.

Future Directions

A striking limitation of all but one study in this systematic review (Cabré-Riera et al., 2019) was reliance on subjective sleep measures. Moreover, Cabré-Riera et al. did not support the hypothesis that increased PSU is associated with poorer actigraphically-measured sleep duration. A further limitation is that objective measures of PSU were omitted in all studies. Therefore, as will be argued in the following paragraphs, the evidence to support the relationship between sleep and PSU must be considered tentative until the findings are supported by studies employing objective measures.

Operationalising Problematic Smartphone Use

Despite the wealth of smartphone-generated data which could inform psychological research, few studies have capitalised upon this possibility (Gan & Goh, 2016; Piwek et al. 2016). In support of the use of such data, several researchers have concluded that subjective and objective frequency of use are poorly correlated (Andrews et al., 2015; Ellis et al., 2019). Moreover, subjective reporting of screen-time is affected by distortions of time perception (Lin et al., 2015; McLoughlin, 2012; Rau et al., 2006). Therefore, in light of these observations, subjective PSU scales ought to be augmented with objective measures of smartphone use. Such an approach would be in line with the first proposed diagnostic criteria for PSU (Billieux, 2012). This framework recommends evaluating three aspects: the user’s profile through semi-structured interviews, actual use through objective data and problematic use through validated scales.

Operationalising Sleep

Despite the clinical and research utility of subjective sleep scales (Mollayeva et al., 2016; Vanable, 2000), the validity of such measures is equivocal. In support of this, numerous studies have failed to support the validity of subjective sleep measures when compared to polysomnography or actigraphy (Baker et al., 1999; Lauderdale et al., 2008; Regestein et al., 2004). For instance, Lauderdale et al. found that participants with an objective mean sleep duration of six hours reported a subjective mean of almost seven hours. These findings were mirrored by Van Den Berg et al. (2008) who found that, among a third of participants, self-reported sleep duration deviated over one hour from actigraphically measured sleep duration. Similarly, several studies have demonstrated that the most commonly used subjective sleep measure, the PSQI (Buysse et al., 1989; Mollayeva et al., 2016), correlates poorly with objective sleep, as measured by actigraphy or polysomnography (Backhaus et al., 2002; Grandner et al., 2006). Grandner et al. posit that subjective sleep complaints may be more indicative of cognitive outlook than sleep quality. However, despite the questionable validity of subjective sleep measures, there is also evidence to support their use.

Subjective sleep quality, as measured by the PSQI, is associated with sleepiness, sleep problems and restlessness (Buysse et al., 1989; Carpenter & Andrykowski, 1998). In addition, the PSQI has demonstrated strong discriminant validity. In support of this, studies with patients with primary insomnia (Grandner et al., 2000; Nowell et al., 1999), obstructive sleep apnoea (Gliklich et al., 2000) and cancer (Owen et al., 1999) have demonstrated that the PSQI can distinguish between good and poor sleepers. Moreover, despite the evidence demonstrating poor correlations between the PSQI and objective measures discussed in the previous paragraph, the most comprehensive review conducted to date indicated strong validity and reliability of the PSQI among clinical and non-clinical samples (Mollayeva et al., 2016). Such self-report tools appear to have comparable validity to objective measures with large sample sizes (Brand et al., 2014b; Wolfson et al., 2003). Van Den Berg et al. (2008) speculate that disagreement between subjective and objective measures of sleep may not reflect misperception, but rather, may indicate an aspect of poor sleep quality that is not captured by actigraphy. For instance, since actigraphy detects sleep based on the presence or absence of movement, long periods of motionless wakefulness may be misidentified as sleep.

It appears, therefore, that although the use of subjective sleep measures may be instructive, the limitations of these scales must also be acknowledged. Therefore, in line with the recommendations of numerous studies (Landry et al., 2015; Rowe et al., 2008; Van Den Berg et al., 2008; Voderholzer et al., 2003), both objective and subjective measures of sleep ought to be employed to confirm the preliminary findings of this systematic review on the relationship between sleep and PSU among adolescents.

Conclusion

This systematic review indicates that there is a weak-to-moderate correlation between subjective sleep quality and PSU. However, given the recency of the phenomenon of PSU and the dearth of methodologically rigorous studies, this finding must be interpreted tentatively. Specifically, there is a need for research employing objective measures of sleep and smartphone use and experimental designs. Addressing the public health concern of adolescent sleep insufficiency is a formidable challenge because, to date, sleep promotion interventions have failed to produce lasting effects (Blunden et al., 2012; Blunden & Rigney, 2015; Cassoff et al., 2013; Gruber, 2017). Therefore, remediation of adolescent sleep insufficiency may necessitate greater consideration of the impact of PSU on sleep.

Systematic Review Two: Sleep and Mental Toughness

Search Strategy

A comprehensive search of the peer-reviewed literature was conducted during December 15th - 17th, 2020. The following databases were searched: PsychArticles, PsychInfo, Education Resources Information Centre (ERIC) and Academic Search Complete. Searches were conducted using Boolean operators as presented in Table 10. Search filters were applied in line with the exclusion criteria in Table 11.

The search process, following duplicate removal, produced 23 results. The results were then screened by title, which excluded 15 articles. Next, the abstracts of the remaining eight articles were screened, all of which met the inclusion criteria. After a full-text review, it was found that five articles met the inclusion criteria and would be included in the systematic review. The rationale for the exclusion of three studies is presented in Appendix 3. The literature search process is represented in the PRISMA chart in Figure 3, in line with Liberati et al. (2009).

Table 10

Search Terms for Systematic Review Two

	Variables	
Sleep* OR Circadian Rhythm* OR REM OR NREM	AND	Mental* tough*

Table 11

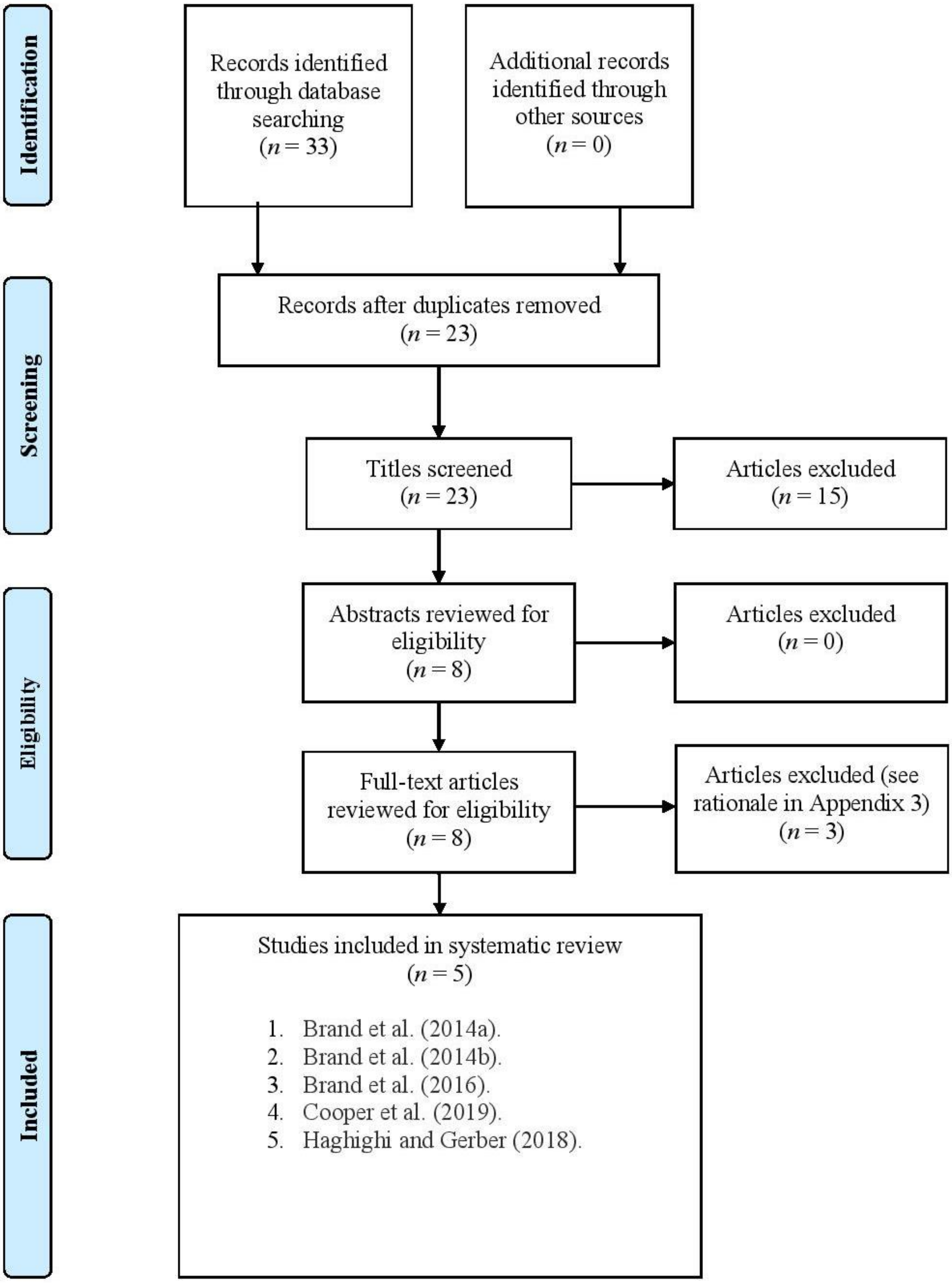
Inclusion and Exclusion Criteria for Systematic Review Two

Domain	Inclusion criteria	Exclusion criteria	Rationale
1. Publication year.	Studies published on or after 2002.	Studies published before 2002.	The construct of MT was first operationalised in 2002 (Clough et al., 2002).
2. Publication type.	Studies published in peer-reviewed academic journals.	Studies not published in peer-reviewed academic journals.	To ensure the academic rigour of the review findings.
3. Research design.	1. Experimental designs. 2. Longitudinal designs. 3. Correlational designs or between-groups designs examining differences	Studies not employing an experimental, longitudinal or correlational design.	To ensure that the relationship between sleep and MT may be explored.

	between high/low MT groups or good/poor sleep groups.		
4. Variables.	Studies with at least one variable related to sleep and one related to MT.	Studies without variables related to sleep and MT.	To ensure that the review question is addressed.
5. Target group.	All ages.	None.	Due to the predicted dearth of research on the relationship between MT and sleep, age restrictions were not applied.
6. Scope of research.	Studies which examine the relationship between sleep and MT.	Studies which do not examine the relationship between sleep and MT.	To address the review question.

Figure 3

Search Process for Systematic Review Two



Method

Mapping the Field and Review Framework

In line with the recommendations of Gough et al. (2017), the five studies identified through the literature search process are summarised in Table 12. The identified studies were evaluated using Gough's (2007) Weight of Evidence (WoE) framework. This framework examined three areas of study quality. First, the methodological quality of the studies was evaluated (WoE A: methodological quality). Second, the methodological relevance of the studies' chosen methodology was evaluated (WoE B: relevance of the methodology). Third, the findings and focus of each study were evaluated for relevance to the specific research question of this systematic review (WoE C: relevance to the research question). Finally, to obtain an overall score to assess the strengths of the research evidence, the mean of the scores for WoE A-C was calculated to produce an overall WoE score (WoE D: overall weight of evidence).

Table 12.

Summary of Identified Studies in Systematic Review Two

Authors	Country	Sample characteristics	Study design	Variables relevant to the review question	Findings relevant to the review question
1. Brand et al. (2014a).	Switzerland.	*N* = 92 (60 males; 32 females). Age: *M* = 18.9.	Cross-sectional correlational design with a between-groups component.	1. MT: German version of the Mental Toughness Questionnaire 48 (MTQ-48) (Clough et al., 2002; Gerber et al., 2012; Perry et al., 2013). 2. Sleep quality and Quantity:	Objective measures demonstrated that, relative to the low MT group, the high MT group had higher sleep efficiency ($p < .001$), more deep sleep ($p < .05$), more rapid eye movement (REM) sleep ($p < .01$), less light sleep ($p < .01$) and fewer awakenings after sleep onset ($p < .001$).

		electroencephalogram sleep recording. 3. Sleep disturbance: Insomnia Severity Index (ISI) (Bastien et al., 2001). 4. Sleepiness: Epworth Sleepiness Scale (ESS) (Johns, 1991).	Subjective data demonstrated that the high MT group had lower scores on the ISI ($p < .001$) and the ESS ($p < .001$). Significant positive correlations were detected between MT and sleep efficiency ($r = .74$, $p = .001$), deep sleep duration ($r = .34$, $p = .01$) and REM sleep duration ($r = .29$, $p = .01$). Significant negative correlations were detected between MT and number of awakenings after sleep onset ($r = -.69$, $p = .001$),

					light sleep (*r* = -.37, *p* = .001), ISI scores (*r* = -.73, *p* = .001) and ESS scores (*r* = .88, *p* = .001).
2. Brand et al. (2014b).	Switzerland.	*N* = 284 (185 females; 99 males). Age: *M* = 18.2, *SD* = 4.2.	Cross-sectional mediation moderation analysis.	1. MT: MTQ-48 (Clough et al., 2002). 2. Sleep disturbance: ISI (Bastien et al., 2001). 3. Sleep quality: Adapted PSQI (Buysse et al., 1989). 4. Sleepiness: ESS	MT was associated with fewer sleep disturbances as measured by the ISI (*r* = -.51, *p* = .001), decreased daytime sleepiness as measured by the ESS (*r* = -.36, *p* = .001), shorter sleep onset latency (*r* = -.19, *p* = .001), fewer awakenings after sleep onset (*r* = -.37, *p* = .001) and sleep quality (*r* = .37, *p* = .001). No association was noted with

	(Johns, 1991). 5. Subjective stress: Perceived stress scale (PSS) (Cohen et al., 1983). 6. Depression: Beck Depression Inventory (Beck et al., 1961).	sleep duration or evening sleepiness. Structural equation modelling indicated a direct association between MT and sleep disturbance (β = -.53, $p < .001$). Multiple regression indicated that ISI scores were predicted (R = .602, R^2 = .362) by daytime sleepiness (β = .22, $p < .01$), sleep onset latency (β = .35, $p < .001$) and awakenings after sleep onset (β = .34, $p < .01$), but not by sleep duration (β = .05).

3. Brand et al. (2016).	Switzerland.	*N* = 1475 (720 males; 755 females). Age: 11 – 16 (*M* = 13.4).	Cross-sectional correlational design with a between-groups component.	1. MT: German version of the MTQ-48 (Clough et al., 2002; Gerber et al., 2012; Perry et al., 2013). 2. Sleep disturbance: ISI (Bastien et al., 2001).	MT was associated with fewer sleep disturbances, as measured by the ISI ($r = -.25$, $p < .001$). Significant differences in ISI scores were noted between high and low MT groups ($p < .001$), with fewer sleep disturbances among the high MT group.
4. Cooper et al., (2019).	The UK.	Sub-study 1: *N* = 181 (no gender ratio details).	Sub-study 1: Cross-sectional correlational design.	Sub-studies 1 and 2: 1. Self-reported sleep duration (no use of a	Sub-study 1: Winsorized correlations were performed due to violations of the assumptions of normality. MT, as measured by the MTI,

	Age: details not available. Sub-study 2: N = 6 (5 males; 1 female). Age: 42 – 55 (*M* = 49.3 *SD* = 4.2).	Sub-study 2: N-of-1 design.	validated scale). 2. Sleep quality: Richards-Campbell Sleep Questionnaire (RCSQ) (Richards et al., 2000). 3. MT: Mental Toughness Index (MTI) (Gucciardi et al., 2015a).	was positively correlated with both sleep duration (r_w = .18 [.033, .316], p = .02) and sleep quality, as measured by the RCSQ (r_w = .41 [.270, .541], p = .001). Robust regression analysis revealed that sleep quality was predictive of MTI scores (β = .177, [.117, 0,238], p = .001), but sleep duration was not (β = .45, [-.33, 1.22], p = .26). Sub-study 2:

					Time in bed extension (9 hours) and restriction (5 hours) was related to MT in 4 of 6 participants. The authors concluded that the effect was less pronounced than predicted. Time in bed was not related to sleep quality as measured by the RCSQ.
5. Haghighi and Gerber (2018).	Iran.	*N* = 207 (106 males; 101 females).	Cross-sectional moderation design.	1. MT: MTQ-48 (Clough et al., 2002; Perry et al., 2013).	Scores on the MTQ-48 and the ISI were negatively correlated (r = -.40, p = .001).
		Age: *M* = 22.0, *SD* = 2.8.		2. Sleep disturbance: ISI (Bastien et al.,	Regression analyses suggested that MT is a significant predictor of sleep disturbances,

		2001).	as measured by the ISI (β = -.16, $p < .05$).
		3. Subjective stress: PSS (Cohen et al., 1983).	MT did not moderate the relationship between scores on the PSS and ISI.

WoE A: Methodological Quality

Risk of bias was assessed with quality checklists. As identified by numerous authors, there is an absence of validated quality appraisal tools specifically designed to evaluate cross-sectional correlational studies (Faragher et al., 2005; Hoffmann et al., 2017; Protogerou & Hagger, 2018). In light of this absence, WoE A (methodological quality) was evaluated with a checklist adapted from the National Heart, Lung and Blood Institute's Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (items 1-7) (National Institutes of Health, 2014) and Thompson et al.'s (2005) recommendations regarding the quality appraisal of correlational research (items 8-10). Summed points from the checklist indicated the overall methodological quality of the study, with 0 points indicating that none of the quality criteria had been met, and 10 points indicating that all criteria had been met. High-quality studies (≥ 8 points) were assigned a WoE score of 3, acceptable quality studies (4-7 points) a WoE score of 2 and low-quality studies (≤ 3 points) a WoE score of 1. The N-of-1 sub-study of Cooper et al. (2019) was evaluated using the CONSORT statement for the reporting of N-of-1 designs (Vohra et al., 2015). This checklist was chosen because journal endorsement of CONSORT guidelines has been found to be associated with more rigorous scientific reporting (Turner et al., 2012). However, no guidelines were available for converting data from this checklist to WoE A scores. Therefore, in line with the cross-sectional checklist used in this review, high-quality studies (≥ 80% of criteria met) were assigned a WoE score of 3, acceptable quality studies (40-70% of criteria met) a WoE score of 2 and low-quality studies (≤ 30% of criteria met) a WoE score of 1. Scores for each quality assessment checklist and the corresponding WoE A score are presented in Table 13. The completed quality assessment checklist for each study is available in Appendix 4.

Table 13.

WoE A Scores for Systematic Review Two

	Study	Quality Assessment Score	WoE A Score (1 – 3)
1	Brand et al. (2014a).	8	3 (high)
2	Brand et al. (2014b).	9	3 (high)
3	Brand et al. (2016).	9	3 (high)
4	Cooper et al. (2019), Sub-study 1.	7	2 (acceptable)
	Cooper et al. (2019), Sub-study 2.	89.2%	3 (high)
5	Haghighi and Gerber (2018).	9	3 (high)

Note. Mean quality score (standard deviation) = 8.4 (.75).

WoE B: Methodological Relevance

This review sought to establish the relationship between sleep and MT. Therefore, to answer the review question, evidence gleaned from certain study designs were more heavily weighted than others, in line with the hierarchy of evidence (Brannen, 2017). Specifically, experimental designs, in which causal relationships may be established, were more heavily weighted than cross-sectional correlational designs. The criteria used to determine the methodological relevance to the research question are presented in Table 14. The WoE B score for each study may be found in Table 15.

Table 14.

WoE B Criteria and Rationale for Systematic Review Two

Quality	Criteria	WoE B score	Rationale
High	Systematic reviews, meta-analyses, randomised controlled trials or controlled experimental designs.	3	Informed by Brannen (2017).
Acceptable	Uncontrolled experimental designs, quasi-experimental designs, cohort studies, case-control studies or N-of-1 studies.	2	
Low	Qualitative studies, cross-sectional surveys or case reports.	1	

Table 15

WoE B Scores for Systematic Review Two

Authors	WoE B Score
1. Brand et al. (2014a).	1
2. Brand et al. (2014b).	1
3. Brand et al. (2016).	1
4. Cooper et al. (2019), Sub-study 1.	1
Cooper et al. (2019), Sub-study 2.	2
5. Haghighi and Gerber (2018).	1

WoE C: Relevance to the Research Question

Two criteria contributed to the WoE C scores in this systematic review. First, criterion one evaluated the proportion of participants who fell within the age range of interest to this review, 14 - 24 years (inclusive). The rationale for this criterion was to maximise the generalisability of the findings to those within this age range because, as outlined in the introduction, adolescent sleep is unique relative to other age groups (Campbell & Feinberg, 2009; Carskadon et al., 1993; Crowley et al., 2014; Jenni & Carskadon, 2007; Hirshkowitz et al., 2015). Therefore, criterion one of WoE C weighted studies as detailed in Table 16. Second, criterion two considered the use of objective sleep measures. Inclusion of this criterion was deemed important due to the questionable validity of subjective measures of sleep (Baker et al., 1999; Lauderdale et al., 2008; Regestein et al., 2004) and the recommendation of numerous studies to employ both objective and subjective measures (Landry et al., 2015; Rowe et al., 2008; Van Den Berg et al., 2008; Voderholzer et al., 2003). The WoE C scores for each study are presented in Table 17.

Table 16.

WoE C Criteria and Rationale for Systematic Review Two

Criteria	Weighting		Rationale
1. Proportion of participants between the ages of 14 and 24 (inclusive).	3 (high)	All participants between the ages of 14 and 24 (inclusive).	Adolescent sleep is unique relative to other age groups (Campbell & Feinberg, 2009; Carskadon et al., 1993; Crowley et al., 2014; Jenni & Carskadon, 2007; Hirshkowitz et al., 2015).
	2 (acceptable)	More than 50% of participants between the ages of 14 and 24 (inclusive).	
	1 (low)	Fewer than 50% of participants between the ages of 14 and 24 (inclusive).	
2. Variables for sleep.	3 (high)	Both objective and subjective measures of sleep.	Subjective measures of sleep have questionable validity (Baker et al., 1999; Lauderdale et al.,
	2 (acceptable)	Objective measures of sleep only.	

	1 (low)	Subjective measures of sleep only.	2008; Regestein et al., 2004). Moreover, the inclusion of both objective and subjective measures has been recommended by a number of studies (Landry et al., 2015; Rowe et al., 2008; Van Den Berg et al., 2008; Voderholzer et al., 2003).

Table 17.

WoE C Scores for Systematic Review Two

Authors	WoE C Scores		
	WoE C Criterion 1	WoE C Criterion 2	WoE C Mean Scores
1. Brand et al. (2014a).	3	3	3
2. Brand et al. (2014b).	3	1	2
3. Brand et al. (2016).	2	1	1.5
4. Cooper et al. (2019), Sub-study 1.	1	1	1
Cooper et al. (2019), Sub-study 2.	1	1	1
5. Haghighi and Gerber (2018).	3	1	2

WoE D: Overall Weight of Evidence

For each study, the mean score of WoE A-C was calculated to produce WoE D, the overall study weighting. The WoE D scores for each study are presented in Table 18. Overall, the weight of evidence was moderate. One study (Cooper et al., 2019, sub-study 1) obtained a low WoE D score of 1.3. The results from this study, therefore, should be interpreted cautiously. All other studies in this systematic review obtained moderate WoE D scores, ranging from 1.8 to 2.3.

Table 18.

WoE Summary Table for Systematic Review Two

Authors	Quality of Methodology (WoE A)	Relevance of the Methodology (WoE B)	Relevance for the Research Question (WoE C)	Overall Weighting (WoE D)
1. Brand et al. (2014a).	3	1	3	2.3
2. Brand et al. (2014b).	3	1	2	2
3. Brand et al. (2016).	3	1	1.5	1.8
4. Cooper et al. (2019), Sub-study 1.	2	1	1	1.3
Cooper et al. (2019), Sub-study 2.	3	2	1	2
5. Haghighi and Gerber (2018).	3	1	2	2

Results

Participants

This systematic review of the relationship between sleep and MT included data from 2245 participants across five publications. The range in sample sizes reflected the variety of methodologies employed. For instance, Brand et al. (2016) employed a cross-sectional correlational design and had the largest sample size (*N* = 1447). However, comparatively smaller sample sizes were used by Brand et al. (2014a), who employed objective measures of sleep (*N* = 92), and Cooper et al. (2019), who employed an N-of-1 design (*N* = 6). The gender ratio of the total sample was approximately equal (54% females), although the participant gender statistics were not reported in a sub-study of Cooper et al.

Due to the dearth of research on the relationship between sleep and MT, studies which gathered data from participants outside of the age range of interest to this study, 14 – 24 years (inclusive), were not excluded. However, the proportion of participants falling within this age range was considered in criterion one of WoE C. Accordingly, sub-study one of Cooper et al. received a low score for this criterion, as participant age statistics were not available. Similarly, since all six participants of the N-of-1 sub-study fell outside of the 14-24 years (inclusive) age range in Cooper et al., a low score was assigned for criterion one of WoE C. Contrastingly, three studies received a high score on criterion one of WoE C as all participants fell within the target age range (Brand et al., 2014a; Brand et al., 2014b; Haghighi & Gerber, 2018).

Research Design

All five studies employed a cross-sectional correlational design (Brand et al., 2014a; Brand et al., 2014b; Brand et al., 2016; Cooper et al., 2019; Haghighi & Gerber,

2018) and a sub-study of Cooper et al. employed an N-of-1 design. All studies computed correlational coefficients and three studies also included a between-groups component in which high and low MT groups were compared on measures of sleep (Brand et al., 2014a; Brand et al., 2016; Cooper et al., 2019). Mediation-moderation analysis was conducted by two studies (Brand et al., 2014b; Haghighi & Gerber, 2018). Unlike correlational research, N-of-1 designs have the potential to reveal causal relationships between variables (Edgington & Onghena, 2011). However, since such designs employ small sample sizes, N-of-1 studies have limited generalisability. Therefore, Cooper et al. was assigned a WoE B score of 2, whereas the remaining studies, which employed correlational designs, were assigned a score of 1.

As mentioned previously, adolescent sleep is markedly different compared to other age groups. Therefore, it is considered important to control for age as a potential confounding factor. However, two studies did not control for this variable (Brand et al., 2014a; Cooper et al. 2019). This limitation was, therefore, considered in the WoE A scores for these studies.

Measures

A variety of self-report measures were used to assess sleep. Specifically, sleep quality was assessed using the PSQI (Buysse et al., 1989) or the Richards-Campbell Sleep Questionnaire (Richards et al., 2000), sleep disturbance was assessed with the Insomnia Severity Index (Bastien et al., 2001) and sleepiness was assessed using the Epworth Sleepiness Scale (Johns, 1991). Two studies employed multiple measures of subjective sleep (Brand et al., 2014a; Brand et al., 2014b). The use of multiple measures of a construct is desirable as it improves internal validity and generalisability, and reduces method bias (Lerner et al., 2015). Just one study employed both objective and subjective measures. Brand et al. (2014a) employed electroencephalography to objectively measure sleep duration, sleep efficiency, sleep onset latency, slow-wave sleep, rapid eye movement sleep and number of awakenings after sleep onset.

With regard to MT, all but one study (Cooper et al., 2019) employed the MTQ-48, a psychometrically validated multi-dimensional measure of MT (Perry et al., 2013). Cooper et al., on the other hand, employed the Mental Toughness Index (Gucciardi et al., 2015a) which conceptualises MT as a unidimensional construct.

Findings

WoE D, which refers to the overall weight of evidence to address the research question, is presented in Table 18. All studies in this systematic review support the hypothesis that MT is associated with sleep. Overall, there was a moderate weight of evidence for a relationship between MT and sleep. There was a large discrepancy in the effect sizes among studies which explored the relationship between sleep disturbance, as measured by the ISI. For instance, the strongest correlation was detected by Brand et al. (2014a) (r = -.73, p = .001), whereas a weak correlation was detected by Brand et al. (2016) (r = -.25, p < .001). Brand et al. (2014a) has a greater weight of evidence due to a higher WoE D score of 2.3. A similar discrepancy was observed with scores on the ESS and the MTQ-48. Brand et al. (2014b) found a weak correlation (r = -.36, p = .001), but a strong correlation (r = -.88, p = .001) was detected by Brand et al. (2014a). Contrastingly, studies which investigated the relationship between sleep quality and MT produced more consistent findings. Cooper et al. (2019), using the RCSQ and MTI, found a moderate correlation (r_w = .41, p = .001) and Brand et al. (2014b) found a similar strength of relationship using the PSQI and the MTQ-48 (r = .37, p = .001). However, Cooper et al.'s study should be interpreted with caution due to a low WoE D score (1.3).

With regard to between-subjects comparisons, all studies which compared high and low MT groups found highly significant differences ($p < .001$) in sleepiness, as measured by the ESS, and in sleep disturbances, as measured by the ISS (Brand et al., 2014a; Brand et al., 2016). These between-subjects findings were bolstered by Brand et al. (2014a) who used objective measures to demonstrate that, relative to their low MT counterparts, high MT participants had higher sleep efficiency ($p < .001$), more deep sleep ($p < .05$), more REM sleep ($p < .01$), less light sleep ($p < .01$) and fewer awakenings after sleep onset ($p < .001$). All studies which examined between subjects comparisons had a moderate (1.8 – 2.3) WoE D score.

There were two other important findings of the systematic review. First, just one study attempted to establish causation, and the results were equivocal. Cooper et al. (2019) found that time in bed extension (nine hours) and restriction (five hours) was related to MT in just four of six participants. The authors concluded that the effect was less pronounced than hypothesised. It must also be noted that the overall weight of evidence for this study was low (1.3). Second, although there was strong evidence that MT is associated with sleep quality, sleepiness and sleep disturbance, REM sleep duration and deep sleep duration, the relationship between total sleep duration and MT is less conclusive. For instance, although a weak negative correlation ($r_w = .18$, $p = .02$) was detected by Cooper et al., Brand et al. (2014) did not find statistically significant differences between objectively measured total sleep duration among high and low MT groups ($p > .05$). Similarly, no associations were noted between sleep duration and MT in Brand et al. (2014b). Moreover, regression analysis by Cooper et al. revealed that sleep quality was predictive of MTI scores ($\beta = .177$, [.117, 0,238], $p = .001$), but sleep duration was not ($\beta = .450$, [-.3254, 1.22], $p = .26$).

Discussion

This systematic review provides support for the hypothesis that there is a positive correlation between MT and sleep quality. Overall, there was a moderate weight of evidence (WoE D 1.3 – 2.3). What remains inconclusive, however, is whether sleep plays a causal role in MT, as is the case with constructs such as depression (Lovato et al., 2014) and anxiety (Taylor & Pruiksma, 2014). Alternatively, as hypothesised by Brand et al. (2016), MT may cause improved sleep via reduced stress, reduced emotional arousal and reduced dysfunctional thinking. A bidirectional causal relationship between sleep and MT is also plausible. Establishing the direction of causality has important implications for interventions which aim to improve sleep or MT. Unfortunately, the methodological limitations and inconclusive findings of the only experimental design in this review (Cooper et al., 2019) failed to disentangle cause and effect. Moreover, this experimental study was conducted with adults (M = 49.3 SD = 4.18) rather than adolescents. Several authors have proposed that interventions to improve sleep may boost MT, or vice versa (Brand et al., 2014a; Brand et al., 2014b; Brand et al., 2017; Cooper et al., 2019). Although, based on this systematic review, the effectiveness of such a sleep promotion intervention is certainly plausible, an expansion of the limited research body on the topic of sleep and MT is required to confirm this assertion. Specifically, as will be detailed below, there is a need for experimental designs and increased use of objective sleep measures. Addressing these limitations may clarify the strength or the relationship between sleep and MT and the direction of causality.

Overcoming Measurement Bias and Financial Constraints

The limitations of subjective sleep scales have already been discussed in detail in this thesis[5]. Hence, in line with the recommendations of numerous studies (Landry et al., 2015; Rowe et al., 2008; Van Den Berg et al., 2008; Voderholzer et al., 2003), both objective and subjective measures of sleep ought to be employed to confirm the preliminary findings of the current research body on the relationship between sleep and MT. However, given the impracticality of large-scale employment of polysomnography and the prohibitive cost of both actigraphy and polysomnography (Martin & Hakim, 2011), alternative approaches are needed.

A growing number of validation studies have supported the use of affordable, commercially available sleep tracking devices (de Zambotti et al., 2018; Degroote et al., 2020; Dickinson et al., 2016; El-Amrawy & Nounou, 2015; Lerner et al., 2018; Lee et al., 2017; Liang & Martell, 2018; Montgomery-Downs, 2012; Pesonen & Kuula, 2018; Tedesco et al., 2019). These devices do not yet appear to validly assess sleep staging (Liang & Martell, 2018). However, they have comparable validity to polysomnography and actigraphy on other sleep parameters including sleep duration, time in bed, frequency of awakenings and sleep consistency. Moreover, these devices are particularly suitable to evaluate the sign of an intervention effect (Dickinson et al, 2016). Therefore, given the questionable validity of subjective sleep measures (Landry et al., 2015; Rowe et al., 2008; Van Den Berg et al., 2008; Voderholzer et al., 2003), it is recommended that these devices be employed to overcome the financial constraints and measurement bias of previous studies on the relationship between sleep and MT.

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[5] The limitations of subjective sleep scales are discussed in Chapter Two: Literature Review, page 67.

Establishing Causation

As detailed above, the current research body on the relationship between sleep and MT has not yet established the direction of causation. Although one study used an experimental design with sleep extension and restriction to attempt to establish causation (Cooper et al., 2019), the results were inconclusive. Moreover, sleep restriction is in direct contravention of Section 3.04 of the American Psychological Association’s (2016) Code of Ethics which prescribes that psychologists must “…take reasonable steps to avoid harming…research participants…” (p. 6). In light of the enormous body of evidence demonstrating the deleterious effects of sleep restriction outlined in the introduction of this literature review, employing sleep restriction is not a tenable line of inquiry. Alternatively, experimental sleep extension designs with short sleepers or sleep promotion interventions may help to disentangle cause and effect and bring significant health benefits to participants.

As outlined in the introduction, adolescents are disproportionately affected by sleep insufficiency. In support of this, analysis by the Centres for Disease Control (CDC) (Wheaton et al., 2018) indicates that fewer than 28% of high school students obtain the sleep duration recommended by the National Sleep Foundation (Hirshkowitz et al., 2015). Adolescent sleep insufficiency appears to have been compounded by early school start times (Paksarian et al., 2015). For instance, according to the CDC, fewer than 18% of public middle and high schools have observed the recommendation of the American Academy of Pediatrics (2014) to start school no earlier than 8:30 a.m. (Wheaton et al., 2015). Adolescent sleep insufficiency, therefore, is a major public health concern which warrants urgent action.

To date, school-based sleep promotion interventions, with some notable exceptions (Barber & Cucalon, 2017; Brown et al., 2006; Sousa et al., 2013), have shown limited effectiveness (Sheldon, 2015). However, several systematic reviews of school-based sleep promotion interventions indicated that the limited effectiveness may largely be attributed to the methodological limitations and poor theoretical underpinnings of prior studies (Blunden & Rigney, 2015; Blunden et al., 2012; Cassoff et al., 2013; Gruber, 2017). These reviews emphasised the importance of progressing research efforts in this field and have provided valuable recommendations on how to proceed. It may be fruitful, therefore, to determine whether a methodologically rigorous school-based sleep promotion intervention could improve not only parameters of sleep, but also MT. Such an approach would be an ethical way to begin to disentangle cause and effect in the relationship between sleep and MT.

Conclusion

This systematic review found evidence of a weak-to-moderate relationship between sleep and MT, such that greater sleep quality is associated with higher MT. The strength of the association varied according to the measures employed. At present, there is insufficient evidence to support a relationship between sleep duration and mental toughness. However, the findings of this systematic review must be considered tentative until more methodologically rigorous studies are available. Therefore, two main recommendations are offered. First, to date, just one study examining the relationship between sleep and MT has employed objective sleep measures. Given the financial constraints of polysomnography and actigraphy, it is proposed that commercially available sleep tracking devices be employed to confirm the preliminary findings of this systematic review. Second, the correlational evidence on the relationship between sleep and MT should be bolstered with studies using experimental designs. It is proposed that this may be facilitated by the evaluation of the effectiveness of a school-based sleep promotion intervention.

Literature Review: Conclusions and Emerging Research Questions

Systematic Review One, which explored the relationship between sleep and PSU, concluded that there is a weak-to-moderate relationship between these factors. It was cautioned, however, that further research is needed to confirm these preliminary findings. Specifically, the use of objective measures of PSU and sleep are needed along with experimental research designs. Nonetheless, the review indicates that there is sufficient evidence to warrant consideration of PSU in sleep promotion interventions. This is an important conclusion because, to date, the majority of school-based sleep promotion efforts have neglected the impact of PSU on sleep (Barber & Cucalon, 2017; Gruber et al., 2017).

Systematic Review Two examined the relationship between sleep and MT. It was concluded that there is a weak-to-moderate correlation between sleep quality and MT. Again, this finding should be interpreted with caution due to the dearth of studies employing objective measures of sleep and the limited use of experimental studies. Regarding the shortage of experimental evidence supporting the link between sleep and MT, it is proposed that this literature gap may be addressed by evaluating the effectiveness of a school-based sleep promotion intervention. Specifically, a fruitful line of inquiry would be to determine whether such a sleep promotion initiative could improve not only sleep quality and duration, but also boost MT. Such an evaluation may begin to disentangle the direction of causality in the relationship between sleep and MT.

Based on the findings of this systematic literature review, it is possible that a school-based sleep promotion intervention which considers the impact of PSU may improve sleep parameters and boost MT. Given the prevalence and consequences of adolescent sleep insufficiency, as well as the limited effectiveness of school-based sleep promotion efforts to date, there is urgency for such an intervention. Emerging research questions and hypotheses are presented in Table 19.

Table 19

Emerging Research Questions and Hypotheses

Research Questions		Hypotheses
Can a school-based sleep promotion intervention (SBSPI), which considers problematic smartphone use, improve objectively and subjectively measured sleep parameters?	Null	The SBSPI will not improve sleep quality, lengthen objectively measured sleep duration or improve sleep hygiene in the intervention group, compared to the control group.
	Alternate	The SBSPI will improve sleep quality, lengthen objectively measured sleep duration or improve sleep hygiene in the intervention group, compared to the control group.
Can the SBSPI reduce objectively and subjectively measured problematic smartphone use?	Null	The SBSPI will not reduce subjective or objective smartphone use in the intervention group, compared to the control group.
	Alternate	The SBSPI will reduce subjective or objective smartphone use in the intervention group, compared to the control group.
Can the intervention increase mental toughness?	Null	The SBSPI will not increase mental toughness in the intervention group, compared to the control group.
	Alternate	The SBSPI will increase mental toughness in the intervention group, compared to the control group.

Chapter Three: Empirical Paper

Introduction

Sleep: a Health Imperative

Sleep has been described by the American Academy of Sleep Medicine as a "health imperative" (Luyster et al., 2012, p. 1). This assertion is supported by meta-analytic research demonstrating the deleterious impact of sleep insufficiency on a range of domains including cognition (Hayes & Bainton, 2020; Leong et al., 2019; Lim & Dinges, 2010; Olaithe & Bucks, 2013; Wardle-Pinkston et al., 2019), mental health (Baglioni et al., 2016; Malik et al., 2014) body weight (Cappuccio et al., 2008; Li et al., 2017), cardiovascular function (Sofi et al., 2014; Yin et al., 2017), blood pressure (Meng et al., 2013; Wang et al., 2012), blood glucose levels (Cappuccio et al., 2010a; Shan et al., 2015) and all-cause mortality (Cappuccio et al., 2010b; Gallicchio & Kalesan, 2009).

Most studies that have examined the impact of sleep on health indicators among adults report a U-shaped association, whereby both short and long sleep duration are associated with health risks. It should be noted, however, that the claim that long sleep duration may be associated with health risks is based on epidemiological data with omitted confounding variables (Bliwise & Young, 2007; Knutson & Turek, 2006). In support of this, experimental research has failed to demonstrate a causal link between long sleep duration and ill-health (Knutson & Turek, 2006). Data with children and adolescents, in contrast to that of adults, show a linear relationship in which longer sleep duration is associated with better outcomes (Chaput, 2016). Given the strong evidence demonstrating the adverse effects of sleep insufficiency on health and wellbeing, it is concerning that, among adolescents, sleep quality and duration have been in decline over the past few decades (Twenge et al., 2017).

Declines in Adolescent Sleep Quality and Duration

Research on trends in adult sleep duration has shown contradictory results. Some studies suggest that sleep duration has decreased over time (Ford et al., 2015; Jean-Louis et al., 2014; National Center for Health Statistics, 2005), but systematic research has indicated either an increase over time (Bin et al., 2012) or mixed results (Bin et al., 2013; Hoyos et al., 2015; Youngstedt et al., 2016). Contrastingly, meta-analytic research on trends in child and adolescent sleep is more conclusive, finding a consistent decline in sleep duration between 1905 and 2008 (Matricciani et al., 2012). This meta-analysis found that the rate of decline was sharpest among adolescents, a finding which has been replicated by later studies (Jiang et al., 2015; Keyes et al., 2015; Kronholm et al., 2015; Matricciani et al., 2017). Moreover, data indicate that this decline in adolescent sleep duration has continued beyond 2008. In support of this, a large-scale (N = 369,595) study concluded that the number of adolescents reporting a sleep duration of less than seven hours per night increased by 16% between 2009 and 2015 (Twenge et al., 2017). Data on adolescents' susceptibility to sleep insufficiency may explain this consistent decline in sleep duration.

Adolescents' Susceptibility to Sleep Insufficiency

Meta-analytic research has confirmed that adolescents are more susceptible to sleep insufficiency compared to the general population (Jiang et al., 2015). Developmental changes contribute to this susceptibility. Compared to other age groups, adolescents have a slower accumulation of homeostatic sleep drive (Jenni & Carskadon, 2007) and delayed circadian timing (Carskadon et al., 1993; Hagenauer et al., 2009). These biological changes result in delayed sleep onset compared to other age groups. However, the natural sleep cycle is then often pre-maturely terminated due to socio-cultural factors, mainly school attendance (Phillips et al., 2017). Other potential contributors to adolescent sleep insufficiency include poor sleep hygiene (Bartel et al., 2015; Gellis et al., 2014), homework burden (Li et al., 2014; Sun et al., 2014), academic stress (Waqas et al., 2015; Yan et al., 2018), increased independence from parent-imposed sleep schedules (Carskadon, 2011; Pyper et al., 2017) and problematic smartphone use (PSU) (Mac Cárthaigh et al., 2020). These factors have resulted in a high prevalence of sleep insufficiency among adolescents.

The Centres for Disease Control found that fewer than 28% of American high school students meet the sleep duration recommendations of the National Sleep Foundation and the American Academy of Sleep Medicine (8-10 hours for adolescents aged 14-17 years) (Hirshkowitz et al., 2015; Paruthi et al., 2016; Wheaton et al., 2018). Although little research using validated measures is available in the Irish context[6], international studies also indicate widespread sleep insufficiency among school-age children (Gariepy, et al., 2020). Similarly, a study of university students across 26 countries found that 39% slept less than six hours per night (Peltzer & Pengpid, 2016). This mounting evidence for a high prevalence of adolescent sleep insufficiency, however, has done little to shape national policy in the UK or Ireland.

National Policy on Sleep

Sleep insufficiency and its consequences have not been acknowledged in policy documents in Ireland. Several Irish governmental policy documents have outlined strategies to improve youth wellbeing. These include A Framework for Improved Health and Wellbeing 2013-2025 (Department of Health, 2013), the National Youth Strategy 2015-2020 (Department of Children and Youth Affairs [DCYA], 2015), the

[6] In 2014, a questionnaire circulated by Crosscare's East Wicklow Youth Service and the School Completion Programme found that 38% of young people experience sleep onset difficulties (Comerford et al., 2018). This finding, however, should be interpreted cautiously as validated scales were not used and the study has not been peer reviewed.

Value for Money and Policy Review of Youth Programmes (DCYA, 2014a), State of the Nation's Children (DCYA, 2012), Better Outcomes Brighter Futures (DCYA, 2014b), Wellbeing Policy Statement and Framework for Practice (Department of Education and Skills [DES], 2018a) and Delivering Equality of Opportunity in Schools Plan 2017 (DES, 2017). These policy documents help to establish how children can be supported to thrive physically, socially and emotionally. However, each document neglects to refer to the crucial role of sleep.

Despite the absence of guidance in national policy documents, The Health Service Executive in Ireland recently launched The Sleep Programme, a five-week sleep education intervention developed to improve sleep hygiene among children and adolescents (Comerford et al., 2018). A review of the effectiveness of the Sleep Programme, however, did not show statistically significant improvements in sleep quality, sleep duration or sleep hygiene (McGrath, 2018). Effective sleep promotion interventions, therefore, are needed in the Irish context.

Sleep is also absent in national policy documents in the UK. The Royal Society for Public Health (2016) has urged the UK government to introduce measures including the implementation of a national sleep strategy, sleep hygiene content within school curricula and further research on school start times. This appeal has recently been echoed by two voluntary bodies, The Sleep Council and The Sleep Charity (2020). These bodies have argued that the inclusion of sleep in national policy is required, firstly, to increase awareness of the consequences of sleep insufficiency and, secondly, to deliver sleep support at an early stage to avoid the development of sleep disorders. A Department of Health and Social Care (2019) green paper reported that a UK government subcommittee would review the evidence to inform national guidelines on sleep hygiene and sleep duration for different demographics. To date, however, there remains no national sleep strategy in the UK. Keeping sleep off the national policy agenda may have adverse effects.

Adverse Effects of the Absence of Sleep in National Policy

Considering both the Irish and UK contexts, three possible consequences of the continued neglect of sleep at the national policy level will be detailed. First, in addition to the evidence already presented for sleep as a health imperative, there is also strong evidence that sleep is associated with academic performance (Curcio, et al., 2006; Gomes et al., 2011; Kronholm et al., 2015; Okano, 2019; Phillips et al., 2017; Sun et al., 2019; Urrila et al., 2017). Therefore, the absence of national policy to address sleep insufficiency may undermine the Irish and UK governments' policy of improving students' wellbeing and academic performance (Department for Education, 2015, 2018; DES, 2018a, 2018b). Second, the continued neglect of sleep insufficiency in governmental policy may disproportionally affect those from disadvantaged backgrounds. In support of this, it is a well-replicated finding that socio-economic status is correlated with sleep duration (Chen et al., 2018; Ryu et al., 2011; Tomfohr-Madsen et al., 2020) and sleep quality (Arber et al., 2009; Felden et al., 2015; Patel et al., 2010). Similarly, socio-economic health disparities are evident in the conditions which arise from chronic sleep insufficiency including cardiovascular disease (Davis et al, 2007), mental health difficulties (Aneshensel, 2009), obesity (Frederick et al., 2014) and diabetes (Agardh et al., 2011). Eliminating or reducing these health disparities, therefore, will require remediation of sleep health disparities, as recommended by the National Heart, Lung and Blood Institute (Laposky et al., 2016) and the National Institutes of Health (Jean-Louis & Grandner, 2016). However, without addressing the importance of sleep in national policy, it is difficult to envisage the large-scale implementation of sleep promotion interventions at the community or population levels. Finally, addressing the importance of sleep in national policy documents may begin to address the economic consequences of sleep insufficiency. In the UK, for instance, sleep insufficiency is estimated to cost 1.7% - 2.4% of gross domestic product through health and social care costs, accidents and reduced productivity (Colten & Altevogt, 2006; Hafner et al., 2017). At present, data on the economic consequences of sleep insufficiency are not available within the Irish context.

Addressing Adolescent Sleep Insufficiency

To date, two main approaches have been employed in an attempt to alleviate adolescent sleep insufficiency on a large scale: first, school-based sleep promotion interventions and, second, the adjustment of school start times. Meta-analytic research has found that later school start times are associated with longer sleep duration, less daytime sleepiness and less tardiness among adolescents (Bowers & Moyer 2017). Increasingly, these associations are being recognised by policymakers in the US and the UK, prompting several school systems to delay school start times. For instance, an urban public school in the UK delayed the start time from 8:50 a.m. to 10:00 a.m. (Illingworth et al., 2019). In the US, most schools that changed school start times delayed them by approximately one hour, to start at approximately 9:00 a.m. (Kelley et al., 2017). To date, there have been promising preliminary results. For instance, systematic reviews of longitudinal (Wheaton et al., 2016) and experimental studies (Minges & Redeker, 2016) have concluded that delaying school start times increases sleep duration, reduces daytime sleepiness and improves grades. Moreover, evidence also suggests that even a modest fifteen-minute delay can cause a significant increase in sleep duration (Chan et al., 2017). Effects are also evident in cultural contexts in which sleep is frequently curtailed in pursuit of academic achievement (Kim, 2020; Lo et al., 2018; Yang & Choi, 2020). However, despite these positive initial findings, the most recent systematic review of the effectiveness of later school start times has cautioned that most studies conducted to date had a high risk of bias due to methodological shortcomings (Marx et al., 2017). Therefore, more methodologically rigorous studies are needed to confirm the effectiveness of later school start times. At present, research on later school start times is unavailable in the Irish context.

The second attempted approach to address adolescent sleep insufficiency on a large scale is school-based sleep promotion interventions (SBSPIs). SBSPIs may be grouped into two broad categories: first, those which seek to impart sleep-related knowledge and, second, those which complement knowledge synthesis with cognitive and behavioural strategies to promote behavioural change (Cassoff, et al., 2013). To date, however, SBSPIs have shown limited success. For instance, three systematic reviews of the effectiveness of SBSPIs found that the interventions showed no improvement in sleep quality, sleep duration or sleep hygiene at a follow-up assessment (Blunden et al., 2012; Chung et al., 2017; Dietrich et al., 2016). It remains unclear, however, whether the lack of an effect may be attributed to the design of the interventions, methodological shortcomings of the evaluation studies, the resistance of sleeping habits to change by SBSPIs, or a combination of these factors. However, several systematic (Blunden et al., 2012; Chung et al., 2017; Dietrich et al., 2016) and critical reviews (Blunden et al., 2016; Blunden & Rigney, 2015; Cassoff et al., 2013; Gruber, 2017; Sheldon, 2015) have highlighted the limitations of SBSPIs to date and have provided directions for future research efforts.

School-Based Sleep Promotion: Limitations of Efforts to Date

Systematic research has identified six main limitations of SBSPIs conducted to date (Blunden et al., 2012; Chung et al., 2017; Dietrich et al., 2016). First, the majority of SBSPIs have omitted a control group (Blunden & Rigney, 2015). This omission is problematic because research has demonstrated the seasonality of sleep duration (Suzuki et al., 2019) and sleep quality (Hashizaki et al, 2018). Uncontrolled studies, therefore, may fail to distinguish between genuine improvements in sleep parameters due to the intervention and artefacts of seasonal fluctuations in sleep. Second, the majority of SBSPIs have employed didactic methods of intervention delivery (Blunden & Rigney, 2015). This mode of content delivery, however, does not align with meta-analytic research demonstrating that non-interactive, lecture-oriented school-based drug prevention programmes are less effective than interactive content delivery approaches (Tobler et al., 1999; Tobler & Stratton, 1997). Moreover, exit surveys from previous SBSPIs indicated that participants favour a more interactive form of content delivery (Blunden et al., 2012; Kira et al., 2014; Moseley & Gradisar, 2009). Third, few SBSPIs have employed objective measures of sleep parameters (Blunden & Rigney, 2015), despite the questionable validity of self-report measures (Baker et al., 1999; Lauderdale et al., 2008; Van Den Berg et al., 2008). Moreover, the majority of SBSPIs have used self-report measures that have not been psychometrically validated (Blunden et al., 2012). Fourth, few studies have involved parent(s) and/or guardian(s) in SBSPIs (Chung et al., 2017). Bronfenbrenner’s (1992) ecological systems theory posits that lasting behavioural change is unlikely to occur without the inclusion of the family unit (the micro- and meso-systems). The empirical literature adds support to this claim. For instance, several meta-analyses have demonstrated that family involvement improves the effectiveness of behavioural change interventions (McLean et al., 2003; Niemeier et al., 2012). Fifth, few studies have examined intervention effects at a follow-up assessment (Chung et al., 2017). As a result, robust intervention effects have rarely been demonstrated. Sixth, most SBSPIs have not embedded the interventions within a theoretical framework of behavioural change (Blunden et al., 2016; Gruber, 2017; Mead

& Irish, 2020). This is an important omission because, according to meta-analyses of health promotion interventions, the use of a theoretical framework is associated with larger intervention effect sizes (Glanz & Bishop, 2010; Webb et al., 2010).

The Theory of Planned Behaviour as a Framework for Sleep Promotion

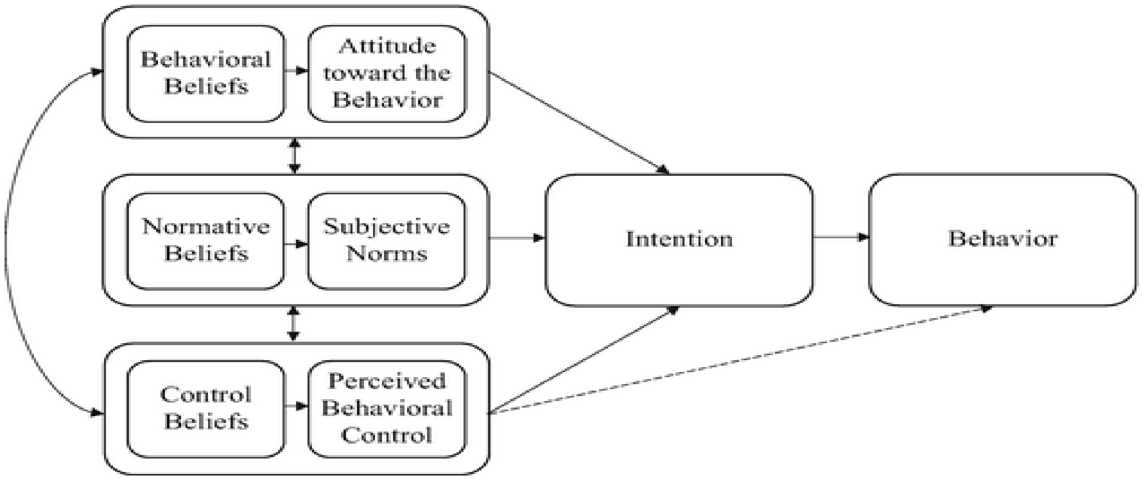
To expand on the sixth limitation outlined above, the need to employ behavioural change theory, the Theory of Planned Behaviour (TPB) (Ajzen, 1985) (Figure 4) appears to be an appropriate theoretical framework for SBSPIs. Although the TPB is among the most widely used conceptual frameworks in the behavioural sciences (Glanz & Bishop, 2010), the model has not previously been applied to the development of a SBSPI.

The TPB posits that three psychological constructs must be addressed to affect behavioural change. With regard to SBSPIs, these would include, first, attitudes towards the importance of sleep hygiene, second, beliefs about the normative expectations of others regarding sleep hygiene and, third, perceived behavioural control in implementing changes in sleep-related behaviours. Three cross-sectional validation studies have confirmed the predictive validity of the three constructs of the TPB in relation to sleep hygiene among adolescents and have supported their application to interventional research (Knowlden et al., 2012; Kor & Mullan, 2011; Lao et al., 2016). In addition, a large body of meta-analytic research supports the use of the TBP in designing interventions to change health-related behaviours (Armitage & Conner, 2001; Cooke et al., 2016; Cooke & French, 2008; Manning, 2009; McDermott et al., 2015; McEachan et al., 2011; Riebl et al., 2015; Rivis & Sheeran, 2003; Starfelt-Sutton & White, 2016). It also appears that the TPB is more efficacious than alternative behavioural change theories. In support of this, the TBP has been found to explain significantly more of the variance in health-related behaviours compared to the Health

Beliefs Model (Lajunen & Räsänen, 2004; Montanaro & Bryan, 2014), the Theory of Reasoned Action (Hunt & Gross, 2009; Madden et al., 1992) and the Trans-theoretical Model (Taylor et al., 2006).

Figure 4

The Theory of Planned Behaviour



Note. Figure source: Kan and Fabrigar (2017).

Recent School-based Sleep Promotion Efforts

Since the publication of the three systematic reviews evaluating the effectiveness of SBSPIs (Blunden et al., 2012; Chung et al., 2017; Dietrich et al., 2016), several studies have shown promising effects. However, each study also had important methodological limitations. These limitations included an uncontrolled design (Illingworth et al., 2020), the use of non-validated scales (Hargadon & Downes, 2019), the absence of objective measures (Bauducco et al., 2020; Bonnar et al., 2015; Düzeninin & Modele, 2020; John et al., 2017; Kurasawa et al. 2020; Masnabadi et al., 2020; Otsuka et al., 2020) and no follow-up assessment (Barber & Cucalon, 2017; Gruber et al., 2016). Just one recently published study has detected objectively measured improvements in sleep which were sustained at a follow-up assessment (Rey et al., 2020). However, Rey et al.'s study included only children aged 8-9 years. To date, therefore, there have been no SBSPIs showing lasting, objectively measured improvements in sleep parameters with adolescents.

The Need to Consider Smartphone Use in Sleep Promotion Interventions

There is preliminary evidence that PSU negatively affects sleep (Twenge et al., 2017). It should be noted, however, that a systematic review of the relationship between these variables identified important limitations of studies to date (Mac Cárthaigh et al., 2020). First, there has been a reliance on cross-sectional designs, so causal inferences cannot be drawn. Second, the majority of studies have omitted objective measures of sleep parameters and smartphone use, which increases the risk of measurement bias. The mechanism of action in the relationship between sleep and PSU is also unclear. Several influential studies have implicated the melatonin-suppressing effects of blue monochromatic light emitted from smartphone screens (Chang et al., 2015; Heo et al., 2017; Oh et al., 2015; Van der Lely et al., 2015; Wright et al., 2004). However, other studies have failed to support this hypothesis (Heath et al., 2014; Rångtell et al., 2016). Other potential mechanisms of action in the relationship between sleep and PSU include sleep displacement (i.e., later bedtimes and shorter sleep duration) caused by smartphone use (Van den Bulck, 2004; Zhang & Wu, 2020) and the affectively, cognitively and physiologically arousing effects of pre-sleep smartphone use (Gradisar et al., 2013; Hale et al., 2018). Despite this ambiguity, however, it seems that there is sufficient evidence to warrant the inclusion of PSU as a target of SBSPIs. In support of this, subjective sleep quality has consistently been shown to be associated with PSU (Mac Cárthaigh et al., 2020).

The impact of PSU on sleep has generally been disregarded in SBSPIs (Barber & Cucalon, 2017; Gruber et al., 2017). Moreover, when addressed, evidence-based behavioural change strategies are frequently neglected. Systematic research has found that goal setting and self-monitoring are important aspects of behavioural change interventions (Harkin et al., 2016; Mac Cárthaigh, 2020; Samdal et al., 2017). Evidence also indicates that simply presenting recommendations regarding sleep and electronic device use is unlikely to lead to lasting improvements in sleep hygiene (Quante et al., 2019). It is concluded, therefore, that evidence-based behavioural change strategies should be employed when addressing PSU during SBSPIs.

The Potential Impact of Sleep Promotion on Mental Toughness

Mental toughness (MT) is a psychological construct associated with tenacious self-belief, resilience, the ability to cope with stress and the ability to retain focus despite distractions (Crust, 2007). A systematic review concluded that there is a weak-to-moderate positive correlation between MT and sleep quality (Mac Cárthaigh et al, 2019). It remains inconclusive, however, whether MT is positively correlated with sleep duration. The possible direction of causality also remains unclear. It may be the case that sleep quality causes an increase in MT, as is the case with mental health conditions such as depression (Manber et al., 2014). Alternatively, MT may cause improvements in sleep parameters due to reduced stress, reduced emotional arousal and fewer dysfunctional cognitions (Brand et al., 2016). The available data also suggest that a bidirectional causal relationship between sleep and MT is plausible (Mac Cárthaigh et al., 2019).

Although the construct of MT was originally developed in the field of sports psychology (Clough et al., 2002), more recently, the importance of MT in educational contexts has been recognised. For instance, within education, MT has been shown to be associated with academic achievement (Bédard-Thom & Guay, 2018; Crust et al., 2012, 2014; St Clair-Thompson et al., 2015), peer relations (St Clair-Thompson et al., 2015), psychological wellbeing (Stamp et al., 2015), academic burnout (Gerber et al., 2015) and favourable transitions to secondary and tertiary education (St Clair-Thompson et al., 2017). In light of this evidence, there has been growing interest in developing interventions to improve MT in educational contexts (Harte et al., 2020; McGeown et al., 2016). There are preliminary data to suggest that MT may be increased by implementing SBSPIs (Brand et al., 2014a; Brand et al., 2014b; Brand et al., 2016; Cooper et al., 2019; Mac Cárthaigh et al., 2019). To date, however, this hypothesis has not been tested with interventional research.

Study Aims

The present study aimed to explore the effectiveness of a SBSPI with a cohort of middle-adolescent students in Ireland. In light of the above literature review, there were three primary aims. The study examined whether the intervention could, first, improve parameters of sleep, second, increase MT and, third, reduce PSU. The study also aimed to address the six main limitations of previous SBSPIs. Addressing these limitations involved, first, employing a controlled research design, second, using an interactive mode of content delivery, third, employing objective measures of sleep and PSU, fourth, involving parents and peers in the intervention, fifth, assessing effects at a follow-up assessment and, finally, using the TPB as a theoretical framework of behavioural change.

Methods

Ethics

This study was approved by the Mary Immaculate Research Ethics Committee (MIREC), Mary Immaculate College, University of Limerick, Ireland. All research procedures adhered to the Code of Professional Ethics of the Psychological Society of Ireland (2019). Valid and informed consent/assent was provided by all participants and their parent(s) and/or guardian(s) (Appendices 5 and 6).

Participants

The target sample size was computed using the G*Power statistical programme (Faul et al., 2007). The analysis indicated that, with two groups and three time point measurements, a sample size of $N = 40$ would be required to detect an effect size of $d = .41$ with power set at 80% and alpha at .05. The effect size of $d = .41$ was based on Ferguson's (2009) recommendations regarding minimum effect sizes for clinically meaningful research. Participants were identified using single-stage cluster sampling. This sampling method was chosen because it is well suited to educational contexts (Ary et al., 2018) and can overcome resource constraints (Ellison et al., 2009). Data from 36 participants were included in the statistical analyses[7]. The waitlist control design allowed for an effective sample size of $N > 40$ for all analyses except the analysis of follow-up effects. All participants were female students from a large, urban, non-disadvantaged, all-girls post-primary school in the Midlands region of the Republic of Ireland. It had originally been planned to conduct the study in both an all-girls school and an all-boys school. However, due to disruption caused by the COVID-19 pandemic

[7] While the retention of participants across the study was 100%, some data was missing at pre-test, post-test and follow-up due to failure to return questionnaires, Mi-Band device malfunction and problems with the collection of objective smartphone metrics. Questionnaire data was missing from $n = 2$ participants at post-test and $n = 3$ participants at follow-up. Mi-band data was missing from $n = 5$ participants at post-test and $n = 3$ participants at follow-up. Screen time data was missing from $n = 3$ participants at pre-test, $n = 5$ participants at post-test and $n = 3$ participants at follow-up.

(World Health Organisation, 2020b) this was not possible. All participants were in transition year (i.e., fourth year of post-primary schooling). All participants were aged fifteen or sixteen years (*M* = 15.4; *SD* = .5) and, therefore, met the definition for "middle adolescence", i.e., those aged 14-17 years (Yeager et al., 2018). Participants indicated their ethnicity as Caucasian (84%), Asian (10%) or Black (6%). No participants indicated that they had been diagnosed with a sleep disorder. During a consultation with the staff member who facilitated the study, it was confirmed that no participants had special educational needs and, therefore, adaptations to research materials (e.g., PowerPoint presentations; progress monitoring questionnaires) would not be required.

Intervention Development

The present SBSPI was adapted from two evidence-based sleep promotion interventions, Brown et al. (2006) and Barber et al. (2017). These interventions consisted of oral presentations, supported by PowerPoint slides. Adaptations to these interventions were informed by the TPB (Ajzen, 1985) (Figure 4) and evidence-based behavioural change strategies. The adaptations are detailed below, under the headings of the three constructs of the TPB: attitudes, subjective norms and perceived behavioural control.

Attitudes

The TPB posits that attitudes towards a behaviour arise from the perceived favourability or unfavourability of performing the behaviour. With regard to influencing attitudes, persuasive communication is the preferred behavioural change strategy within the Theory of Planned Behaviour (Ajzen & Fishbein, 1980). However, the theory also holds that, in addition to presenting a set of reasoned arguments in favour of certain behaviours, the credibility of the arguments should be bolstered (Ajzen & Fishbein, 1980). A review of the empirical evidence adds support to the claim that high-credibility sources are more persuasive than low-credibility sources (Pornpitakpan, 2004). The sleep promotion interventions from which the present study was adapted (Barber et al., 2017; Brown et al., 2006) used persuasive communication in the form of an oral presentation.

In light of the evidence cited above, content from Brown et al. (2006) and Barber et al. (2017) was adapted to clarify that the data emerged from credible sources (peer-reviewed journals and reputable universities). The scope of the information presented to participants was also broadened. Brown et al. (2006) presented information that fell into five categories: prevalence of sleeping difficulties among adolescents; trends in adolescent sleep duration; the impact of sleep on learning and cognition; the impact of sleep on mental and emotional health; and sleep hygiene recommendations. Barber et al. (2017) included a sixth category: the impact of electronic media use on sleep. In the present intervention, these six categories were retained and a seventh category, the impact of sleep on physical health, was added. It was deemed necessary to include this category given the weight of empirical evidence demonstrating the risks of sleep insufficiency for physical health, as outlined in the introduction. The intervention slides for each session are available in Appendix 7 and session overviews are in Appendix 8.

Subjective Norms

According to the TPB, subjective norms are a function of beliefs about the normative expectations of others (Ajzen, 2002). Subjective norms affect social pressure to perform or avoid a behaviour. In the context of a SBSPI, this social pressure can be leveraged by involving family members in the intervention. However, family and peers had not been included in the interventions from which the present SBSPI was adapted (Barber et al., 2017: Brown et al., 2006). In the present study, family involvement was achieved in two ways. First, after each session of the intervention, a letter was sent to parent(s) and/or guardian(s) outlining the content of the session and explaining how the learning may be generalised to the home context (Appendix 9). Second, after each session, a video of an abridged version of the session was made available online to the parent(s) and/or guardian(s) of participants (Appendix 10). The inclusion of family members in the intervention comports with the recommendations of a systematic review on the effectiveness of SBSPIs (Chung et al., 2017). In addition to family involvement, however, the social influence of peers was also leveraged throughout the present study. Three evidence-based strategies which were employed to leverage peer influence are detailed under the subheading *Strategies to Increase Engagement.*

Perceived Behavioural Control

The third construct of the TPB, perceived behavioural control, captures one's perceptions of control over the performance of a focal behaviour (Ajzen, 1991). This construct is conceptually similar to Bandura's (1977) construct of self-efficacy (Ajzen, 2002). Five strategies to increase both constructs are well established by meta-analytic research. These strategies include, first, behavioural goal setting and reviewing, second, progress monitoring, third, relapse planning, fourth, prompting and, fifth, stress management (Ashford et al., 2010; Knowlden et al., 2012; Olander et al., 2013; Prestwich et al., 2014). Therefore, these five evidence-based strategies were employed in the present SBSPI to increase perceived behavioural control. The sleep promotion interventions from which the present SBSPI was adapted (Barber et al., 2017: Brown et al., 2006) did not employ the above-mentioned strategies. Therefore, resources were developed for the present intervention to facilitate these strategies. These resources included a goal setting and review document (Appendix 11) and a progress-monitoring questionnaire (Appendix 12). The development of these resources was informed by literature which emphasises the important of goal setting and progress monitoring for lasting behavioural change (Epton et al., 2017; Mairs & Mullan, 2015). With regard to prompting, participants were provided with self-prompting strategies (digital and visual prompts) and parent(s) and/or guardian(s) were encouraged to prompt behavioural changes. The inclusion of family members in the prompting of behavioral change is in line with the TPB. The visual prompt is presented in Appendix 13. Finally, evidence-based stress management skills—paced breathing (Zaccaro et al., 2018) and progressive muscle relaxation (Manzoni et al., 2008)—were practised during the intervention. Although Brown et al. (2006) and Barber et al. (2017) delivered their sleep promotion interventions in a single session, this approach would not be amenable to the adaptations outlined above. Therefore, the present SBSPI was delivered over three once-weekly sixty-minute sessions. The rational for conducting sessions once weekly was to provide sufficient time for the completion of the assigned self-monitoring exercises. While it had originally been planned to deliver the intervention over five sessions, due to disruption caused by the COVID-19 pandemic (World Health Organisation, 2020b), this was not possible.

Strategies to Increase Participant Engagement

As detailed in the introduction, a systematic review of the effectiveness of SBSPIs cautions against a didactic mode of intervention delivery (Blunden & Rigney, 2015). Considering this recommendation, further adaptations were deemed necessary. Both Brown et al. (2006) and Barber et al. (2017) recommend delivering the intervention by reading verbatim from a pre-prepared script. Since this didactic approach does not align with Blunden and Rigney's recommendation, during the present intervention, the script was not read verbatim. Instead, three evidence-based strategies were used to promote participant engagement. First, the active student responding strategy was used. A meta-analysis has demonstrated that this strategy has a large effect on student achievement and engagement (Randolph, 2007). Second, the think-pair-share strategy was used. This strategy has been found to promote student engagement (Kothiyal et al., 2013) and achievement (Bamiro, 2015). Third, a brief group quiz was conducted at the beginning of each session. Pre-lecture quizzes have been shown to increase academic performance and subsequent high-level questions (Narloch et al., 2006).

Influences from Qualitative Research

Qualitative research findings were instructive in developing the present SBSPI. For instance, in an exploration of adolescents' perceptions of barriers to modifying sleep hygiene, Paterson et al. (2019) identified a theme of competing time demands. Specifically, participants cited school or university work as interfering with sleep hygiene modification efforts. Other qualitative studies have also found that sleep is frequently neglected in favour of homework (Orzech, 2013; Quante et al., 2019). Sacrificing sleep in pursuit of academic success, however, is counterproductive. In support of this, longitudinal research with school-age adolescents has found that delaying sleep in favour of additional study time is associated with poorer academic performance (Gillen-O'Neel et al., 2013). More recently, Scullin (2019) evaluated the "eight-hour sleep challenge", during which undergraduate students could earn extra credit if they had an average weekly sleep duration of eight hours in the week before final exams. Compared to their counterparts who did not succeed in the challenge, participants who slept eight or more hours performed better in the final exam, even while controlling for pre-final grades. The studies by Paterson et al. (2019) and Scullin

(2019) contradict the prevalent notion that sacrificing sleep for scores is an effective strategy. It was considered important, then, that this misconception be communicated to participants of the present SBSPI.

Measures

The questionnaire used in this study employed four psychometrically robust scales. Demographic information and objective sleep and smartphone usage data were also reported within this questionnaire (Appendix 15). Objective data were reported at the end of the questionnaire. This format ensured that participants' self-reported responses would not be influenced by objective sleep and smartphone usage data. In order to minimise fatigue effects, shortened versions of several scales were used.

Sleep Quality

The Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) was used to assess subjective sleep quality (Appendix 15). The 19-item PSQI was chosen because its validity has been confirmed in a recent systematic review and meta-analysis (Mollayeva et al., 2016). In addition, the PSQI has been validated for use with adolescents (de la Vega et al., 2015). In previous research, the PSQI has demonstrated good internal consistency with Cronbach's α = .80 (Carpenter & Andrykowski, 1998). Internal consistency values were similar in the present study at pre-test (α = .77) and post-test (α = .79) but lower at follow-up (α = .51).

The PSQI provides data on seven sleep parameters including sleep quality, sleep onset latency, sleep duration, sleep efficiency, sleep disturbance, use of sleep medication and daytime dysfunction. The seven component scores are summed to yield a PSQI global score between 0 and 21, with lower scores indicating higher sleep quality.

Sleep Hygiene

Sleep hygiene was assessed using the Adolescent Sleep Hygiene Scale (ASHS) (LeBourgeois et al., 2005) (Appendix 15). In previous research, the ASHS has demonstrated robust psychometric properties (Cronbach's $\alpha = .84$) and clinical utility in use with adolescents (Lewandowski et al., 2011; Storfer-Isser et al., 2013). In the present sample, internal consistency was $\alpha = .82$ at pre-test, $\alpha = .83$ at post-test and $\alpha = .80$ at follow-up. The 28-item ASHS is comprised of eight subscales: physiological factor, behavioural arousal factor, cognitive/emotional factor, sleep environment factor, sleep stability factor, daytime sleep factor, substance factor and bedtime routine factor. Each item is scored on a six-point Likert scale. The mean score of all eight subscales is calculated to yield an index between one and six, with higher scores denoting better sleep hygiene.

Objective Sleep

Several studies underline the importance of gathering both subjective and objective measures of sleep, as both approaches provide valuable insight into sleep parameters (Landry et al., 2015; Mac Cárthaigh et al., 2020; Werner et al., 2008). In light of these recommendations, objective sleep was assessed with the commercially available Xiaomi Mi-Band 4. This device has been found to have comparable validity to polysomnography in the measurement of the time in bed sleep parameter (Ameen et al., 2019; El-Amrawy & Nounou, 2015). A validation study by Dickinson et al. (2016) concluded that although commercially available sleep tracking devices may lack the overall accuracy of research-grade actigraphy and polysomnography, these devices are, nonetheless, appropriate for identifying the sign of an intervention effect. Validation research has also indicated that consumer-grade sleep tracking devices can validly measure sleep duration, but not sleep staging (Lee et al., 2019; Liang & Martell, 2018).

Therefore, sleep staging data from the Mi-band devices were not used. To ensure correct usage of the device, simplified device usage instructions were developed for participants (Appendix 14). Participants reported objective sleep data in the questionnaire which was developed for this intervention (Appendix 15).

Problematic Smartphone Use

The Smartphone Addiction Scale, Short Version (SAS-SV) (Kwon et al., 2013) was used to assess PSU (Appendix 15). In previous samples, the 10-item SAS-SV has demonstrated good validity and internal consistency (Harris et al., 2020; Kwon et al., 2013), with Cronbach's α = .91. In the present sample, internal consistency was α = .76 at pre-test, α = .78 at post-test and α = .85 at follow-up. Items are scored on a six-point Likert scale. Summed scores yield an index between 10 and 60, with higher scores indicating a greater level of PSU. The SAS-SV was adapted by including one additional item: "Smartphone use interferes with my sleep". Inclusion was due to theoretical interest. However, to avoid disrupting the established psychometric properties of the SAS-SV, this item was not included in statistical analyses.

Research suggests that the validity of PSU measures may be improved by including objective use metrics (Mac Cárthaigh et al., 2020; Ohme et al., 2020). Therefore, objective data regarding screen time and pickups were gathered with the pre-installed Screen Time application for iOS. Screen time refers to the duration of screen activation, whereas pickups refer to the frequency of screen activation. For Android users, the Your Hour application, which is freely available through the Google Play Store, was used to gather data regarding screen time and frequency of use. Participants reported these data in the questionnaire (Appendix 15).

Mental Toughness

MT was assessed using the 24-item MTQ-4Cs (Strycharczyk et al., 2021). This is a shortened version of the MTQ-48 (Clough et al., 2002), which has been validated on multiple large samples (Perry et al., 2013; in press). The MTQ-4Cs yields factor scores for control, commitment, challenge and confidence and has presented good factor structure (comparative fit index = .94, root mean square error of approximation = .04) in multiple large samples (Strycharczyk et al., 2021). In the present sample, internal consistency was $\alpha = .74$ at pre-test, $\alpha = .72$ at post-test and $\alpha = .63$ at follow-up. Items are scored on a five-point Likert scale. Summed scores yield an MT index between 0 and 120. Higher scores indicate mental toughness, whereas lower scores indicate mental sensitivity (Appendix 15).

Engagement

Given Blunden and Rigney's (2015) recommendation to use an interactive mode of content delivery, it was necessary to include a measure of engagement. Therefore, participants' subjective engagement was assessed with a single-item measure developed by Atroszko (2014) (Appendix 16). This measure has demonstrated good validity (Łukowicz et al., 2017) and test-retest reliability ($r = .77$) (Atroszko, 2014) with adolescents. This brief measure has the advantage of minimising response fatigue effects.

Exit Survey

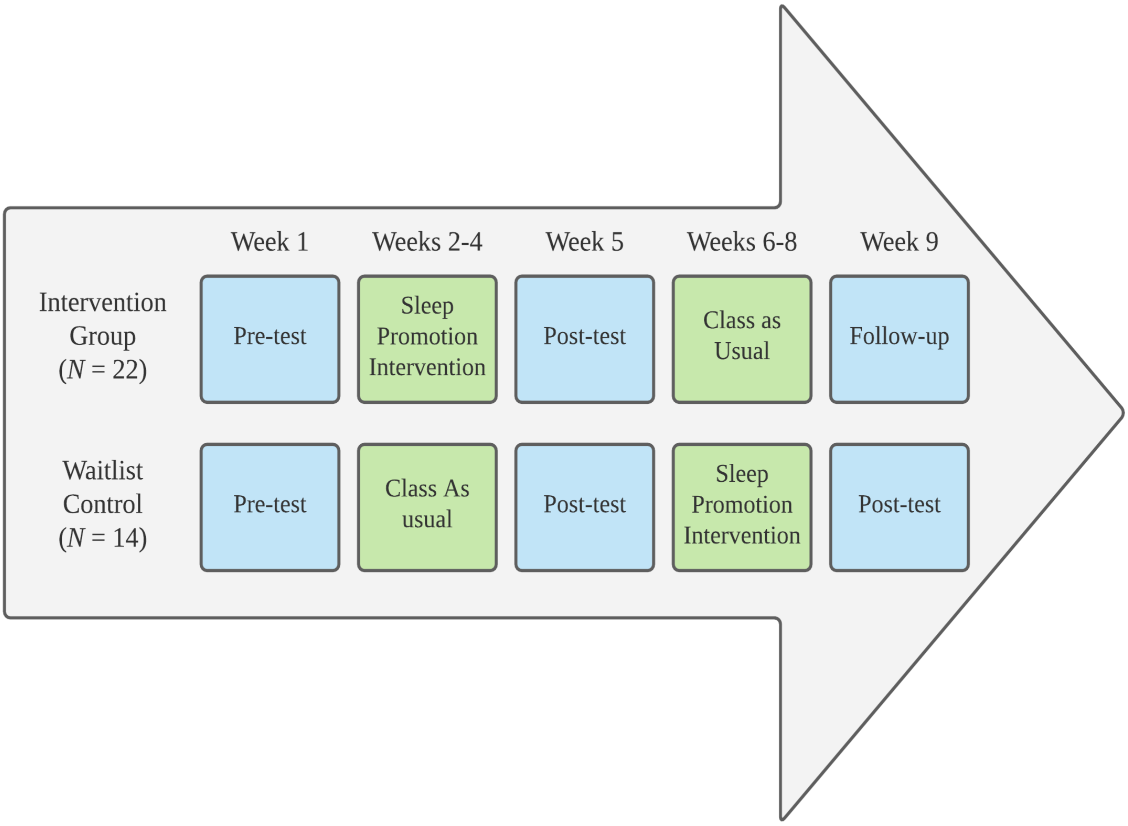
The exit survey consisted of four brief implementation outcome measures (Appendix 17). Three of these measures were developed and psychometrically validated by Weiner et al., (2017). In Weiner et al's study, Cronbach's alpha for all measures was between $\alpha = .85$ and $\alpha = .91$. In the present study, internal consistency was lower with $\alpha = .67$. The exit survey provides data regarding participants' perceptions of, first, intervention acceptability, second, intervention appropriateness and, third, intervention feasibility. These three constructs are considered the leading indicators of implementation success (Proctor et al., 2011). A fourth item was added to the exit survey to determine participants' perceived knowledge gained following the intervention, in line with the recommendation of Blunden and Rigney (2015). The four items were scored on a six-point Likert scale. Participants also had the option of providing qualitative feedback regarding the intervention through an open-ended question.

Study Design and Procedures

A quasi-experimental, waitlist-controlled study design with one independent variable with two levels (sleep promotion intervention vs. class as usual) and three assessment time points (pre-test, post-test and four-week follow-up) was used to address the research questions, as displayed in Figure 5. While the use of a randomised study design would have increased the internal validity of the findings, due to resource constraints, randomisation was not possible. The PSQI, ASHS, SAS-SV and MTQ-4Cs were completed one week before and after the intervention and at a four-week follow-up assessment. Objective sleep and smartphone usage data were collected for seven consecutive days before each assessment time point. The engagement scale and exit survey were completed after the final session of the sleep promotion intervention. Statistical analyses were conducted using the IBM SPSS statistical software, version 27. All data were collected between September 29th and November 31st, 2020.

Figure 5

Research Design



Results

Descriptive Statistics

At pre-test, objectively measured sleep data indicated that 39% of participants did not meet the minimum sleep duration recommendations of the national sleep foundation for adolescents aged 14-17 years (8-10 hours) (Hirshkowitz et al., 2015). In addition, using the established PSQI cut-off of 5, 50% of participants were identified as poor sleepers (Buysse et al., 1989). At pre-test, the mean daily screen time was 6 hours 3 minutes (M = 363.9 SD = 152.7). Descriptive statistics for the PSQI, ASHS, SAS-SV, MTQ-4Cs, objective sleep, screen time and pickups are presented in Table 20. A correlation matrix of the dependent variables at pre-test, post-test and follow-up is presented in Appendix 18.

Table 20

Dependent Variables at Pre-test, Post-test and Follow-up

Variable	**Group**	**Time**		
		Pre-test	**Post-test**	**Follow-up**
Pittsburgh Sleep Quality Index[8]	Intervention	6.3	4.6*	4.8
	Control	6.5	6.3*	
Adolescent Sleep Hygiene Scale	Intervention	4.3	4.5	4.4
	Control	4.1	4.2	
Smartphone Addiction Scale, Short Version	Intervention	33.6	33.1	33.0
	Control	35.7	34.2	
Mental Toughness Questionnaire, 4Cs	Intervention	79.1	77.9	77.8
	Control	80.0	80.2	
Objective Sleep Duration in Minutes	Intervention	488.9	498.7	508.9
	Control	498.1	475.4	
Screen Time in Minutes	Intervention	338.2	351.2	342.5
	Control	374.7	463.8*	
Pickups	Intervention	100.9	91.5	96.8
	Control	100.5	185.5	

***** Mean pre-test-post-test difference significant at $p \leq .05$

[8] Lower PSQI scores indicate better sleep quality.

Scale Reliability Analysis

Scale reliability analysis was conducted on the PSQI, ASHS, SAS-SV and MTQ-4Cs. As shown in Table 21, both pre-and post-test, each of these scales had acceptable-to-good internal consistency, according to Lavrakas' (2008) criteria. However, at follow-up, the PSQI and MTQ-4Cs had poor ($\alpha = .51$) and questionable ($\alpha = .63$) internal consistency, respectively. The sample size at follow-up ($n = 19$) was considerably smaller than pre- and post-test ($n = 50$). Charter (2003) cautions that small samples sizes may produce imprecise alpha coefficients. Nonetheless, since good internal consistency of the PSQI and MTQ-4Cs was not established at follow-up, these data were interpreted with caution.

Table 21

Internal Consistency for the PSQI, ASHS, SAS-SV and MTQ-4Cs

Scale	**Cronbach's α**		
	Pre-test	**Post-test**	**Follow-up**
Pittsburgh Sleep Quality Index	$\alpha = .77$	$\alpha = .79$	$\alpha = .51$
Adolescent Sleep Hygiene Scale	$\alpha = .82$	$\alpha = .83$	$\alpha = .80$
Smartphone Addiction Scale, Short Version	$\alpha = .76$	$\alpha = .78$	$\alpha = .85$
Mental Toughness Questionnaire, 4Cs	$\alpha = .74$	$\alpha = .72$	$\alpha = .63$

Inferential Analyses

Normality Tests and Baseline Equivalence

Shapiro-Wilk tests and inspection of Q-Q plots were used to assess normality. At each level of the independent variable (group), all dependent variables except smartphone pickups were approximately normally distributed[9]. A Shapiro-Wilk test indicated that post-test smartphone pickups deviated significantly from normality for both the intervention (p = .001) and control groups (p = .000). Although an inspection of Q-Q plots for the intervention group indicated that the data were approximately normally distributed, the Q-Q plots and kurtosis values for the control group revealed a highly non-normal distribution[10]. There was also an unacceptable number of outliers in both the intervention and control group. In light of the significant deviation from normality, the pickups variable was excluded from further analyses. Since this study employed a quasi-experimental design, baseline equivalence had to be established. ANOVA did not indicate statistically significant differences in any outcome variables at pre-test[11].

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[9] Shapiro-Wilk tests indicated no statistically significant deviation from normality for objective sleep (pre-test: intervention p = .44, control p = .77; post-test: intervention p = . 58, control p = . 58), sleep hygiene (pre-test: intervention p = .29, control p = .50; post-test: intervention p = . 58, control p = . 58) or problematic smartphone use (pre-test: intervention p = .80, control p = .35; post-test: intervention p = . 59, control p = . 52). While Shapiro-Wilk tests for screen time were not statistically significant at post-test (intervention p = . 43, control p = . 39), pre-test scores indicated a statistically significant deviation from normality in the intervention group (intervention p = . 01, control p = . 35). However, inspection of Q-Q plots indicated that pre-test intervention scores were approximately normally distributed. Some deviation from normality was indicated by the Shapiro-Wilk test for sleep quality (pre-test: intervention p = .00, control p = .01; post-test: intervention p = . 03, control p = . 24). Q-Q plot inspection, however, indicated that scores were approximately normally distributed. With MT, Shapiro-Wilk tests indicated a deviation from normality in post-test intervention scores (pre-test: intervention p = .70, control p = .46; post-test: intervention p = . 01, control p = . 38). However, inspection of Q-Q plots indicated that this deviation was minor. Since ANOVA and ANCOVA are robust to violations of normality (Rutherford, 2001), it was deemed appropriate to proceed with these analyses with the above variables

[10] Kurtosis values for the pickups variable: pre-test 4.81 (SE = .70); post-test 5.82 (SE = 1.2).

[11] The assumption of homogeneity of variance was satisfied for all outcome variables (all p > .05). Statistically significant differences between groups at pre-test were not detected in objective sleep (F(1, 48) = .03 p = .86), screen time (F(1, 44) = .44 p = .51), PSQI (F(1, 48) = .01 p = .91), ASHS (F(1, 48) = 1.59 p = .21), SAS-SV (F(1, 48) = .79 p = .38) or MTQ-4Cs (F(1, 48) = .08 p = .77).

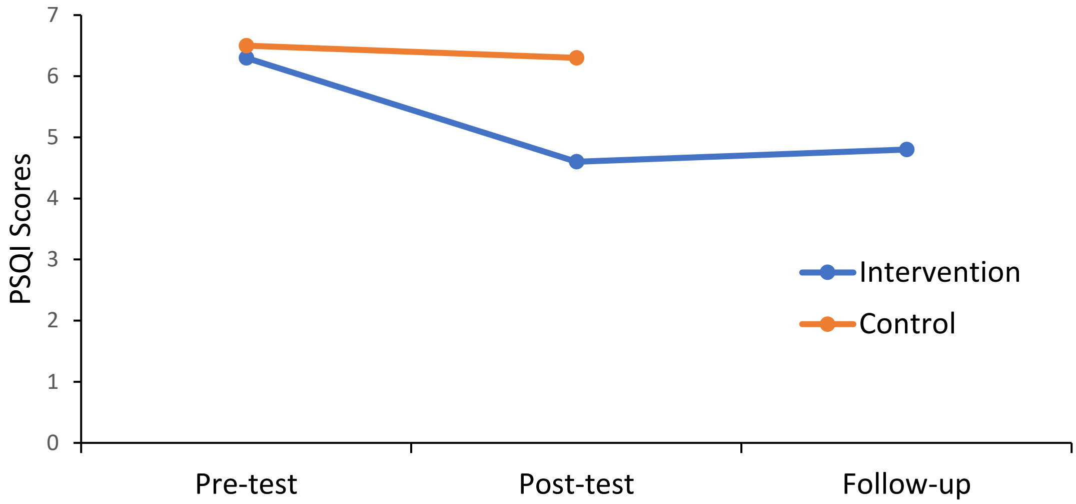
Intervention Effects on Dependent Variables

Repeated-measures ANOVAs were conducted to compare the main effects of time (pre- and post-test) and group (sleep promotion intervention and class as usual) and the interaction effect between time and group on the dependent variables (PSQI, ASHS, SAS-SV, MTQ-4Cs, objective sleep and screen time) pre- and post-intervention. To minimise data loss due to listwise deletion, three repeated-measures ANOVAs were conducted: the first ANOVA examined scores on the PSQI, ASHS, PSU and MTQ-4Cs; the second examined objective sleep; and the third examined screen time. The assumption of sphericity was met since there were just two levels of repeated measures (Field, 2013). Effect sizes were calculated with η^2 and Cohen's (1988) benchmarks for small ($\eta^2 = .01$), medium ($\eta^2 = .06$) and large ($\eta^2 = .14$) effects were used. Where required, Šidák correction was used to counteract the increased risk of type I error caused by multiple comparisons. Šidák correction provides more statistical power compared to alternative procedures such as Bonferroni correction (Sauder, 2017).

In the first repeated-measures ANOVA, Box's *M* indicated that the assumption of homogeneity of variance had been satisfied ($M = 53.4$, $p = .31$). The main effect for time on PSQI scores was statistically significant $F(1, 46) = 20.56$, $p < .001$, $\eta^2 = .31$. The main effect for group was not statistically significant $F(1, 46) = 1.33$, $p = .25$, $\eta^2 = .03$. There was a statistically significant interaction effect on PSQI scores $F(1, 46) = 5.81$, $p = .02$, $\eta^2 = .11$. In light of the statistically significant interaction effect for the PSQI, pairwise comparisons using Šidák correction was inspected. Pairwise comparisons indicated that the intervention significantly increased PSQI scores between pre- and post-test in the intervention group ($p < .001$), whereas no change was observed in the control group ($p = .68$) (Figure 6).

Figure 6.

Intervention Effect on Sleep Quality

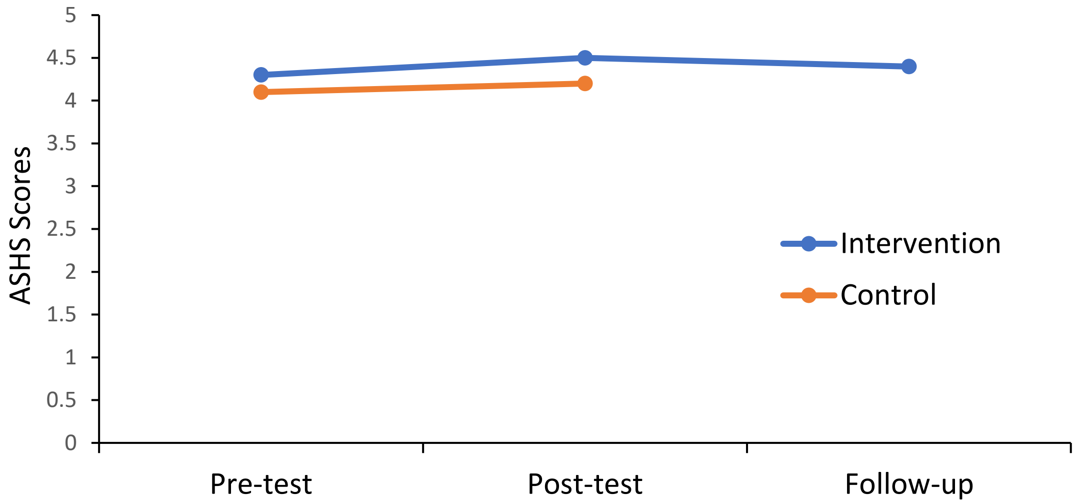


Note. Statistically significant interaction effect ($p < .05$). Lower PSQI scores indicate better sleep quality.

The main effect of time on ASHS scores was statistically significant $F(1, 46) = 8.13$, $p = .007$, $\eta^2 = .15$, but the main effect of group was not $F(1, 46) = 1.58$, $p = .22$, $\eta^2 = .03$ The interaction effect on ASHS scores was not statistically significant $F(1, 46) = .04$, $p = .85$, $\eta^2 = .001$ (Figure 7).

Figure 7.

Intervention Effect on Sleep Hygiene

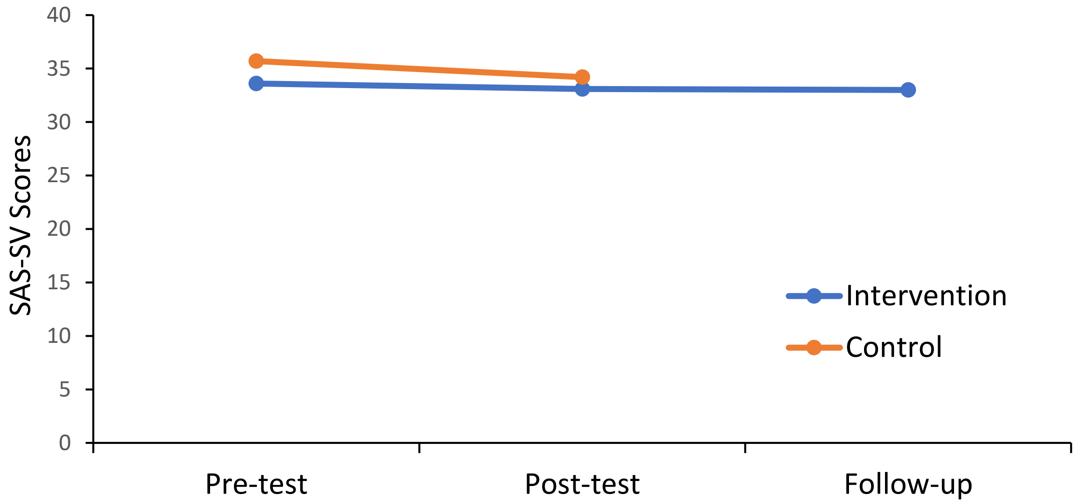


Note. The interaction effect was not statistically significant ($p > .05$).

The main effects of time ($F(1, 46) = .93$, $p = .34$, $\eta^2 = .02$) and group ($F(1, 46) = .39$, $p = .54$, $\eta^2 = .01$) on SAS-SV scores were not statistically significant. The interaction effect between time and group was also not statistically significant $F(1, 46) = .34$, $p = .56$, $\eta^2 = .01$ (Figure 8).

Figure 8.

Intervention Effect on Self-reported Problematic Smartphone Use

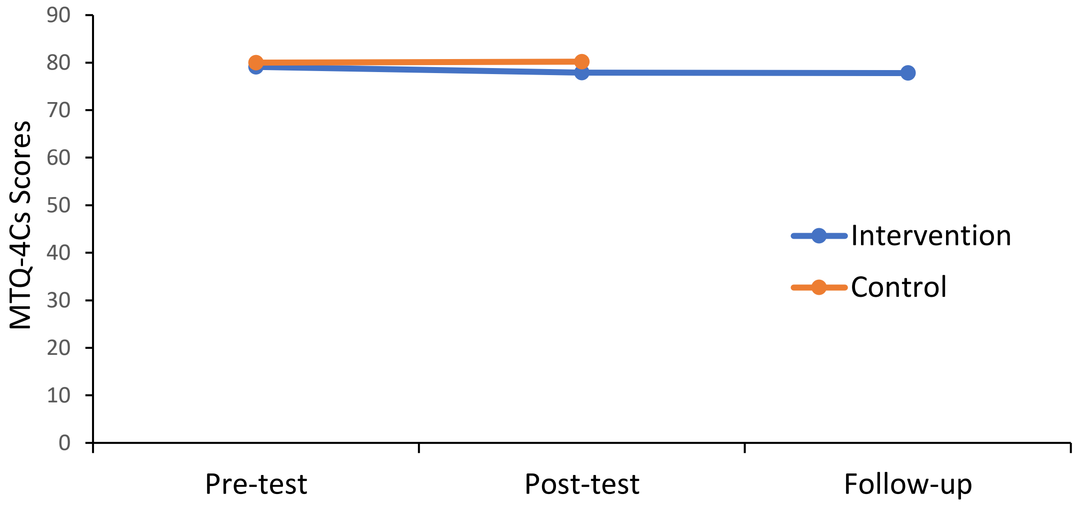


Note. No statistically significant changes were detected ($p > .05$).

The main effects of time ($F(1, 46) = .54$, $p = .47$, $\eta^2 = .01$) and group ($F(1, 46) = .35$, $p = .58$, $\eta^2 = .01$) on MTQ-4Cs scores were not statistically significant. The interaction effect between time and group was also not statistically significant $F(1, 46) = .31$, $p = .56$, $\eta^2 = .01$ (Figure 9).

Figure 9.

Intervention Effect on Mental Toughness

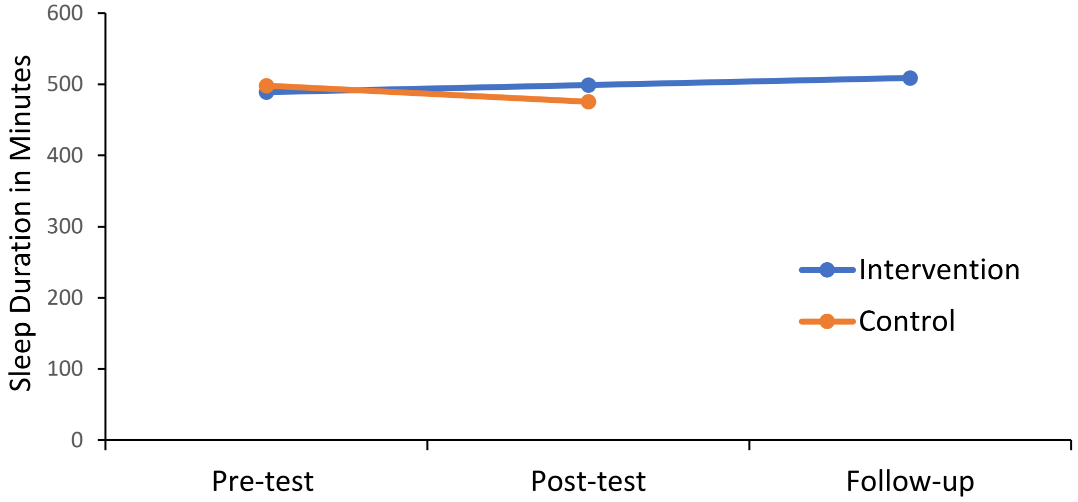


Note. No statistically significant changes were detected ($p > .05$).

The second repeated-measures ANOVA compared the main effects of time (pre- and post-test) and group (sleep promotion intervention and class as usual) and the interaction effect between time and group on objective sleep scores. Box's *M* indicated that the assumption of homogeneity of variance had been satisfied ($M = 3.50$, $p = .35$). The main effects for time ($F(1, 43) = .003$, $p = .954$, $\eta^2 = .00$) and group ($F(1, 43) = .310$, $p = .58$, $\eta^2 = .01$) on objective sleep was not significant. The interaction effect between time and group on objective sleep scores, however, fell just above statistical significance $F(1, 46) = 5.81$, $p = .051$, $\eta^2 = .09$. In light of the near-significant effects for objective sleep, pairwise comparisons using Šidák correction were inspected. Pairwise comparisons indicated that the objectively measured sleep of the intervention group increased by 9.8 minutes between pre- and post-test, whereas a 22.6-minute decrease was observed in the control group. These changes, however, were not statistically significant (intervention: *p* = *.27;* control*:* *p* = .10) (Figure 10).

Figure 10.

Intervention Effect on Sleep Duration

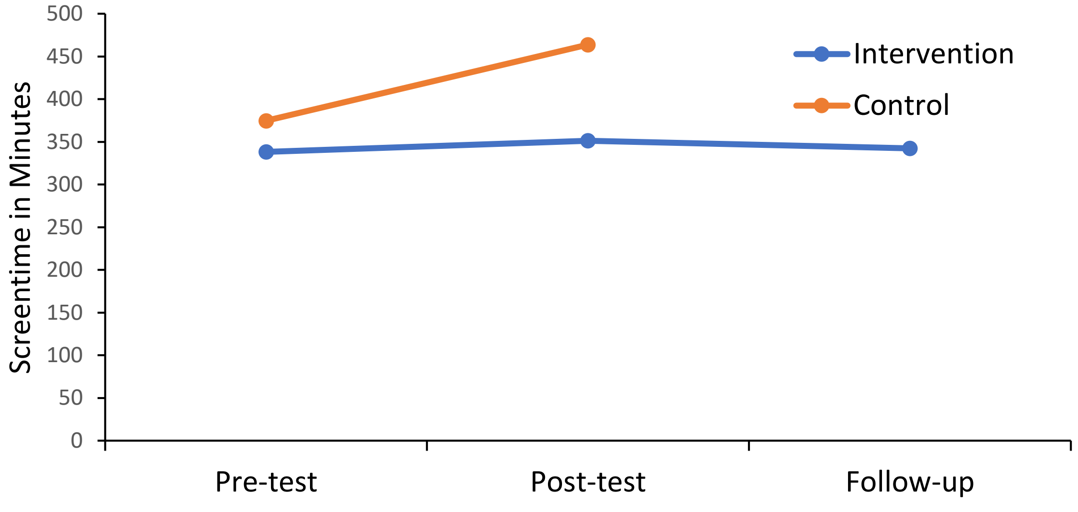


Note. The interaction effect did not reach statistical significance (*p* = .051).

The third repeated-measures ANOVA compared the main effects of time (pre- and post-test) and group (sleep promotion intervention and class as usual) and the interaction effect between time and group on screen time. Box's *M* indicated that the assumption of homogeneity of variance had been satisfied (*M* = 7.07, *p* = .31). The main effects for time ($F(1, 38) = 3.43$, $p = .07$, $\eta^2 = .08$) and group ($F(1, 38) = 2.87$, $p = .10$, $\eta^2 = .07$) were not statistically significant. The interaction effect between time and group ($F(1, 38) = 3.24$, $p = .08$, $\eta^2 = .08$) on screen time did not reach statistical significance. However, in light of the near-significant alpha levels, pairwise comparisons using Šidák correction were inspected. Pairwise comparisons indicated that, between pre-test and post-test, screen time had increased in the intervention group by 13 minutes, however, this increase was not statistically significant. Contrastingly, a statistically significant screen time increase of 89 minutes was observed in the control group (p = .02).

Figure 11.

Intervention Effect on Screen Time



Note. Pairwise comparisons indicated a statistically significant increase in the control group ($p < .05$) but not in the intervention group.

Subscale-level Analysis for the Adolescent Sleep Hygiene Scale

A simple linear regression was calculated to predict sleep quality, as measured by PSQI scores, from ASHS scores. A statistically significant regression equation was detected ($F(1, 48) = 22.84$, $p < .001$). The R^2 indicated that 32.2% of the variance in sleep quality was explained by sleep hygiene, as measured by the ASHS. Therefore, to determine whether sub-constructs of sleep hygiene may have increased PSQI scores during the intervention, a repeated-measures ANOVA was conducted at the subscale level of the ASHS at pre- and post-test. ASHS subscales were assessed for normality. Although the Shapiro-Wilk test was violated, skewness and kurtosis values fell within an acceptable range of between −2 and +2 (George & Mallery, 2010) for the physiological, behavioural, cognitive-emotional, environmental, stability and routine subscales, indicating that these variables were approximately normally distributed. However, skewness and kurtosis values fell outside the acceptable range for the daytime dysfunction and substance subscales[12]. While ANOVA is robust to violations of normality (Rutherford, 2001), caution was exercised in interpreting results for these subscales given the magnitude of the kurtosis values. Levene's test of equality of error variances indicated that the assumption of homogeneity of variance had been satisfied for all ASHS subscales at pre- and post-test (p > .05).

ASHS subscale-level analysis is summarised in Table 22. Šidák correction was used to counteract the risk of bias caused by multiple comparisons. The main effect for time was statistically significant for the physiological (F(1, 46) = 7.22, p = .01, η^2 = .14), cognitive-emotional (F(1, 46) = 7.12, p = .01, η^2 = .13), and stability (F(1, 46) = 10.93, p = .002, η^2 = .19) subscales. The main effects for the remaining subscales were not statistically significant (behavioural: F(1, 46) = .02, p = .90, η^2 = .00; environmental: F(1, 46) = .15, p = .70, η^2 = .00; daytime dysfunction: F(1, 46) = .33, p = .57, η^2 = .01; substance: F(1, 46) = .81, p = .37, η^2 = .02; routine: F(1, 46) = .37, p = .55, η^2 = .01). The interaction effect between time and group for each subscale was not statistically significant (physiological: F(1, 46) = .21, p = .65, η^2 = .00; behavioural: F(1, 46) = .14, p = .71, η^2 = .00; cognitive-emotional: F(1, 46) = .02, p = .89, η^2 = .00; environmental: F(1, 46) = .01, p = .94, η^2 = .00; stability: F(1, 46) = .45, p = .51, η^2 = .01; daytime: F(1, 46) = 10.93, p = .002, η^2 = .19; substance: F(1, 46) = .55, p = .46, η^2 = .01; routine: F(1, 46) = .37, p = .55, η^2 = .01). The pairwise comparisons, however, indicated that the

[12] Pre-test daytime dysfunction subscale: skewness = -1.6 (standard error (*SE*)= .34); kurtosis = 2.0 (*SE* = .67). Post-test daytime dysfunction subscale: skewness = -2.0 (*SE* = .34); kurtosis = 3.1 (*SE* = .67). Pre-test substance subscale: skewness = -2.8 (*SE* = .34); kurtosis = 7.0 (*SE* = .67). Post-test substance subscale: skewness = -3.7 (*SE* = .34); kurtosis = 13.0 (*SE* = .67).

intervention significantly increased scores on the physiological (p = .05), cognitive-emotional (p = .03) and stability subscales (p < .01)among the intervention group. Scores in the control group did not change significantly between pre-test and post-test in any subscales (physiological p = .07; behavioural p = .71; cognitive-emotional p = .19; environmental p = .89; stability: p = .23; daytime dysfunction p = .86; substance p = .27; routine p = .34).

Table 22

ASHS Subscales at Pre-test, Post-test and Follow-up

Adolescent Sleep Hygiene Scale Subscale	Group	Time		
		Pre-test	**Post-test**	**Follow-up**
Physiological	Intervention	4.15	4.43*	4.22
	Control	3.99	4.39	
Behavioural	Intervention	2.79	2.77	3.17
	Control	1.98	2.09	
Cognitive-Emotional	Intervention	3.37	3.70*	3.63
	Control	3.15	3.44	
Environmental	Intervention	5.30	5.25	5.31
	Control	5.19	5.16	
Stability	Intervention	2.92	3.51*	3.37
	Control	2.57	2.93	
Daytime Dysfunction	Intervention	5.19	5.29	5.47
	Control	5.04	5.00	
Substance	Intervention	5.91	5.93	5.94
	Control	5.89	5.96	
Routine	Intervention	4.65	4.74	4.42
	Control	4.64	5.0	

*Mean pre-test-post-test difference significant at $p \leq .05$

Analysis of Effects at Follow-up

Analyses were conducted to determine whether intervention effects on the PSQI, ASHS subscales and screen time were sustained at follow-up. Skewness and kurtosis values were within acceptable ranges (George & Mallery, 2010), indicating that these variables were approximately normally distributed. A repeated-measures ANOVA indicated that these variables did not change significantly between post-test and follow-up (PSQI: $F(1, 18) = .04$, $p = .85$, $\eta^2 = .00$; ASHS cognitive-emotional: $F(1, 18) = .25$, $p = .62$, $\eta^2 = .01$; ASHS stability: $F(1, 18) = .37$, $p = .44$, $\eta^2 = .03$; ASHS physiological: $F(1, 18) = 1.14$, $p = .29$, $\eta^2 = .06$; screen time: $F(1, 16) = .21$, $p = .65$, $\eta^2 = .03$). While analyses of intervention effects did not indicate that objective sleep increased significantly between pre-test and post-test, since the alpha level fell just above statistical significance ($p = .051$), analysis of effects at follow-up were conducted for this variable. The repeated-measures ANOVA indicated that objective sleep did not change significantly between post-test and follow-up (+11.1 minutes) ($F(1, 18) = .76$, $p = .39$, $\eta^2 = .04$). Therefore, while it cannot yet be concluded that the intervention led to a statistically significant improvement in objectively measured sleep duration, there are indications that there may have been positive effects which were sustained at follow-up.

The Impact of MT and PSU on Change in PSQI Scores

There was insufficient statistical power to conduct mediation analysis (Fritz & MacKinnon, 2007). However, an examination of analysis of covariance (ANCOVA) and pairwise comparisons can indicate the possible presence of a covariate effect of MT on the change in PSQI scores. Assumptions of ANCOVA were satisfied[13]. Therefore,

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[13] First, Shapiro-Wilk tests indicated no statistically significant deviation from normality for MTQ-4Cs subscales (all $p > .05$). Second, matrix scatterplots indicated that there was a linear relationship between the covariates (MTQ-4Cs subscales) and PSQI scores for each level of the independent variable

ANCOVA was conducted to examine the change in PSQI scores from pre-test to post-test, with pre-test MT subscales entered as covariates. The rationale for using pre-test MT subscale scores was that pre- and post-test scores did not differ significantly ($p > .05$).

The repeated-measures ANCOVA indicated that the commitment ($F(1, 42) = 6.91$, $p = .01$, $\eta^2 = .14$) and confidence ($F(1, 42) = 4.66$, $p = .04$, $\eta^2 = .10$) subscales of the MTQ-4Cs significantly covaried with PSQI scores. No other statistically significant covariates were detected. Pairwise comparisons from this ANCOVA were then explored. As shown in Table 23, there was a slight increase in the mean PSQI score while controlling for MT, indicating that there may be a covariate effect. Further research, however, is required to confirm this preliminary finding.

Due to violations of the assumption of homogeneity of variance, ANCOVA could not be conducted to examine the change in PSQI scores from pre-test to post-test, with SAS-SV[14] scores or screen time[15] entered as covariates. Instead, as shown in Table 24, bivariate correlations between PSQI change and both SAS-SV scores and screen time were computed with 1000 bootstrap samples. MTQ-4Cs subscales were also included in this analysis. The change in PSQI scores did not correlate with either SAS-SV scores or screen time. The absence of a significant correlation indicates that PSU at pre-test had little impact on the change in PSQI scores. However, the commitment and control subscales of the MTQ-4Cs correlated significantly with the change in PSQI. This indicates that participants with higher scores on the commitment and control

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(group). Third, the assumption of homogeneity of regression slopes was satisfied ($p = .19$). Finally, Levene's test of equality of error variances indicated that the assumption of homogeneity of variance was satisfied (pre-test: $p = .88$; post-test $p = .09$).

[14] Box's *M* indicated that the assumption of homogeneity of variance had been violated ($M = 9.53$, $p = .03$).

[15] Box's *M* indicated that the assumption of homogeneity of variance had been violated ($M = 8.62$, $p = .045$).

subscales of the MTQ-4Cs benefited more from the sleep education programme compared to lower scoring individuals.

Table 23.

Pairwise Comparisons from ANOVA and ANCOVA

	ANOVA	ANCOVA with MTQ-4Cs subscales as covariates
Mean PSQI Change from Pre-test to Post-test.	+1.68 (standard error = .33)	+1.76 (standard error = .29)

Table 24.

Bivariate Correlations for PSQI change, SAS-SV, Screen Time and MTQ-4Cs Subscales

	Mean PSQI Change [95% CI]
SAS-SV	.18 [-.06, .40]
Screen time	-.18 [-.41, .07]
MTQ-4Cs Challenge	-.12 [-.40, .18]
MTQ-4Cs Commitment*	.30 [.01, .54]
MTQ-4Cs Control*	.32 [.01, .54]
MTQ-4Cs Confidence	-.09 [-.33, .21]

* Significant at $p \leq .05$

Participant Engagement

As shown in Table 25, the engagement scale indicated that the large majority of participants felt engaged in learning during the sleep promotion intervention. An ANOVA indicated no statistically significant difference in engagement between the intervention and control groups ($F(1, 32) = 3.0$, $p = .09$).

Table 25

Participant Engagement

Item	**Response**	**Frequency**
I felt engaged in learning during the Sleep Education Programme.	Strongly Agree	*n* = 14
	Agree	*n* = 16
	Neutral	*n* = 3
	Disagree	*n* = 0
	Strongly Disagree	*n* = 0
	Form not Returned	*n* = 3

Exit Survey

The findings of the exit survey are presented in Table 26. Participants indicated that the intervention was acceptable, appropriate and feasible. Participants also indicated that the programme had led to knowledge gains. The intervention and control groups did not differ significantly in terms of total satisfaction (mean of items 1-4) (t (1, 33) = 1.8, p = .09). With the present sample, scale reliability analysis indicated that the exit survey had questionable (α = .67) internal consistency, so these findings should be interpreted with caution. Qualitative feedback was provided by n = 10 participants. This feedback consisted of comments about enjoying or benefiting from the programme (n = 8), a suggestion to deliver the programme over a longer period to support habit formation (n = 1) and a suggestion to include alternative relaxation strategies in the programme (n = 1).

Table 26

Exit Survey Findings

Outcome Measure	**Item**	***M* (*SD*)**
1. Intervention acceptability	I enjoyed the sleep programme.	5.5 (.56)
2. Intervention appropriateness	The sleep programme was suitable for people my age.	5.6 (.49)
3. Intervention feasibility	I think the programme will result in changes in my sleep.	4.9 (.79)
4. Perceived knowledge gained	I learned a lot about sleep.	5.6 (.56)

Note. 1 = strongly disagree; 2 = disagree; 3 = weakly disagree; 4 = weakly agree; 5 = agree; 6 = strongly agree.

Discussion

This study sought to determine the effectiveness of a SBSPI by examining three research questions. First, the study examined whether a SBSPI could improve objectively and subjectively measured sleep parameters. There was evidence of a medium-to-large improvement in subjective sleep quality following the intervention. There was tentative evidence that this improvement may have been driven by increased sleep stability and reduced physiological and cognitive-emotional arousal before sleep. Regarding objectively measured sleep, although a promising trend towards significance emerged, the findings did not support a statistically significant post-intervention increase in sleep duration. The results demonstrated that the effects on sleep parameters were maintained at a four-week follow-up assessment. The second research question examined whether the SBSPI could reduce objectively and subjectively measured PSU. There was tentative evidence that the intervention reduced objectively measured screen time, however, there was no effect on subjectively measured PSU. The effect on screen time was maintained at follow-up. The third research question examined whether the SBSPI could boost MT. The findings did not support the hypothesis that the SBSPI would increase MT.

Causal Mechanisms in Improved Sleep Quality

There is tentative evidence that several subscales of the ASHS increased post-intervention. While there was no significant interaction effect, the less restrictive pairwise comparisons detected a statistically significant change in the intervention group, but not in the control group, for three subscales: sleep stability, physiological arousal and cognitive-emotional arousal. However, there was no change in the overall sleep hygiene scores post-intervention. This finding is surprising for two reasons. First, since regression analysis indicated that almost a third of the variance in PSQI scores was explained by ASHS scores, a medium-to-large increase in post-intervention PSQI scores would be expected to be accompanied by increased ASHS scores. Second, both studies from which the present intervention was adapted (Barber et al., 2017; Brown et al., 2006) detected a statistically significant increase in overall ASHS scores post-intervention.

One possible explanation for the lack of an effect for overall ASHS scores is that improvements in PSQI scores may have resulted from factors other than sleep hygiene. This explanation is plausible given that over two-thirds of the variance in PSQI scores was not accounted for by ASHS scores. For instance, post-intervention changes in the construct of bedtime procrastination may have contributed to improved sleep quality. Kroese et al. (2016) define bedtime procrastination as delaying bedtime without valid external reasons for doing so, despite foreseeable negative consequences. The construct is strongly correlated with sleep insufficiency (Kroese et al., 2014), indicating that it is a suitable target for sleep promotion interventions. Like general procrastination, bedtime procrastination is considered to result from self-regulatory failure (Baumeister, 2002; Kroese et al., 2016). While experimental research on bedtime procrastination is not yet available, a review of the construct has proposed four key elements for interventional studies. These elements include, first, raising awareness of the benefits of sleep sufficiency, second, goal setting, third, progress monitoring and, fourth, prompting. It is noteworthy that each of these elements was employed in the present SBSPI. These elements may have helped to overcome self-regulatory difficulty, thereby reducing bedtime procrastination and improving sleep quality. This assertion, however, remains speculative. It may be fruitful, therefore, to employ a psychometrically validated measure of bedtime procrastination (Kroese et al., 2014) during future research with the present SBSPI.

The Impact of the Intervention on Problematic Smartphone Use

As detailed in a recent systematic review (Mac Cárthaigh, 2020), remediating PSU among adolescents is a formidable challenge. It is promising, therefore, that there is tentative evidence that the present SBSPI impacted upon objectively measured screen time. It may be that the evidence-based behavioural change strategies employed in the SBSPI—psychoeducation, goal setting, progress monitoring, prompting and relapse prevention—contributed to this effect. Since data collection occurred in October and November, it is plausible that the increased screen time in the control group was due to darker evenings and more time indoors. The SBSPI may have acted as a protective factor against increased screen time in the intervention group. Although the findings indicated that the frequency of smartphone use may have been reduced by the SBSPI, the quality of data collected precluded the use of inferential analyses. Surprisingly, however, post-intervention subjective PSU did not differ from baseline.

In the present study, the discrepancy in effects between objective and subjective PSU underscores the importance of not relying on self-report measures, as doing so may fail to reveal important behavioural changes. In support of this, empirical evidence indicates that self-report measures of PSU may lack the sensitivity to accurately predict smartphone usage patterns (Ellis et al., 2019). The poor sensitivity of such self-report tools may result from their inability to assess unconscious, automatic smartphone usage (Ryding & Kuss, 2020). Additionally, research indicates that smartphone usage leads to distortions of subjective time perception (Lin et al., 2015; McLoughlin, 2012; Rau et al., 2006; Turel et al. 2018), thereby limiting the accuracy of self-reported usage. Therefore, given the limited sensitivity of subjective PSU measures and the ease with which objective smartphone usage data may be passively collected (Keusch, 2019), it seems difficult to justify their omission in future interventional research.

Although the causal mechanisms in the relationship between sleep and PSU remain unclear, there is sufficient evidence to warrant the targeting of PSU in SBSPIs (Mac Cárthaigh et al., 2020). This study adds to the limited body of research demonstrating that SBSPIs which consider PSU can affect sleep parameters (Barber & Cucalon, 2017). This is not to say, however, that reduced PSU caused the improvement in sleep quality. It may be the case that the other elements of the study (e.g., sleep regularity recommendations and weekly tasks) explained most of the variance in sleep quality improvement. Further interventional research with several different treatment groups will be required to establish causation in this regard. For instance, it may be fruitful to examine whether an abridged version of the present SBSPI which omits content on PSU remains effective. This would be an instructive line of inquiry given the emerging evidence that the impact of PSU on sleep duration may have been overstated (Mac Cárthaigh et al., 2021b).

The Impact of the Intervention on Mental Toughness

A systematic review has indicated that sleep quality, but not necessarily sleep duration, is correlated with mental toughness (Mac Cárthaigh et al., 2019). This association has led several researchers to propose that sleep promotion interventions, in addition to improving sleep quality, may also boost MT (Brand et al., 2014a; Brand et al., 2014b; Brand et al., 2016; Cooper et al., 2019; Mac Cárthaigh et al, 2019). The findings of the present study, however, do not support this hypothesis. Clinical intervention studies with individuals with sleep disorders frequently lead to large effect size improvements in sleep quality (Davidson et al., 2019). It is plausible that, in such cases, mental toughness may increase in the context of substantial gains in sleep quality. Alternatively, it may be useful to examine whether interventions to improve mental toughness can also boost sleep quality. Several effective interventions to develop mental toughness have been developed in the field of sport psychology (Stamatis et al., 2020) and such interventions have been proposed for educational contexts (e.g., self-reflection training) (Lin et al., 2017; St Clair-Thompson et al., 2015). It may be useful, therefore, for future mental toughness development interventions to examine whether there are added benefits for sleep quality.

While the intervention did not impact upon MT, there was preliminary evidence of a covariate effect between several MTQ-4Cs subscales and the intervention gains in sleep quality. Specifically, higher scores on these subscales were associated with larger gains in sleep quality. This finding may have implications for the implementation of SBSPIs. For instance, MT pre-screening could identify participants who score low on certain subscales and compensatory strategies could be provided. The literature on the development of mental toughness may be helpful in identifying such strategies. In a review of empirical research, Crust and Clough (2011) identified several effective strategies including visualisation, establishing a social support system, and providing additional experiential learning opportunities. It should be noted, however, that this preliminary data on a covariate effect requires replication with a larger sample size and moderation analysis.

The Need for Sleep Interventions in the Irish Context

The descriptive data in this study underscore the need for sleep promotion interventions in Ireland. First, pre-intervention, objective sleep data indicated that 39% of participants failed to reach the established minimum sleep duration requirements (Hirshkowitz et al., 2015). This figure, however, should be interpreted with caution, as evidence from validation research indicates that commercially available sleep trackers overestimate sleep duration (Dickinson et al., 2016; Kolla et al., 2016; Mouritzen et al., 2020; Sargent, 2018). It is likely, therefore, that the proportion of participants meeting the minimum sleep duration recommendations was overestimated in the present study. Second, pre-intervention, 50% of participants were classified as poor sleepers using the established PSQI cut-off (>5). This study, therefore, clarifies the prevalence of sleep insufficiency among middle-adolescent females in the Irish context and highlights the need for effective interventions.

Theoretical Implications

The theoretical basis for SBSPIs has been largely neglected in previous research (Blunden et al., 2012; Blunden & Rigney, 2015). This TPB-informed study provided mixed empirical support for the TPB for application to sleep promotion interventions. Consideration of the three constructs of the TPB—attitudes, subjective norms and perceived behavioural control—was associated with significant improvements in sleep quality. It was surprising, however, that improvements in overall sleep hygiene scores were not detected. Three cross-sectional validation studies have supported the predictive validity of TPB constructs in relation to sleep hygiene among adolescents (Knowlden et al., 2012; Kor & Mullan, 2011; Lao et al., 2016). In light of this predictive validity, these researchers have supported the application of the TPB to interventional research. The present study, however, did not support the hypothesis that a TPB-informed intervention improves overall adolescent sleep hygiene scores. It should be noted, however, that the present study is not an empirical validation study of the TPB. Rather, the study employed an extended-TPB approach (Sniehotta et al., 2014). Extended-TPB approaches complement the TPB model with self-regulatory behavioural change strategies and strategies to promote engagement (Sniehotta et al., 2014). It may be the case that more faithful adherence to the TPB may result in sleep hygiene improvements.

Research should continue to investigate which theoretical frameworks are most suited to SBSPIs (Blunden & Rigney, 2015). It may be useful, for instance, to employ theoretical models which are more specific to adolescent development. In support of this, several literature reviews indicate that behavioural change interventions targeting adolescents are less effective compared to those which are aimed at younger age groups (Heckman & Kautz, 2013; Steinberg, 2015). This age-related decline in effectiveness indicates that the most commonly used theories of behavioural change may not account for the social and neuro-developmental changes which occur during adolescence. Specifically, Yeager et al. (2018) argue that current theories of behavioural change neglect the heightened sensitivity to threats to respect, status and autonomy which occur during adolescence. Yeager et al. detail a theoretical approach to behavioural change which addresses these social and neurodevelopmental changes. Future SBSPIs may benefit from considering this novel theoretical perspective.

Lasting Intervention Effects

Few SBSPIs have demonstrated sustained effects at follow-up assessment (Blunden et al., 2012; Chung et al., 2017; Dietrich et al., 2016). Due to value-for-money considerations, establishing the lasting effectiveness of SBSPIs is likely a prerequisite to the national implementation of such a programme. It is promising, therefore, that the effects detected in the present intervention were maintained at a four-week follow-up assessment. However, despite these encouraging preliminary findings, a longer duration between post-test and follow-up is needed to conclusively demonstrate the durability of the intervention effects. Sleep promotion research with younger children, for instance, has demonstrated lasting effectiveness at a one-year follow-up assessment (Rey et al., 2020). It is recommended that future research investigates the long-term durability of the effects of the present SBSPI.

Limitations

This study has several limitations. First, due to resource constraints, the sample size is limited. There was a non-significant increase in objectively measured sleep duration post-intervention. It is possible that the effect would reach significance in a replication with a larger sample due to increased statistical power. A second limitation is the limited duration and intensity of the intervention. Some of the most promising findings in the sleep promotion literature have employed more intensive or longer duration designs. For instance, Rey et al. (2020) delivered sessions twice weekly for one month and demonstrated objective post-intervention improvements in sleep duration. Similarly, Otsuka et al. (2020) delivered an effective SBSPI over twelve weeks. It would be instructive to determine whether delivering the present intervention over a longer duration would lead to larger effect sizes. Importantly, a longer intervention duration was suggested in the intervention exit survey of the present study. A third limitation is that data on adherence to homework was not collected. Systematic research demonstrates that adherence to homework is predictive of the effectiveness of health promotion interventions (Kelders et al., 2012). Therefore, data on homework completion with the present sample would be instructive for the development of future SBSPIs. However, Allen et al. (1994) found that feelings of autonomy moderate the effectiveness of school-based health promotion interventions. In the present study, there was a concern that weekly checking of homework may have undermined this sense of autonomy, thereby impeding intervention effectiveness. Nonetheless, future studies may benefit from the administration, at the end of the intervention, of a validated measure of homework adherence. An adapted version of the Competence and Adherence Scale for Cognitive Behavioral Therapy (Bjaastad et al., 2016) for instance, may be an appropriate tool.

Conclusion

Adolescent sleep insufficiency is an unmet public health concern with implications for mental and physical health and academic performance. This study demonstrates that a three-week, theory-informed, school-based sleep promotion intervention can improve sleep quality with a cohort of middle-adolescent females in Ireland. There was tentative evidence that the intervention may have reduced screen time. Tentative evidence also indicated that the improvements in sleep quality may have been driven by reduced physiological, cognitive and emotional arousal and increased sleep stability. While a promising trend towards significance emerged, the intervention did not produce a statistically significant increase in objectively measured sleep duration. The data indicated that participants found the intervention acceptable, appropriate, feasible and engaging. Given the consequences, prevalence and limited awareness of adolescent sleep insufficiency, continued research and development on school-based sleep promotion is needed. The final chapter, Critical Review and Impact Statement, will explore in detail the strengths and limitations of the study, ethical considerations and implications for theory, research, policy and practice.

Chapter Four:

Critical Review and Impact Statement

Introduction

This final chapter critically reviews and summarises the process, findings and implications of the thesis. To begin, the ontological, epistemological and axiological lenses through which the thesis was viewed is examined. Following this, the strengths and limitations of the thesis are discussed. This discussion involves a critical appraisal of the research design, measures, sample and intervention. Next, the impact of the COVID-19 pandemic on the thesis is detailed. Two ethical considerations are then explored. First, privacy and confidentiality issues and, second, ethical concerns which arose during the systematic review. Next, the theoretical, research, policy and practice implications of the thesis are outlined. Following this, dissemination details are provided. To close, an impact statement is provided. The impact statement aims to summarise the potential benefits of the research.

Ontology, Epistemology and Axiology

In this section, the ontological, epistemological and axiological lenses through which this thesis was viewed are detailed. An ontological position refers to the assumptions which are made about the nature of the world and what can be known about it (Snape & Spencer, 2003). This project adopted a position of ontological realism. This position assumes that reality consists of structures and objects which have a cause-and-effect relationship with one another (Willig, 2013). Ontological realism also accepts that this reality exists independently of human perceptions and constructions (Maxwell, 2012).

Regarding epistemology, which refers to the assumptions which are made about the nature of knowledge (Richards, 2003), this thesis adopted a positivist perspective. Positivism emphasises the importance of objectivity in gaining knowledge through observation and the distinction between facts and values (Snape & Spencer, 2003). This perspective was adopted for three reasons. First, a positivist epistemology allows for an exploration of causal relationships between phenomena (Houghton, 2011). The ability to make causal inferences was a requirement of the present study since it aimed to determine whether sleep parameters may be improved by a SBSPI. Second, the findings of a sleep promotion evaluation study ought to be replicable and generalisable. Without replicability and generalisability, it is unlikely that a sleep promotion intervention would attract funding from bureaucracies, such as government departments, which are mandated to make value-for-money considerations. These goals of demonstrating replicability and generalisability can be achieved by a positivist theoretical perspective (Wellington, 2000). Third, several reviews of the research body related to school-based sleep promotion have been conducted, and all identified studies adopted a positivist epistemological stance (Blunden, Chapman, & Rigney, 2012; Blunden & Rigney, 2015; Cassoff, Knäuper, Michaelsen, & Gruber, 2013; Gruber, 2017). This indicates that a positivist epistemological perspective was best suited to the exploration of the research questions posed in this thesis.

Alternative epistemological positions, such as constructivism, were not deemed appropriate to address the research questions in this thesis. Compared to positivism, constructivism is more concerned with the inter-subjective meaning of phenomena (Craig, 2000). This epistemological position is appropriate for certain research questions. For instance, constructivism helps establish perceived barriers and perceived enablers to adequate sleep hygiene. Indeed, such research questions have been addressed by constructivist researchers (Orzech, 2013; Paterson et al., 2019; Quante et al., 2019) and were considered during the development of the present sleep promotion intervention[16]. Specifically, Paterson et al.'s finding that sleep is frequently sacrificed for study time was considered during intervention development. Therefore, while some constructivist research certainly informed this thesis, the research questions regarding the effectiveness of the sleep promotion intervention were better suited to a positivist epistemological approach.

Axiology is the branch of philosophy dealing with values (Smith & Thomas, 1998). Traditionally, positivists have endorsed undertaking research in a value-free way to maintain objectivity (Thornhill et al., 2009). However, this position was challenged by the post-positivist perspective. Post-positivists grant that, in reality, research is inherently value laden. To address this issue, post-positivists endorse a commitment to scientific values: scepticism, objectivity, rigour and modesty (Dorsey, 2018). This thesis aligned with the post-positivist axiological perspective by acknowledging the value-laden (and, therefore, bias-laden) nature of research. These biases were then guarded against by remaining committed to scientific values.

Strengths and Limitations

As was done in the literature review in Chapter Two, Gough's (2007) Weight of Evidence (WoE) framework was used to critically appraise the present study. The WoE framework examined three areas of research quality. First, the methodological quality of the study was assessed (WoE A: methodological quality). Second, the relevance of the study's chosen methodology was determined (WoE B: methodological relevance). Third, the focus of the study was evaluated for relevance to the specific research questions (WoE: relevance to the research question). Finally, to obtain an overall

[16] For details about the qualitative research, please see Chapter 3: Empirical Paper, 121.

quality index, the mean of scores A-C was calculated to produce an overall WoE score (WoE D: overall weight of evidence).

WoE A: Methodological Quality

Methodological quality was assessed with the Johanna Briggs Institute's critical appraisal checklist for quasi-experimental studies (Tufanaru et al., 2017). The use of this nine-item checklist is supported by several reviews of quality assessment tools (Santos et al., 2018; Zeng et al., 2015). Summed points from the checklist indicated the overall methodological quality of the study, with 0 points indicating that none of the quality criteria had been met, and 9 points indicating that all criteria had been met. In line with the systematic reviews in chapter two, the study may be described as high quality (≥ 8 points), acceptable quality (4-7 points), or low-quality (≤ 3 points). High, acceptable and low-quality studies are assigned a WoE A score of 3, 2 and 1, respectively. As shown in Table 29 (WoE summary table), the present study was assigned a WoE A score of 2 (acceptable quality). The completed WoE A quality assessment checklist is available in Appendix 19.

Completion of the WoE A quality assessment checklist revealed a profile of methodological strengths and weaknesses. Two key methodological strengths will be detailed. First, demographic similarity between the intervention and control groups is a strength of the present study. In both groups, participants were female, aged 15-16 years, in transition year, and had no diagnosed sleep disorders. In addition, ethnic representation was similar in both groups[17]. There are well-replicated gender (Cheng et al., 2012; Galland et al., 2017; Johnson et al., 2006; Tsai et al., 2004; Zhang & Wing, 2006) and age-related (Hirshkowitz et al., 2015) differences in sleep parameters. In

[17] Intervention: Caucasian 86%, Asian 8% and Black 6%. Control: Caucasian 79%, Asian 14% and Black 7%.

addition, meta-analytic research indicates that there are ethnic differences in sleep quality (Ruiter et al., 2011). Demographic discrepancies between the intervention and control group may, therefore, have confounding effects which threaten internal validity. However, in the present study, demographically similar groups protected against this confounding effect. A second methodological strength of the present study was the use of a follow-up assessment of intervention effectiveness. As noted in the literature review, a limitation of previous research evaluating the effectiveness of SBSPIs is the limited use of follow-up assessments (Blunden et al., 2012; Chung et al., 2017; Dietrich et al., 2016). Sleep promotion interventions that fail to demonstrate effects beyond the immediate post-test period may have limited practical significance since there is unlikely to be governmental support for the large-scale roll-out of such programmes. It must be noted, however, that a longer duration between pre-test and follow-up would have been preferable in the present study. Rey et al. (2020), for instance, demonstrated the effectiveness of a SBSPI with primary school-aged children at a one-year follow-up assessment. The resource constraints of the current SBSPI, however, precluded the use of a longer follow-up assessment. Future research should address this limitation.

Three methodological limitations will be examined. First, measurement of outcome variables was not conducted at multiple time points pre-intervention. The collection of multiple measures pre-intervention allows for the exploration of the plausibility of alternative explanations, other than the SBSPI, for the observed effect (Tufanaru et al., 2017). Alternative explanations, for instance, could include seasonal fluctuations in sleep parameters[18] (Hashizaki et al, 2018; Suzuki et al., 2019) or regression towards the mean (Tufanaru et al., 2017). While the use of a control group mitigated these confounding factors to some extent, multiple pre-intervention

[18] Seasonal fluctuations in sleep are discussed in Chapter 3: Empirical Paper, page 109.

measurements would have further improved the robustness of the findings. A second limitation is the sample size discrepancy between the intervention and control groups. Unequal sample sizes across groups can decrease statistical power and decrease robustness to violations of statistical assumptions (Weiner, 2003). However, the cause of the sample size discrepancy has implications for the risk of bias. Sample size inequality due to the planned study design, as was the case in the present study, has a lower risk of bias compared to inequality caused by attrition. Nonetheless, future research efforts could address this limitation by employing equal sample sizes or a larger control group. A third limitation of this study relates to the validation of the sleep tracking device. While there is empirical support for earlier versions of the device which was used in this study (Xiaomi Mi-Band 2 and 3) (Ameen et al., 2019), validation studies have not yet been conducted with the more recent model which was used in this study, the Xiaomi Mi-Band 4. This limitation, however, highlights an issue which will continue to affect sleep research which employs commercial sleep tracking devices. Specifically, the peer-review of validation studies will frequently fail to keep pace with the release of newer models of devices. As noted in a comprehensive review of wearable sleep trackers in research settings, although this technology holds great promise for understanding sleep health, guidelines for standardised validation research are required (de Zambotti et al., 2018).

WoE B: Methodological Relevance

This study sought to establish whether a SBSPI can improve sleep parameters, increase MT and reduce PSU. Accordingly, a study design which facilitates causal inferences was required. Brannen's (2017) hierarchy of evidence delineates the most useful research designs in this regard. The criteria used to determine methodological relevance (WoE B) is presented in Table 27. These criteria indicated that the present study had a WoE B score of 2 (acceptable relevance). The quasi-experimental design which was used in the present study, unlike true experiments, does not employ random group assignment. Randomisation is challenging (Ary et al., 2018) but not infeasible in educational contexts. Given the promising preliminary results of the present study, it may be fruitful to attempt to replicate these findings with a randomised experimental design.

Table 27

WoE B Criteria and Rationale

Quality	Criteria	WoE B Score	Rationale
High	Systematic reviews, meta-analyses, randomised controlled trials or controlled experimental designs.	3	Informed by Brannen (2017).
Acceptable	Uncontrolled experimental designs, quasi-experimental designs, cohort studies, case-control studies or N-of-1 studies.	2	
Low	Qualitative studies, cross-sectional surveys or case reports.	1	

WoE C: Relevance to the Research Questions

WoE C evaluated the relevance of the focus of the study to the research questions. In line with the literature review in Chapter Two, there were three WoE C criteria[19], as detailed in Table 28. Criterion one evaluated the proportion of participants who fell within the target age range. Since all participants were within the target age range, a score of 3 (high) was assigned to WoE C criterion one. Criterion two examined the use of objective PSU outcome measures. A score of 3 (high) is assigned if the study employs two objective measures of PSU. While it had been planned to analyse both screen time and frequency of use data, the poor quality of the latter precluded its inclusion in inferential analyses. Therefore, a score of 2 (acceptable) was assigned for WoE C criterion two. Future research efforts could attempt to address this limitation. Finally, WoE C criterion three evaluated the use of both objective and subjective sleep outcome measures. The present study was assigned a score of 3 (high) for WoE C criterion three.

[19] The rationale for the WoE C criteria is detailed in Chapter 2: Literature Review, page 52.

Table 28

WoE C Criteria

Criteria	Weighting	
1. The proportion of participants between the ages of 14 and 24 (inclusive).	3 (high)	All participants between the ages of 14 and 24 (inclusive).
	2 (acceptable)	More than 90% of participants between the ages of 14 and 24 (inclusive).
	1 (low)	Fewer than 75% of participants between the ages of 14 and 24 (inclusive).
2. Variables for PSU.	3 (high)	Two or more objective measures of smartphone use, such as duration and frequency of use.
	2 (acceptable)	One objective measure of smartphone use.
	1 (low)	No objective measures of smartphone use.
3. Variables for sleep.	3 (high)	Both objective and subjective measures of sleep.
	2 (acceptable)	Objective measures of sleep only.
	1 (low)	Subjective measures of sleep only.

WoE D: Overall Weight of Evidence

The mean score of WoE A-C was calculated to produce WoE D, the overall weight of evidence, as shown in Table 29. The overall weight of evidence was 2.2 (acceptable). The WoE evaluation has highlighted several strengths and limitations. Future research efforts should attempt to address these limitations.

Table 29

WoE Summary Table

Quality of Methodology (WoE A)	Relevance of the Methodology (WoE B)	Relevance for the Research Question (WoE C)	Overall Weighting (WoE D)
2 (acceptable)	2 (acceptable)	2.7 (high)	2.2 (acceptable)

The Impact of the COVID-19 Pandemic

Contingency Planning

Originally, it had been planned to run the sleep promotion intervention twice: once in spring 2020 and once in autumn 2020. The rationale for running the intervention twice was two-fold. First, to maximise statistical power with a large sample size. Second, to allow for a comparison of the effectiveness of the intervention between an all-girls and all-boys school. This comparison would have been instructive given the well-replicated gender differences in adolescent sleep quality (Cheng et al., 2012; Galland et al., 2017; Tsai et al., 2004) and sleep disorder prevalence (Johnson et al., 2006; Zhang & Wing, 2006). However, in response to the COVID-19 pandemic (World Health Organization, 2020b), school closures were implemented by the Irish government on March 12th, 2020 (Department of Education and Skills [DES], 2020). As a result, data collection in spring 2020 was not possible. Given the risk of further data collection disruption in autumn 2020, it was deemed necessary to establish a contingency plan.

As a contingency plan, an online cross-sectional study was designed. This new design was based on three additional research questions which emerged from systematic reviews one and two. First, what is the relationship between objectively measured sleep duration and objectively measured PSU? Second, what is the relationship between objectively measured sleep duration and mental toughness? Third, what is the relationship between objectively and subjectively measured PSU and mental toughness? Since the study was concerned with the relationship between these variables among middle-to-late adolescents, the inclusion criterion required participants to be aged 14-24 years. Self-report scales which were employed in the sleep promotion study were also used in the contingency study. These scales included the PSQI (Buysse et al., 1989), SAS-SV (Kwon et al., 2013) and MTQ-4Cs (Strycharczyk et al., 2021). To collect objective data, participants were asked to report sleep data from sleep tracking devices and smartphone usage data collected through pre-installed applications. The study produced a large dataset of N = 2053 participants.

The contingency study produced an original contribution to knowledge by contradicting the prevalent notion that PSU has a clinically significant impact on sleep quality and duration. Using self-reported data, sleep quality was found to correlate weakly with both PSU and MT. These findings comport with previous research on the relationship between sleep quality, PSU and MT (Mac Cárthaigh et al., 2019; Mac

Cárthaigh et al., 2020). The results from objective data, however, contrasted sharply with subjective data. While several significant correlations emerged (screen time and sleep quality; screen time and MT; pickups and MT; objective sleep duration and screen time), in all cases, the effect sizes were negligible. Furthermore, objective sleep duration did not correlate with self-reported MT or PSU. Regression analysis indicated that screen time explained just 1.3% of the variance in sleep quality. Similarly, smartphone usage metrics explained just 2% of the variance in MT. Regression analysis indicated that smartphone usage metrics were not predictive of objective sleep duration. Finally, objective sleep duration was not found to be predictive of MT.

In light of the findings of the contingency study, the recommendation to minimise screen time should not be prioritised over sleep hygiene advice with more well-established empirical support. Four examples will be detailed. First, stimulus control strategies are well established as a means of improving objectively measured sleep quality (Perlis et al., 2006). Stimulus control strengthens the association between bed and sleep, while simultaneously weakening the association between bed and wake-promoting activities (Bootzin et al., 1991). Harvey et al. (2002) demonstrated that stimulus control is the strongest predictor of clinical gains during cognitive behavioural therapy for insomnia. Second, meta-analytic research suggests that early-morning light exposure produces moderate effect size improvements in objectively measured sleep parameters (Van Maanen et al., 2016). Third, the recommendation to minimise evening consumption of caffeine is also well-supported by randomised, placebo-controlled studies (Roehrs & Roth, 2008). A fourth recommendation which is well-supported by the empirical literature is to minimise evening light exposure in general, rather than selectively reducing exposure to light emitted from smartphones (Bartel et al., 2015; Munch et al., 2006; Phillips et al., 2019; Santhi et al., 2012; Te Kulve et al., 2019).

Since there were no further school closures in autumn 2020, the contingency plan was not required. Although the option of including the contingency study in the thesis was considered, it was decided that doing so may leave insufficient space to comprehensively describe the sleep promotion study. Therefore, it was decided to publish the contingency study separately, but briefly refer to its original contribution to knowledge in the critical review chapter of the thesis.

COVID-19 and Sleep

Given the emerging evidence on the relationship between COVID-19 and sleep, a brief discussion of this connection is warranted. Sleep insufficiency is well-recognised as a risk factor for susceptibility to viral infections. For instance, experimental research has shown that, compared to those who habitually sleep seven or more hours per night, those who sleep fewer than five hours per night are 2.9 (Cohen et al., 2009) to 4.5 (Prather et al., 2015) times more likely to develop symptoms when exposed to rhinoviruses. Evidence also suggests that sleep insufficiency is a risk factor for respiratory infections (Prather & Leung, 2016; Su et al., 2014). While research is not yet available to directly link sleep quality or duration to susceptibility to the SARS-CoV-2 virus, several researchers argue that this connection is likely (Cohen, 2020; Ferini-Strambi et al., 2020; Leone et al., 2020).

Another well-replicated finding is that sleep duration and quality affect anti-body response following hepatitis A (Lange et al., 2003; Lange et al., 2011), hepatitis B (Prather et al., 2012) and influenza vaccinations (Prather et al., 2020; Spiegel et al., 2002; Taylor et al., 2017). Again, while there is no evidence yet to indicate that the same is true for COVID-19 vaccines, it is plausible that this may be the case (Garbarino & Scoditti, 2020). It is likely, then, that sleep promotion efforts could play an important role not only in reducing COVID-19 symptoms, but also in enhancing herd immunity through improved antibody response following vaccination.

Ethical Considerations

Ethical approval for the SBSPI was granted on December 6th, 2019 by the Mary Immaculate Research Ethics Committee (MIREC) (Appendix 20.1). However, due to disruption caused by COVID-19 restrictions, it was necessary to submit a second application to MIREC for the contingency study described above. Ethical approval for this study was granted by MIREC on June 15th, 2020 (Appendix 20.2). Two ethical issues are discussed. First, participants' right to confidentiality and anonymity and, second, ethically questionable research methods which emerged during the systematic literature review.

Prioritising Privacy and Confidentiality

Section 1.2 of the Psychological Society of Ireland's Code of Professional Ethics (2019) mandates that psychologists uphold the values of privacy and confidentiality. There is also, however, a statutory responsibility to abide by these ethical guidelines. The General Data Protection Regulations (GDPR) (European Parliament and Council of European Union, 2016) legally uphold European Union citizens' right to have their personal data protected. In light of these ethical and statutory mandates, steps needed to be taken to protect participants' privacy and confidentiality during the present study. Steps which were taken included but were not limited to: adhering to data protection best practice guidelines (Department of Health, 2018a: Data Protection Commission, 2018); making contingency data storage arrangements in case there was a change of supervisor; developing consent and assent forms to clarify that identifying data would not be collected; adhering to the Mary

Immaculate College Record Retention Schedule (Mary Immaculate College, 2018); and, finally, making arrangements for secure storage of research data.

In addition to the ethical and legislative basis for upholding participants' privacy and confidentiality, doing so also improves the internal validity of research. This is because prioritising privacy and confidentiality reduces demand characteristics, a well-recognised threat to internal validity (Nichols & Maner, 2008). Demand characteristics refer to the confounding effect of participants' awareness of the purpose of an experiment (Orne, 1962). To ensure that the effects on the dependent variable (in this case, sleep parameters) are attributable to the independent variable (in this case, the SBSPI), demand characteristics should be minimised. One of the most well-established approaches to reduce this confounding factor is to prioritise anonymity and confidentiality during the administration of questionnaires. It is important that participants are aware of this prioritisation (Paulhus, 1991). Therefore, it is likely that the steps taken to protect privacy and confidentiality in this thesis improved the internal validity of the findings.

Ethically Dubious Research Designs

One study identified in systematic review two (Cooper et al., 2019) employed an experimental research design involving sleep restriction. These designs, known as negative sleep interventions, are common in the cognitive sciences (De Bruin et al., 2017). Negative sleep interventions have certainly advanced the understanding of the harmful effects of sleep insufficiency on health and well-being. However, it is precisely these revelations which bring into question the ethics of negative sleep interventions. Such research designs contravene the non-maleficence principle of psychological codes of ethics (e.g., APA, 2016; British Psychological Society [BPS], 2018; PSI, 2019). While it could be argued that the principle of beneficence is met in the contribution such research makes to wider society, this comes at the expense of participants' safety. Surprisingly, despite the popularity of negative sleep interventions, just one peer-reviewed paper has explored the ethical implications of such research (Barber, 2017).

Extreme experimental sleep restriction (24-205 hours) was not unusual in the latter half of the 20th century (Waters et al., 2018). These studies found that sleep restriction caused hypertension (Palagini et al., 2013), low mood (Carskadon & Dement, 1979) and psychotic symptoms (Waters et al., 2018). In light of these risks, more recently, research designs employing partial sleep restriction (4-6 hours) have been more common. However, several studies have now shown that even partial sleep restriction can impair cognitive and motor function to the same extent as legal alcohol intoxication (Fairclough & Graham, 1999; Williamson & Feyer, 2000). Despite these risks, as noted by Barber (2017), few negative sleep interventions detail the steps which were taken to reduce the risks to participants, for instance, road traffic safety considerations.

A thorough discussion of the dubious ethics of negative sleep interventions was beyond the scope of the systematic review. It was considered appropriate, however, to flag these ethical concerns for the reader, and to suggest more tenable research designs[20]. Specifically, the research question of the systematic review two (what is the relationship between sleep and MT?) can be investigated just as validly by using experimental sleep extension rather than restriction. There is support for greater consideration of ethical issues in systematic research. For instance, Weingarten et al. (2004) argue that systematic reviews should routinely evaluate the ethical standards of clinical research. Importantly, Weingarten asserts that this routine evaluation would not only promote ethical research, but also improve the internal and external validity of research findings.

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[20] More ethical research designs are suggested in Chapter Two: Literature Review, page 97.

Implications of the Thesis

Implications for Theory

This thesis provides mixed empirical support for the TPB (Ajzen, 1985) as a framework for SBSPIs. The TPB-informed intervention increased sleep quality and reduced screen time. Although there was a promising trend towards significance, statistically significant improvements in objective sleep duration were not detected. No significant improvement was detected in overall sleep hygiene scores, subjective PSU or MT. These findings indicate that targeting the three components of the TBP—attitudes, subjective norms and perceived behavioural control—may be insufficient to influence these constructs. In light of these findings, the limitations of the TPB will be examined.

Although it is among the most well-supported behavioural change models[21], the TPB is not without detractors. Three critiques of the theory will be discussed in the context of the findings of this thesis. First, there are concerns about the empirical validation of the TPB. The majority of validation studies have investigated cross-sectional associations between TPB constructs and behaviours (Noar & Zimmerman, 2005), but little experimental validation is available. Moreover, much of the available experimental research does not fully support the TPB (Hardeman et al., 2002). This thesis adds to this limited body of experimental research by showing that the TPB may be a useful framework to modify sleep parameters. A second critique of the TPB is that few studies have examined the predictive validity of the model in terms of objectively measured behavioural outcomes (McEachan, 2011). Moreover, of the studies which have employed objective measures, the TPB was found to have limited predictive

[21] For an overview of the empirical support for the TPB, please see Chapter Three: Empirical Paper, page 117.

validity. This thesis provides tentative support for the TPB because the SBSPI led to improvements in objectively measured screen time, and there was a trend towards significance in objectively measured sleep duration. A third critique of the TPB is that it is an unrealistically parsimonious account of human behaviour. As a result, researchers frequently deem it necessary to employ extended forms of the theory which include additional behavioural change and psychoeducation strategies (e.g., Cooke et al., 2007; Masser et al., 2009). Indeed, the present SBSPI used an extended-TPB approach due to the inclusion of additional strategies. However, Sniehotta et al. (2014) argue that the extended-TPB approaches may undermine the novel models under investigation by providing unwarranted support to the TPB. For instance, in the present SBSPI, it remains unclear whether the intervention effects can be attributed to TPB constructs, the evidence-based behavioural change and psychoeducation strategies which were used, or a combination of both factors. It may be worth considering, therefore, whether it is useful to retain the TPB in its current form, or whether the constructs within the theory should be amalgamated into a broader model, as recommended by Sniehotta et al.

Implications for Research

This thesis shows that a three-week SBSPI can improve sleep quality among a cohort of middle-adolescent females from a large, non-disadvantaged, urban school in Ireland. These results, however, are not necessarily generalisable to other settings or demographics. To determine the generalisability of the present SBSPI, further research is required. Therefore, replication studies are recommended in mixed-gender, all-boys, rural and disadvantaged schools.

Replication of the present SBSPI should be prioritised in disadvantaged schools. In support of this, a recent meta-analysis has confirmed that socio-economic status is associated with adolescent sleep duration (Tomfohr-Madsen et al., 2020). Similarly, a systematic review has concluded that sleep quality is poorer among socio-economically disadvantaged adolescents (Felden et al., 2015). Sleep promotion efforts may, therefore, be more impactful in disadvantaged schools due to a lower baseline of sleep parameters. Alternatively, sleep parameters may be more resistant to change due to factors such as poverty and reduced access to resources. In light of the impact of sleep on health, well-being and academic performance[22], replication of the present SBSPI may advance the Irish government's commitment to improving equity in health outcomes (Department of Health, 2013) and educational opportunity (DES, 2015).

It may also be useful to evaluate the impact of delivering the present SBSPI over a longer duration. When evaluating behavioural change interventions, judgements of "effectiveness" should be based not only on effect magnitude, but also on cost-effectiveness (National Institute for Health and Care Excellence, 2014). Most commonly, four weekly 50-minute sessions have been used in SBSPIs (Chung et al., 2017). Contrastingly, some SBSPIs ran programmes over twelve weeks (Azevedo et al., 2008) or in a single session (Barber et al., 2017; Brown et al., 2006; Cortesi et al., 2004; Díaz-Morales et al., 2012). To balance cost-effectiveness with the opportunity to affect behavioural change, it had originally been planned to use five weekly 60-minute sessions in the present SBSPI. Unfortunately, due to disruption caused by the COVID-19 pandemic, it was necessary to switch to a three-week intervention. A fruitful line of research would be to determine whether a five-week intervention produces larger effect sizes. Delivering the intervention over a longer period was advised by one participant in the exit survey. In addition, a longer follow-up assessment of intervention effectiveness is required. While this study demonstrated that effects were robust three weeks post-

[22] For an overview of the impact of sleep on health, wellbeing and academic performance, please see Chapter Two: Literature Review, page 103.

intervention, it remains unclear whether the effects were sustained beyond that period. An interesting line of inquiry, therefore, would be to determine whether intervention effects are sustained until the end of the school term, which in Ireland is four months.

To facilitate replication, the resources developed for the present SBSPI have been made available online for future research efforts. These materials include the questionnaire, exit survey, Mi-Band usage instructions, goal setting and review document, progress monitoring questionnaire, PowerPoint presentations with facilitator notes, session overviews and letters and videos for parent(s) and/or guardian(s). In addition, a sleep hygiene resource pack for clinical settings has been made available. All resources are freely available to download and adapt through this link[23]. Inquiries can be directed to sleepeducationprogramme@gmail.com.

Implications for Policy

Internationally, there has been a growing awareness of the prevalence and implications of adolescent sleep insufficiency among policymakers (Morgenthaler et al., 2015). Despite this increased awareness, however, the public health concern of adolescent sleep insufficiency has not been recognised in national policy documents in Ireland[24]. In other countries, two main policies have been implemented to address the issue: adjustment of school start times[25] and school-based sleep promotion. This thesis has implications for the latter.

The Irish government recently published the Wellbeing Policy and Framework for Practice (DES, 2018a). This policy mandates that schools implement a well-being promotion process by 2023. The policy emphasises the need for approaches that are evidence-informed, inclusive of families and outcomes-focused. The present SBSPI

[23] https://drive.google.com/drive/folders/1ZmHCrIstKJ5haeyh0DbqKnqNkwIbjc2_?usp=sharing
[24] For an overview of policy issues, please see Chapter Three: Empirical Paper, page 105.
[25] School start times are discussed in Chapter Three: Empirical Paper, page 108.

meets these requirements. The Wellbeing Policy and Framework for Practice may, therefore, be an opportunity to begin to address adolescent sleep insufficiency by implementing SBSPIs nationally. However, schools may be unlikely to implement SBSPIs unless policymakers are aware of the prevalence, consequences and resolvability of adolescent sleep insufficiency. Therefore, policies are needed to improve attitudes towards sleep at a population level.

Lessons can be learned from public policies on road safety in Ireland. Between 2004 and 2006, there was a mean of 378 annual fatalities on Irish roads. Fourteen years later, the rate had more than halved, with a mean of 145 fatalities annually between 2017 and 2019 (Department of Transport, 2020). This remarkable progress now makes Irish roads the second safest on earth (European Commission, 2020). Improvements in road safety in Ireland are attributed to a range of policies which were established in landmark road safety policy documents (Department of Housing, Local Government and Heritage [DoHLGH], 1998; Road Safety Authority [RSA], 2007, 2013). Actions within these policy documents included the introduction of penalty points, the introduction of the national car test, the establishment of the Road Safety Authority, mandatory alcohol testing, investment in infrastructure and, finally, road safety education campaigns.

As was the case with road safety, public policy has an important role to play in remediating adolescent sleep insufficiency. Four policy issues will be detailed. First, recognition of the issue in national policy documents appears to be an important prerequisite for meaningful improvements in adolescents sleep. As was the case with road safety policy documents (DoHLGH, 1998; RSA, 2007, 2013), a national sleep policy could create an accountable vision for change. Second, sleep health information should be integrated with school curricula. At present, there is no reference to sleep in the senior cycle social, personal and health education (SPHE) curriculum framework (National Council for Curriculum and Assessment, 2011). In contrast, the RSA have prepared a range of educational materials which can be integrated into school curricula (RSA, 2020). Third, mass media campaigns could raise awareness of the importance of sleep among policymakers, school staff and families. Such campaigns were a key part of the road safety strategy in Ireland (Department of Transport, 2020) and their effectiveness has been empirically demonstrated (Delaney et al., 2004; Wakefield et al., 2010). Fourth, in the same way that road safety was improved by establishing the Road Safety Authority, sleep insufficiency could be addressed by establishing a sleep health working group. A working group could bring several benefits, including more research on sleep insufficiency within the Irish context, the development of sleep promotion interventions and the fostering of multi-disciplinary expertise in sleep health.

The four policy issues outlined above may begin to convey to educational policymakers the prevalence and gravity of adolescent sleep insufficiency. Influencing policymakers is important because although this thesis demonstrates that a SBSPI can improve sleep quality, this finding will have limited practical significance if demand for SBSPIs remains low.

Implications for Practice

Implications for Educational and Child Psychologists in Ireland

Three possible implications of this thesis for educational and child psychologists will be discussed. First, the possibility of the National Educational Psychological Service (NEPS) delivering SBSPIs will be explored. Second, barriers to educational and child psychologists' involvement in the promotion of sleep health will be outlined. Third, potential improvements to current sleep promotion efforts in the Health Service

Executive (HSE) will be detailed.

NEPS are well-placed to deliver SBSPIs in Irish schools. There are several reasons for this. First, SBSPIs align with the NEPS model of service delivery. Prevention science (Coie et al., 1993) is the theoretical framework which underpins the NEPS model of service delivery (Nugent et al., 2018). Prevention science emphasises the reduction of risk factors and the promotion of protective factors (Coie et al., 1993). The value of sleep as a protective factor against ill-health has been detailed in this thesis[26]. Therefore, the implementation of SBSPIs would advance NEPS' goal of promoting preventative mental health care. Second, NEPS psychologists have masters or doctoral-level training in child and adolescent development and the delivery of group interventions (Psychological Society of Ireland, 2017). Third, the Department of Education has mandated that all Irish schools implement universal, preventative wellbeing interventions by 2023 (DES, 2018a). NEPS, as an agency of the Department of Education, are well placed to provide leadership with this initiative by implementing evidence-based SBSPIs.

Barriers to Educational and Child Psychologists' Involvement in SBSPIs.

Although this thesis has argued that educational and child psychologists are well-placed to deliver SBSPIs, potential barriers remain. The first barrier is knowledge. In an examination of UK educational psychologists' knowledge of child sleep problems, Furlong (2019) revealed inadequate knowledge of child sleep problems among educational psychologists in the UK. Specifically, there was poor knowledge about recommended sleep durations for children and adolescents. Educational psychologists more commonly underestimated recommended sleep durations compared to parents and

[26] For an overview of the research on the protective value of sleep, please see Chapter Two: Literature Review, page 103.

school staff. This is a concerning finding given the emphasis on evidence-based practice in educational psychology (Kratochwill & Shernoff, 2004).

The second, but related, barrier is a lack of pre-service and in-service training. Furlong (2019) found that the majority (89%) of a sample of educational psychologists in the UK indicated that they would benefit from in-service training on the promotion of sleep health. In addition, the majority of educational psychologists in the sample indicated that information on child sleep health had not been covered during initial doctoral training (73%) or in-service training (89%). Similarly, in the US, Buckhalt et al. (2009) found that although school psychologists are well-placed to deliver interventions, there is a need for increased pre-service and in-service sleep-specific training. Therefore, it may be necessary to address insufficient knowledge and training to ensure that educational and child psychologists are working within their professional competencies, as mandated by codes of professional ethics (BPS, 2018; PSI, 2019).

Anderson and Tyldesley (2019) used a structured consultative process to determine the competencies which may be required for educational psychologists working with clients who sleep insufficiently. Five key competencies emerged: first, knowledge of the impact of sleep insufficiency on learning, development and mental and physical wellbeing, second, questioning techniques to identify sleep insufficiency, third, sleep advocacy skills and, fourth, skills in evidence-based intervention for sleep insufficiency. It may be useful to embed these five competencies in doctoral training programmes for educational and child psychologists and continuing professional development for practising psychologists. In addition, it is recommended to add sleep-related content to accreditation criteria for professional doctoral training in educational psychology in Ireland and the United Kingdom (British Psychological Society, 2019; Psychological Society of Ireland, 2017). Taking these steps would be an important recognition of the problem of adolescent sleep insufficiency and the role educational and child psychologists have in remediating the issue.

Implementation science (Kelly, 2012) could provide an appropriate framework for the implementation of training for psychologists on adolescent sleep insufficiency and SBSPIs with adolescents. Implementation science is a discipline which explores what causes interventions to be effective in real-world contexts (Kelly & Perkins, 2012). The principles of implementation science should be considered during the design, delivery and evaluation of SBSPIs and training for psychologists. Adhering to these principles not only increases programme effectiveness, but also ensures efficient use of resources (Moir, 2018). These principles include but are not limited to the use of a problem-solving framework (e.g., Monsen et al.'s (1988) Problem Analysis Framework), evaluating readiness for change, increasing the voice of the target group (i.e., psychologists or adolescents) and conducting a thorough programme evaluation with standardised tools (Kelly & Perkins, 2012).

Implications for Sleep Promotion Programmes Currently in Use

In 2018, the HSE, in partnership with other organisations[27], launched The Sleep Programme (Comerford et al., 2018). The programme is a five-week sleep promotion intervention for adolescents. This programme has notable strengths, including the inclusion of adolescents during the development of the programme. In addition, the programme is presented as a semi-manualised toolkit which may be easily implemented by school staff, psychologists or other professionals. The Sleep Programme also emphasises the importance of the inclusion of parent(s) and/or guardian(s). Finally, the programme uses an interactive mode of content delivery. The Sleep Programme is an

[27] Other organisations involved in the development of The Sleep Programme included Daughters of Charity Child and Family Service, Crosscare/East Wicklow Youth Service, Bray Sports Promotion Unit and TUSLA Child and Family Agency.

important acknowledgement of the problem of adolescent sleep insufficiency. There are, however, important limitations of the programme.

The main limitation of The Sleep Programme is that it is not evidence-based. The only evaluation study of The Sleep Programme detected no change in sleep quality, sleep duration or sleep hygiene post-intervention (McGrath, 2018). This conclusion should not be overinterpreted as the small sample size ($N = 12$) limited the statistical power of the analysis. It may be the case that an evaluation study with a larger sample size would reach statistical significance. There were, however, other limitations of the evaluation study including the absence of a control group, no validated sleep quality measures and no objective measures. There was also an important limitation of the intervention delivery. The TPB emphasises that the credibility of information should be bolstered during persuasive communication. However, in The Sleep Programme, information about sleep hygiene and the consequences of sleep insufficiency was provided without clarifying the empirical basis for these claims. This may have limited the credibility of the information and, hence, the motivation for change.

The benefits of evidence-based interventions are widely recognised. These benefits include improved quality of healthcare, increased client safety, increased accountability, improved value for money and efficient use of resources (American Psychological Association, 2006). Moreover, the use of non-empirically supported interventions contradicts the Department of Health and the HSE's own policies, which emphasise the need for evidence-based practise (Department of Health, 2018a; HSE, 2019). Therefore, it may be advisable for the HSE to consider either re-evaluating The Sleep Programme with a larger sample or, alternatively, launching a new sleep promotion initiative. The SBSPI in the present thesis may be a suitable starting point for the latter option.

Dissemination

Thesis dissemination is ongoing. Systematic review one, which examined the relationship between sleep and PSU, has been published in *Developmental Review*, a high impact factor academic journal (Mac Cárthaigh et al., 2020). An abridged version of the empirical paper is currently under review with *School Psychology International* (Mac Cárthaigh et al., 2021a). The contingency study is currently under review with *Stress & Health* (Mac Cárthaigh et al., 2021b). In order to disseminate the findings to practising educational and child psychologists in Ireland, a summary of the research project has been prepared for submission to *The Irish Psychologist*, the official magazine of the Psychological Society of Ireland. Finally, some of the resources developed during this thesis are currently being used in two child psychology services in Ireland.

Impact Statement

This thesis has made an original contribution to knowledge and may be impactful in four domains: theory, research, policy and practice. First, with regard to theory, the empirical paper of this project was the first to use the theory of planned behaviour as the framework for a SBSPI. The strengths and limitations of this theoretical approach have been highlighted[28]. In addition, directions have been offered on how the theoretical underpinnings of SBSPIs may be further developed[29].

Second, this thesis impacts upon the empirical understanding of SBSPIs. The empirical paper addressed the limitations of previous SBSPIs. Specifically, there had been a lack of controlled designs, little use of objective measures, reliance on didactic

[28] The strengths of the TPB are outlined in Chapter 3: Empirical Paper, page 117. The limitations of this theory are discussed in Chapter 4: Critical Review and Impact Statement, page 173.

[29] Directions for the development of the theoretical underpinnings of SBSPIs are offered in Chapter 3: Empirical Paper, page 152, and Chapter 4: Critical Review and Impact Statement, page 173.

modes of intervention delivery, a lack of follow-up assessment and inadequate involvement of parent(s) and/or guardian(s) (Blunden et al., 2012; Chung et al., 2017; Dietrich et al., 2016). As well as addressing these shortcomings, this project produced clear improvements in adolescent sleep quality and tentative evidence of reduced screen time. While objectively measured sleep duration did not show a statistically significant improvement, there was a promising trend towards significance which warrants further investigation. Another novel finding of this project is that SBSPIs do not appear to be an effective means of boosting MT.

Third, it is possible that this thesis may impact upon policy in Ireland. Internationally, there has been growing awareness of adolescent sleep insufficiency (American Academy of Pediatrics, 2014). For instance, in the US, due to the influence of numerous advocacy groups[30], the Department of Health and Human Services (DHHS) has committed to improving child and adolescent sleep health through its Healthy People 2030 policy (DHHS, 2020). In contrast, the promotion of sleep health has received little attention in the Irish context[31]. As was the case in the US, the introduction of sleep health policies in Ireland will likely require a concerted effort from academics, practitioners, school systems and advocacy groups. However, it is plausible that the original contribution of this thesis may play a small role in affecting policy change.

Fourth, the findings of this thesis may be impactful in educational and child psychology practice. As discussed under the *Dissemination* subheading, steps have been taken to circulate the original contribution of this thesis not only within academia, but also among practising educational and child psychologists. This thesis has also outlined

[30]American Academy of Child and Adolescent Psychiatry, 2014; American Academy of Pediatrics, 2014; American Medical Association, 2016; American Psychological Association, 2019; National Education Association, 2019; National Parent Teacher Association, 2017; Society of Behavioral Medicine, 2017; Start School Later non-profit, 2021.

[31] For further information on sleep policy issues in Ireland, please see Chapter Three: Empirical Paper, page 105.

the barriers to the involvement of educational and child psychologists in the promotion of adolescent sleep health in Ireland[32].

This thesis opened with the words of screenwriter Harry Rubenstein (1952), "the best bridge between despair and hope is a good night's sleep" (p. 220). Perhaps this thesis can help to convey this wisdom to policymakers, practitioners, academics, schools, families and adolescents.

[32] Barriers to the involvement of educational and child psychologists in the promotion of sleep health in Ireland are detailed in Chapter Four: Critical Review and Impact Statement, page 179.

References and Appendices

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Appendices

Appendix 1: Studies Excluded after Full-text Evaluation (Sleep and PSU)

	Reference	Exclusion Criterion
1.	Boumosleh, J. M., & Jaalouk, D. (2017). Depression, anxiety, and smartphone addiction in university students-A cross-sectional study. *PloS One*, *12*(8), e0182239.	4: Variables
2.	Lee, E. J., & Ogbolu, Y. (2018). Does parental control work with smartphone addiction?: A cross-sectional study of children in South Korea. *Journal of Addictions Nursing*, *29*(2), 128-138.	5: Target Group
3.	Hughes, N., & Burke, J. (2018). Sleeping with the frenemy: How restricting 'bedroom use' of smartphones impacts happiness and wellbeing. *Computers in Human Behavior*, *85*, 236-244.	4: Variables
4.	Winkler, A., Jeromin, F., Doering, B. K., & Barke, A. (2020). Problematic smartphone use has detrimental effects on mental health and somatic symptoms in a heterogeneous sample of German adults. *Computers in Human Behavior*, *113*, 106500.	5: Target Group
5.	Brubaker, J. R., & Beverly, E. A. (2020). Burnout, Perceived Stress, Sleep Quality, and Smartphone Use: A Survey of Osteopathic Medical Students. *The Journal of the American Osteopathic Association*, *120*(1), 6-17.	5: Target Group

Appendix 2: WoE A Quality Assessment Checklists (Sleep and PSU)

1. Cabré-Riera et al. (2019)			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?		✓	
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?		✓	
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?		✓	
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?	✓		

*CD, cannot determine; NA, not applicable; NR, not reported.

2. Chen et al. (2017)			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?			
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?	✓		
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?	✓		
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?		✓	
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?	✓		

*CD, cannot determine; NA, not applicable; NR, not reported.

3. Chang & Choi (2016)			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?	✓		
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?	✓		
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?		✓	
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?		✓	
10. Were confidence intervals reported for the study effect sizes?		✓	

*CD, cannot determine; NA, not applicable; NR, not reported.

4. Chung et al. (2018)			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?	✓		
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?	✓		
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?		✓	
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?	✓		

*CD, cannot determine; NA, not applicable; NR, not reported.

5. Demirci, Akgönül, & Akpinar (2015)			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?		✓	
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?	✓		
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?		✓	
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?		✓	

*CD, cannot determine; NA, not applicable; NR, not reported.

6. Liu et al. (2017)			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?		✓	
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?	✓		
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?		✓	
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?	✓		

*CD, cannot determine; NA, not applicable; NR, not reported.

7. Randler et al. (2016)			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?		✓	
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?	✓		
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?		✓	
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?		✓	

*CD, cannot determine; NA, not applicable; NR, not reported.

8. Wang, Chen, Yang, & Lin (2019)			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?		✓	
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?		✓	
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?	✓		
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?		✓	
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?	✓		

*CD, cannot determine; NA, not applicable; NR, not reported.

9. Xie, Dong, & Wang (2018)			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?		✓	
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?		✓	
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?	✓		
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?		✓	

*CD, cannot determine; NA, not applicable; NR, not reported.

10. Huang et al. (2020)			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?		✓	
5. Was a sample size justification, power description, or variance and effect estimates provided?	✓		
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?		✓	
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?		✓	
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?	✓		

11. Özkaya et al. (2020)			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?		✓	
5. Was a sample size justification, power description, or variance and effect estimates provided?	✓		
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?		✓	
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?		✓	
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?		✓	
10. Were confidence intervals reported for the study effect sizes?	✓		

12. Kaya et al. (2020)			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?	✓		
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?		✓	
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?	✓		
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?		✓	
10. Were confidence intervals reported for the study effect sizes?	✓		

Appendix 3: Studies Excluded after Full-text Evaluation (Sleep and MT)

	Reference	Exclusion Criteria
1.	Jahangard, L., Rahmani, A., Haghighi, M., Ahmadpanah, M., Sadeghi Bahmani, D., Soltanian, A. R., ... & Brand, S. (2017). “Always Look on the Bright Side of Life!”–Higher Hypomania Scores Are Associated with Higher Mental Toughness, Increased Physical Activity, and Lower Symptoms of Depression and Lower Sleep Complaints. *Frontiers in Psychology*, *8*, 2130.	6: Scope of Research
2.	Bahmani, D. S., Gerber, M., Kalak, N., Lemola, S., Clough, P. J., Calabrese, P., ... & Brand, S. (2016). Mental toughness, sleep disturbances, and physical activity in patients with multiple sclerosis compared to healthy adolescents and young adults. *Neuropsychiatric Disease and Treatment, 12*, 1571.	6: Scope of Research
3.	Brand, S., Kalak, N., Gerber, M., Clough, P. J., Lemola, S., Sadeghi Bahmani, D., ... & Holsboer-Trachsler, E. (2017). During early to mid-adolescence, moderate to vigorous physical activity is associated with restoring sleep, psychological functioning, mental toughness and male gender. *Journal of Sports Sciences*, *35*(5), 426-434.	6: Scope of Research

Appendix 4: WoE A Quality Assessment Checklists (Sleep and MT)

Brand et al. (2014a).			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?	✓		
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?		✓	
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?	✓		
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?		✓	

*CD, cannot determine; NA, not applicable; NR, not reported.

Brand et al. (2014b).			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?	✓		
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?	✓		
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?	✓		
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?		✓	

*CD, cannot determine; NA, not applicable; NR, not reported.

3. Brand et al. (2016).			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?	✓		
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?	✓		
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?	✓		
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?		✓	

*CD, cannot determine; NA, not applicable; NR, not reported.

4. Cooper, Wilson and Jones (2019), Sub-study 1			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?		✓	
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?	✓		
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?		✓	
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?	✓		
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?		✓	

*CD, cannot determine; NA, not applicable; NR, not reported.

Section/ Topic	4. Cooper, Wilson and Jones (2019), Sub-study 2			
	No	**Item**		**No**
Title and abstract				
	1a	Identification as a randomised trial in the title	✓	1a
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	×	1b
Introduction				
Background and objectives	2a	Scientific background and explanation of rationale	✓	2a.1
				2a.2
	2b	Specific objectives or hypotheses	✓	2b
Methods				
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	✓	3a
	3b	Important changes to methods after trial start (such as eligibility criteria), with reasons	N/A	3b
Participant(s)	4a	Eligibility criteria for participants	×	4a†
	4b	Settings and locations where the data were collected	✓	4b†
				4c
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	✓	5
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	✓	6a.1
				6a.2
	6b	Any changes to trial outcomes after the trial commenced, with reasons	N/A	6b
Sample size	7a	How sample size was determined	✓	7a
	7b	When applicable, explanation of any interim analyses and stopping guidelines	N/A	7b
Randomisation:				

Sequence generation	8a	Method used to generate the random allocation sequence	✓	8a
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	✓	8b
				8c
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	✓	9
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	✓	10
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	N/A	11a
	11b	If relevant, description of the similarity of interventions	N/A	11b
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	✓	12a
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	✓	12b
				12c
Results				
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	✓	13a.1 13a.2
	13b	For each group, losses and exclusions after randomisation, together with reasons	✓	13c
Recruitment	14a	Dates defining the periods of recruitment and follow-up	✓	14a†
	14b	Why the trial ended or was stopped	N/A	14b
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	✓	15†
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	✓	16
Outcomes and	17a	For each primary and secondary outcome,	✓	17a.1

estimation		results for each group, and the estimated effect size and its precision (such as 95% confidence interval)		17a.2
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	✓	17b
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing prespecified from exploratory	✓	18
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	×	19
Discussion				
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	✓	20
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	✓	21
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	✓	22
Other information				
Registration	23	Registration number and name of trial registry	N/A	23
Protocol	24	Where the full trial protocol can be accessed, if available	×	24
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	✓	25
Total Score	24 of 28 applicable criteria met = 85.7%			

5. Haghighi and Gerber (2018).			
Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓		
5. Was a sample size justification, power description, or variance and effect estimates provided?	✓		
6. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
7. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between variables?	✓		
8. Were study effect sizes interpreted by directly and explicitly comparing study effects with those reported in related prior studies?	✓		
9. Did the authors explicitly consider study design and effect size statistic limitations as part of effect interpretation?	✓		
10. Were confidence intervals reported for the study effect sizes?		✓	

*CD, cannot determine; NA, not applicable; NR, not reported.

Appendix 5: Information Letters

Appendix 5.1: Participant Information Letter

Sleep, Problematic Smartphone Use and Mental Toughness: an Exploration of the Effectiveness of a School-based Sleep Promotion Intervention with a Cohort of Post-primary Students in Ireland

Participant Information Letter

What is the project about?
Obtaining adequate sleep improves mental and physical health. However, evidence suggests that adolescents obtain insufficient sleep and that sleep has deteriorated, both in quality and in quantity, over the past few decades. There is evidence to suggest that this deterioration may, at least in part, be due to the proliferation of smartphones. This project, therefore, will explore the impact of a school-based sleep promotion intervention on adolescent sleep. In addition, the study will explore the impact of the intervention on mental toughness and problematic smartphone use.

Who is undertaking it?
My name is Saoirse Mac Cárthaigh and I am a postgraduate student attending Mary Immaculate College. I am presently completing the Professional Doctorate in Educational and Child Psychology in the Department of Educational Psychology, Inclusive & Special Education, under the supervision of Dr John Perry and Dr Claire Griffin. The current study will form part of my doctoral thesis.

Why is it being undertaken?
This project seeks to determine whether a 3-week school-based sleep promotion intervention can improve the sleep of adolescent students in an Irish post-primary school. In addition, the research seeks to determine whether the intervention can improve mental toughness and reduce problematic smartphone use.

What are the benefits of this research?
There may be benefits both to the scientific community and directly to the participants. In terms of benefits for the scientific community, firstly, the study may clarify the current sleep practices and smartphone use of post-primary school students in Ireland. Secondly, the study may enhance our understanding of the effectiveness of a school-based sleep promotion intervention. Thirdly, the study may clarify the understanding of the relationship between sleep and both mental toughness and problematic smartphone use. In terms of direct benefits to the participants, the study may increase knowledge of the science of sleep, improve sleep hygiene, reduce smartphone overuse and increase mental toughness.

What are the risks of this research?
Participants may gain insight into their poor sleeping habits or problematic smartphone use. It is plausible that this knowledge could induce anxiety. Therefore, to reduce this risk, during the intervention, participants will not be expected to disclose this information unless they volunteer to do so. In addition, participants will be provided with information about how to improve sleeping habits and smartphone use.

Exactly what is involved for the participant

Participants will be asked to participate in a 40-minute school-based intervention once weekly for three weeks. This intervention will consist of presentations from the facilitator, group discussions, activities, games and home-based tasks.

A number of measurements will also be taken. Firstly, participants will be asked to complete 15-minute pre-test and post-test questionnaires. These questionnaires will assess sleep quality, sleep hygiene, problematic smartphone use and mental toughness. Secondly, participants will be asked to monitor and report their sleep with a wrist-mounted device for one week before and after the intervention. This device will be provided by Saoirse Mac Carthaigh, the student researcher. Finally, participants will be asked to monitor and report their smartphone use with an application for one week before and after the intervention.

Right to withdraw
Your anonymity is assured, and you are free to withdraw from the experiment at any time without giving a reason and without consequence.

How will the information be used / disseminated?
The data from the experiment will be combined with that of the other participants in this study and used to form the results section of my thesis. Summary data only will appear in the thesis, individual participant data will not be shown.

How will confidentiality be kept?
All information gathered will remain confidential and will not be released to any third party. A random ID number will be generated for each participant and it is this number rather than the participant's name which will be held with their data to maintain their anonymity.

What will happen to the data after research has been completed?
In accordance with the MIC Record Retention Schedule, all anonymised data may be stored indefinitely.

Contact details
If at any time you have any queries / issues with regard to this study, my contact details are as follows:

- Principal investigator name: Saoirse Mac Cárthaigh 18097073@micstudent.mic.ul.ie
- First supervisor: Dr John Perry john.perry@mic.ul.ie
- Second supervisor: Dr Claire Griffin claire.griffin@mic.ul.ie

If you have concerns about this study and wish to contact someone independent, you may contact:
Mary Collins, MIREC Administrator, Research and Graduate School, Mary Immaculate College, South Circular Road, Limerick. Telephone: 061-204980 / E-mail: mirec@mic.ul.ie

Appendix 5.2: Parent(s)/Guardian(s) Information Letter

Sleep, Problematic Smartphone Use and Mental Toughness: an Exploration of the Effectiveness of a School-based Sleep Promotion Intervention with a Cohort of Post-primary Students in Ireland

Parent / Guardian Information Letter

What is the project about?
Obtaining adequate sleep improves mental and physical health. However, evidence suggests that adolescents obtain insufficient sleep and that sleep has deteriorated, both in quality and in quantity, over the past few decades. There is evidence to suggest that this deterioration may, at least in part, be due to the proliferation of smartphones. This project, therefore, will explore the impact of a school-based sleep promotion intervention on adolescent sleep. In addition, the study will explore the impact of the intervention on mental toughness and problematic smartphone use.

Who is undertaking it?
My name is Saoirse Mac Cárthaigh and I am a postgraduate student attending Mary Immaculate College. I am presently completing the Professional Doctorate in Educational and Child Psychology in the Department of Educational Psychology, Inclusive & Special Education, under the supervision of Dr John Perry and Dr Claire Griffin. The current study will form part of my thesis.

Why is it being undertaken?
This project seeks to determine whether a 3-week school-based sleep promotion intervention can improve the sleep of adolescent students in an Irish post-primary school. In addition, the research seeks to determine whether the intervention can improve mental toughness and reduce problematic smartphone use.

What are the benefits of this research?
There may be benefits both to the scientific community and directly to the participants. In terms of benefits for the scientific community, firstly, the study will clarify the current sleep practices and smartphone use of post-primary school students in Ireland. Secondly, the study will enhance our understanding of the effectiveness of a school-based sleep promotion intervention. Thirdly, the study may clarify the understanding of the relationship between sleep and both mental toughness and problematic smartphone use. In terms of direct benefits to the participants, the study may increase knowledge of the science of sleep, improve sleep hygiene, reduce smartphone overuse and increase mental toughness.

What are the risks of this research?
Participants may gain insight into their poor sleeping habits or problematic smartphone use. It is plausible that this knowledge could induce anxiety. Therefore, to reduce this risk, during the intervention, participants will not be expected to disclose this information unless they volunteer to do so. In addition, participants will be provided with information about how to improve sleeping habits and smartphone use.

Exactly what is involved for the participant

Participants will be asked to participate in a 40-minute school-based intervention once weekly for three weeks. This intervention will consist of presentations from the facilitator, group discussions, activities, games and home-based tasks.

A number of measurements will also be taken. Firstly, participants will be asked to complete 15-minute pre-test and post-test questionnaires. These questionnaires will assess sleep quality, sleep hygiene, problematic smartphone use and mental toughness. Secondly, participants will be asked to monitor and report their sleep with a wrist-mounted device for one week before and after the intervention. This device will be provided by Saoirse Mac Cárthaigh, the student researcher. Finally, participants will be asked to monitor and report their smartphone use with an application for one week before and after the intervention.

Right to withdraw
Anonymity is assured, and participants are free to withdraw from the experiment at any time without giving a reason and without consequence.

How will the information be used / disseminated?
The data will be combined with that of the other participants in this study and used to form the results section of my thesis. Summary data only will appear in the thesis, individual participant data will not be shown.

How will confidentiality be kept?
All information gathered will remain confidential and will not be released to any third party. A random ID number will be generated for each participant and it is this number rather than the participant's name which will be held with their data to maintain their anonymity.

What will happen to the data after research has been completed?
In accordance with the MIC Record Retention Schedule, all anonymised data may be stored indefinitely.

Contact details
If at any time you have any queries / issues with regard to this study, my contact details are as follows:

- Principal investigator name: Saoirse Mac Cárthaigh 18097073@micstudent.mic.ul.ie
- First supervisor: Dr John Perry john.perry@mic.ul.ie
- Second supervisor: Dr Claire Griffin claire.griffin@mic.ul.ie

If you have concerns about this study and wish to contact someone independent, you may contact:
Mary Collins, MIREC Administrator, Research and Graduate School, Mary Immaculate College, South Circular Road, Limerick. Telephone: 061-204980 / E-mail: mirec@mic.ul.ie

Appendix 6: Consent Forms

Appendix 6.1: Participant Consent Form

BRIATHAR DÉ MO LÓCHRANN
MIC
MARY IMMACULATE COLLEGE
COLÁISTE MHUIRE GAN SMÁL

Sleep, Problematic Smartphone Use and Mental Toughness: an Exploration of the Effectiveness of a School-based Sleep Promotion Intervention with a Cohort of Post-primary Students in Ireland

Parent / Guardian Consent Form

Dear parent(s) / guardian(s),

As outlined in the **Participant Information Letter** the current study will investigate the effectiveness of a school-based sleep-promotion intervention. The participant information letter should be read fully and carefully before consenting to your son or daughter taking part in the project.

Participants' anonymity is assured, and they are free to withdraw from the intervention at any time. All information gathered will remain confidential and will not be released to any third party.

Please read the following statements before signing the consent form.

- I have read and understood the **Participant Information Letter.**
- I understand that, as part of the study, data regarding my child's sleep will be recorded with a wrist-mounted device.
- I understand that, as part of this study, smartphone usage data will be collected. I understand that these data are limited to frequency and duration of smartphone use and that no identifying data are collected.
- I understand what the project is about, and what the results will be used for.
- I am fully aware of all of the procedures involving my child, and of any risks and benefits associated with the study.
- I know that participation is voluntary and that my child can withdraw from the study at any stage without giving any reason.
- I am aware that results will be kept confidential.

Name (PRINTED): ________________________________

Name (signature): ________________________________

Date: ____

Appendix 6.2: Parent(s)/Guardian(s) Consent Form

Sleep, Problematic Smartphone Use and Mental Toughness: an Exploration of the Effectiveness of a School-based Sleep Promotion Intervention with a Cohort of Post-primary Students in Ireland

Parent / Guardian Consent Form

Dear parent(s) / guardian(s),

As outlined in the **Participant Information Letter** the current study will investigate the effectiveness of a school-based sleep-promotion intervention. The participant information letter should be read fully and carefully before consenting to your son or daughter taking part in the project.

Participants' anonymity is assured, and they are free to withdraw from the intervention at any time. All information gathered will remain confidential and will not be released to any third party.

Please read the following statements before signing the consent form.

- I have read and understood the **Participant Information Letter.**
- I understand that, as part of the study, data regarding my child's sleep will be recorded with a wrist-mounted device.
- I understand that, as part of this study, smartphone usage data will be collected. I understand that these data are limited to frequency and duration of smartphone use and that no identifying data are collected.
- I understand what the project is about, and what the results will be used for.
- I am fully aware of all of the procedures involving my child, and of any risks and benefits associated with the study.
- I know that participation is voluntary and that my child can withdraw from the study at any stage without giving any reason.
- I am aware that results will be kept confidential.

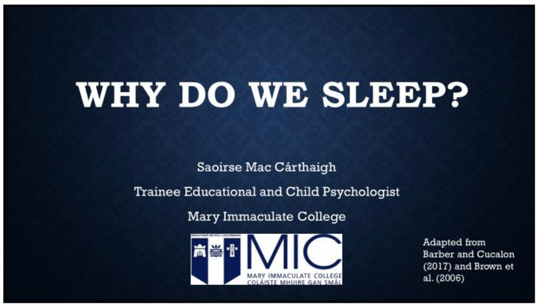
Name (PRINTED): ________________________________

Name (signature): ________________________________

Date: ____

Appendix 7: PowerPoint Slides

Appendix 7.1: Session 1 Slides



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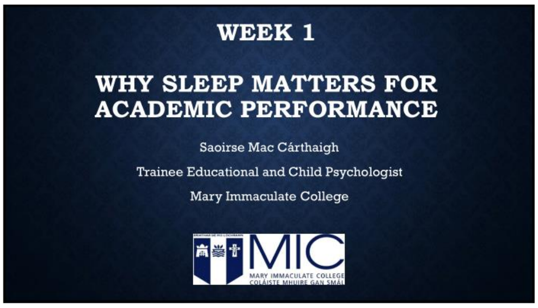

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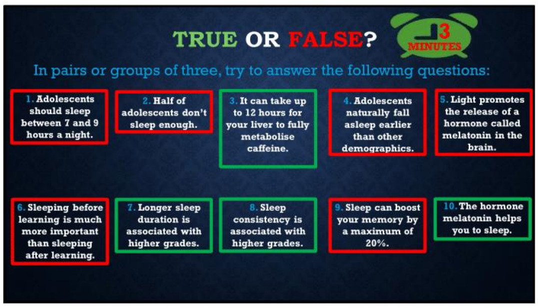

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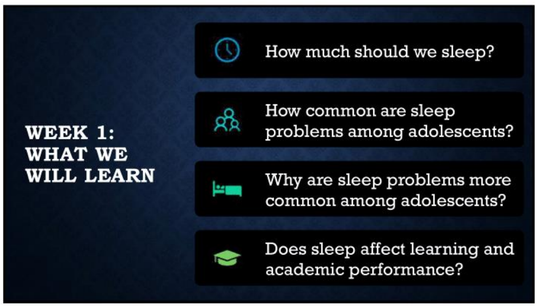

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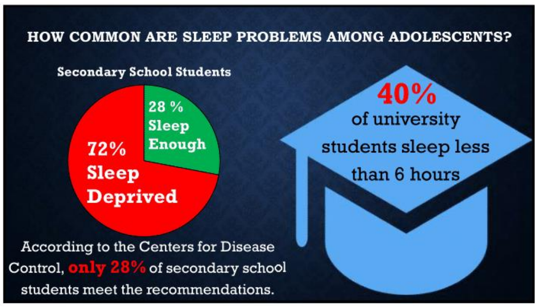

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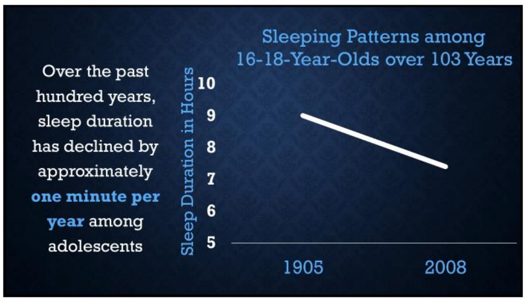
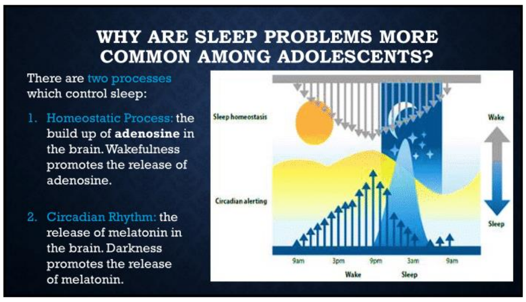

Over the past hundred years, sleep duration has declined by approximately one minute per year among adolescents
Sleeping Patterns among 16-18-Year-Olds over 103 Years
Sleep Duration in Hours
10
9
8
7
6
5
1905
2008

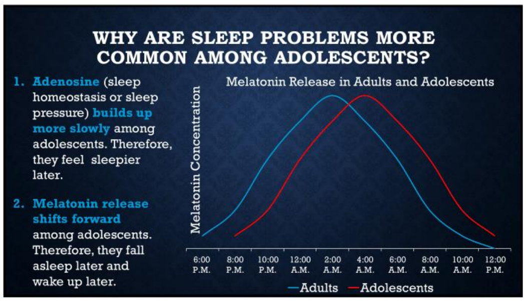
7


WHY ARE SLEEP PROBLEMS MORE COMMON AMONG ADOLESCENTS?
There are two processes which control sleep:
1. Homeostatic Process: the build up of adenosine in the brain. Wakefulness promotes the release of adenosine.
2. Circadian Rhythm: the release of melatonin in the brain. Darkness promotes the release of melatonin.
Sleep homeostasis
Circadian alerting
Wake
Sleep
9am
3pm
9pm
3am
9am
Wake
Sleep

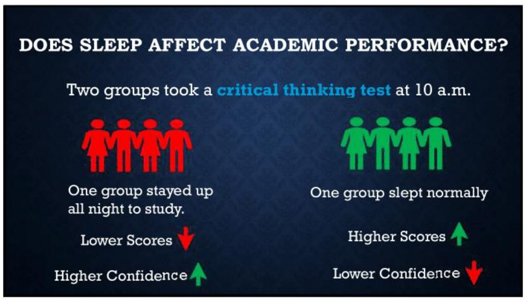
8


UNDERSTANDING THE TWO PROCESS MODEL OF SLEEP

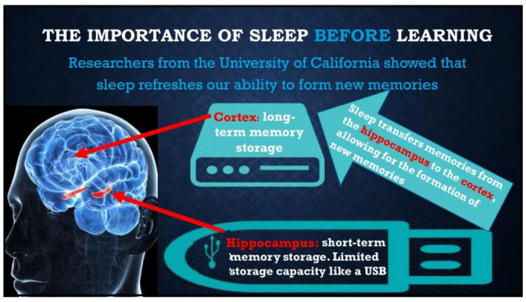
9


WHY ARE SLEEP PROBLEMS MORE COMMON AMONG ADOLESCENTS?
1. Adenosine (sleep homeostasis or sleep pressure) builds up more slowly among adolescents. Therefore, they feel sleepier later.
2. Melatonin release shifts forward among adolescents. Therefore, they fall asleep later and wake up later.
Melatonin Release in Adults and Adolescents
Melatonin Concentration
6:00 P.M.
8:00 P.M.
10:00 P.M.
12:00 A.M.
2:00 A.M.
4:00 A.M.
6:00 A.M.
8:00 A.M.
10:00 A.M.
12:00 P.M.
Adults
Adolescents

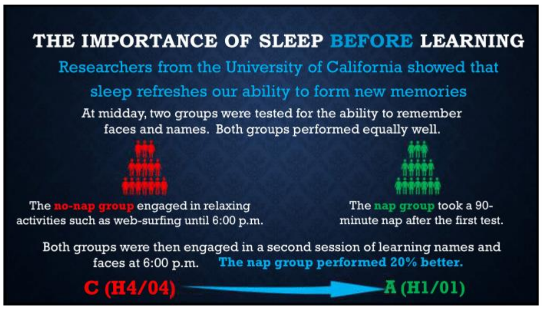
10


DOES SLEEP AFFECT ACADEMIC PERFORMANCE?
Two groups took a critical thinking test at 10 a.m.
One group stayed up all night to study.
Lower Scores
Higher Confidence
One group slept normally
Higher Scores
Lower Confidence

11


THE IMPORTANCE OF SLEEP BEFORE LEARNING
Researchers from the University of California showed that sleep refreshes our ability to form new memories
Cortex: long-term memory storage
Sleep transfers memories from the hippocampus to the cortex, allowing for the formation of new memories
Hippocampus: short-term memory storage. Limited storage capacity like a USB

12



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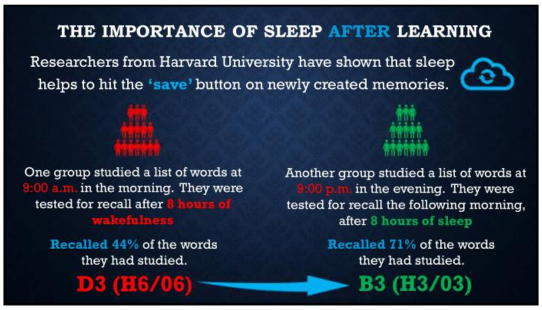

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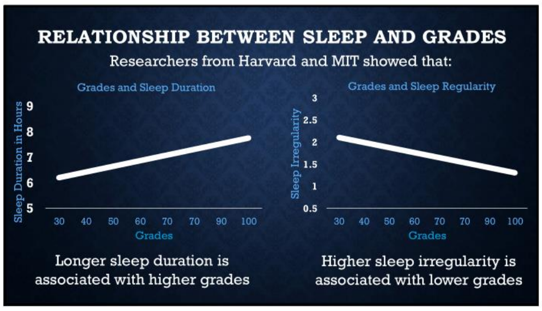

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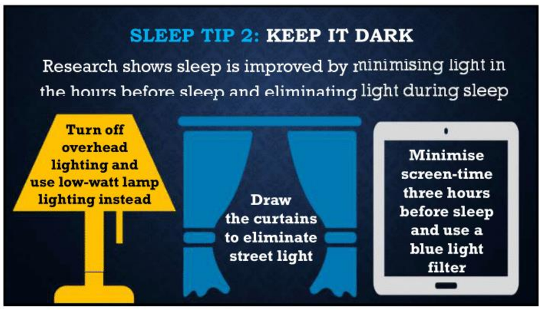

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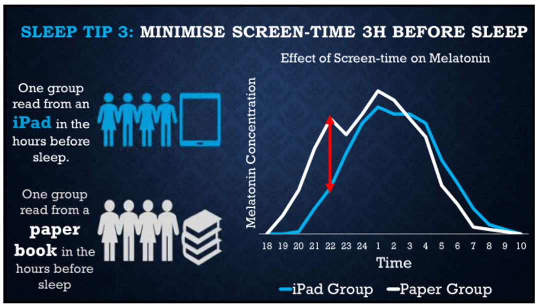
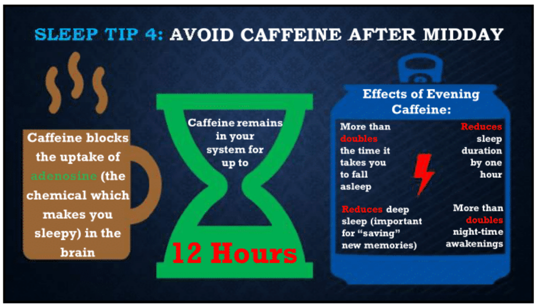

SLEEP TIP 3: MINIMISE SCREEN-TIME 3H BEFORE SLEEP
Effect of Screen-time on Melatonin
One group read from an iPad in the hours before sleep.
One group read from a paper book in the hours before sleep
Melatonin Concentration
18 19 20 21 22 23 24 1 2 3 4 5 6 7 8 9 10
Time
iPad Group
Paper Group

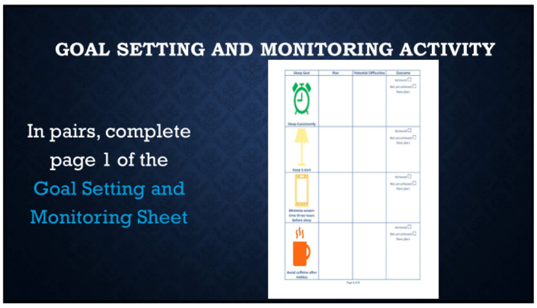
19


SLEEP TIP 4: AVOID CAFFEINE AFTER MIDDAY
Caffeine blocks the uptake of adenosine (the chemical which makes you sleepy) in the brain
Caffeine remains in your system for up to
12 Hours
Effects of Evening Caffeine:
More than doubles the time it takes you to fall asleep
Reduces sleep duration by one hour
Reduces deep sleep (important for "saving" new memories)
More than doubles night-time awakenings

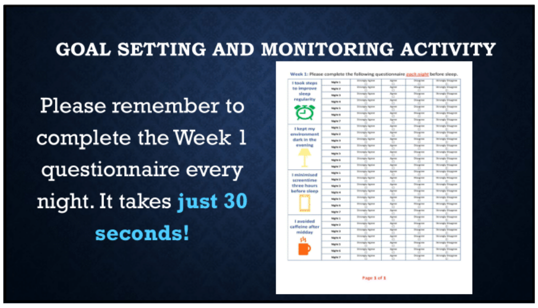
20


YOUR BRAIN ON
COFFEE

21

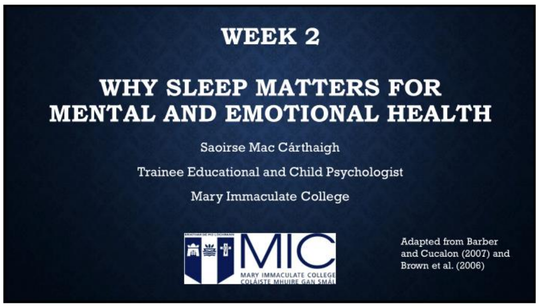

GOAL SETTING AND MONITORING ACTIVITY
In pairs, complete page 1 of the Goal Setting and Monitoring Sheet

22


GOAL SETTING AND MONITORING ACTIVITY
Please remember to complete the Week 1 questionnaire every night. It takes just 30 seconds!

23

Appendix 7.2: Session 2 Slides



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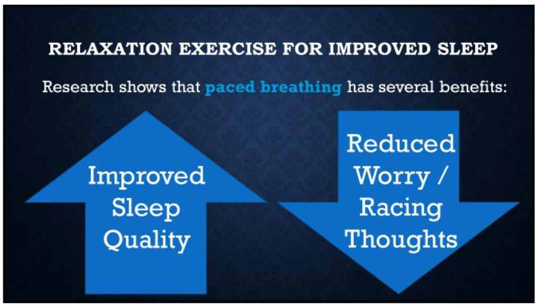

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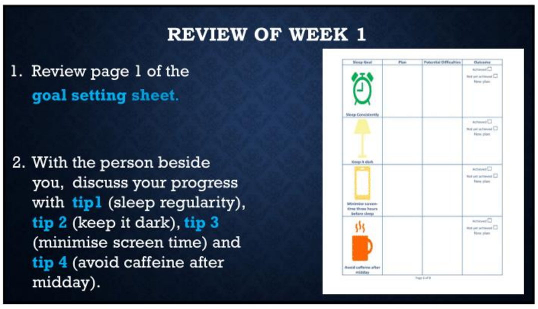

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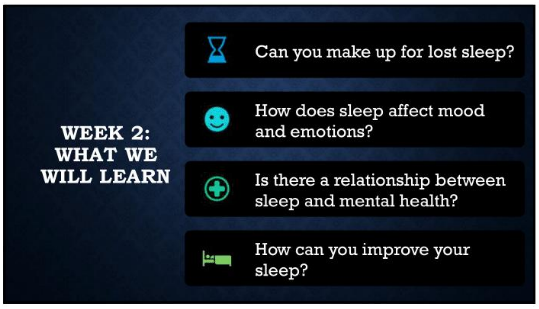
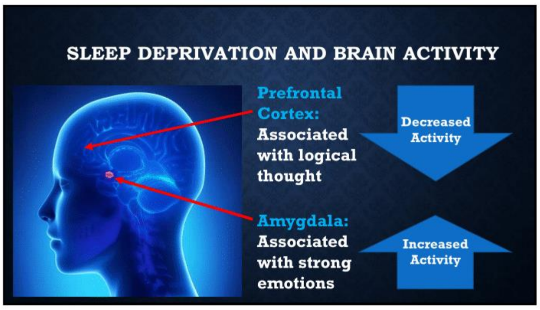


5

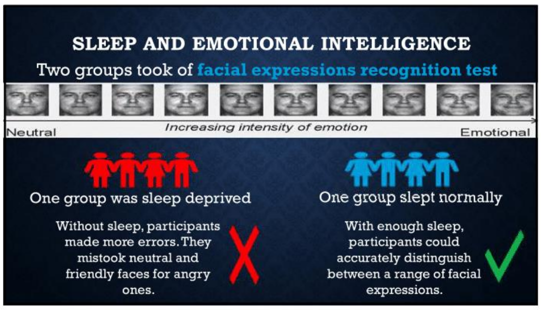
6


CAN YOU "SLEEP BACK" WHAT YOU HAVE LOST?
DEBT
DEBT
Unlike financial debt, sleep debt can never be fully repaid

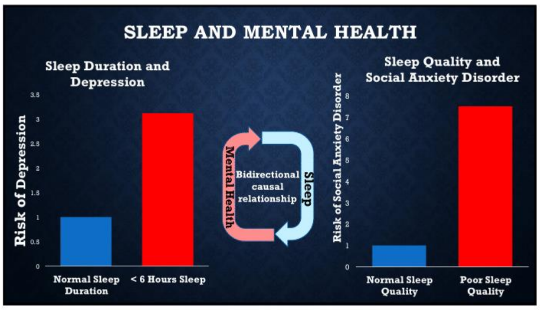
7


SLEEP DEPRIVATION AND BRAIN ACTIVITY
Prefrontal Cortex: Associated with logical thought
Decreased Activity
Amygdala: Associated with strong emotions
Increased Activity

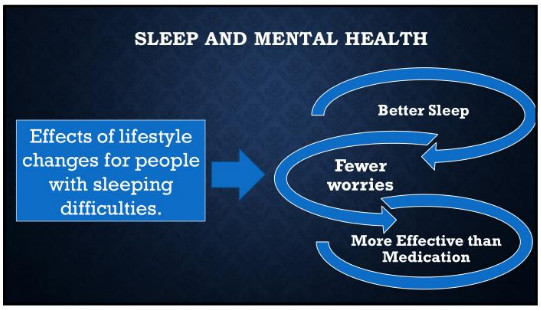
8


SLEEP AND EMOTIONAL INTELLIGENCE
Two groups took of facial expressions recognition test
Neutral
Increasing intensity of emotion
Emotional
One group was sleep deprived
One group slept normally
Without sleep, participants made more errors. They mistook neutral and friendly faces for angry ones.
With enough sleep, participants could accurately distinguish between a range of facial expressions.

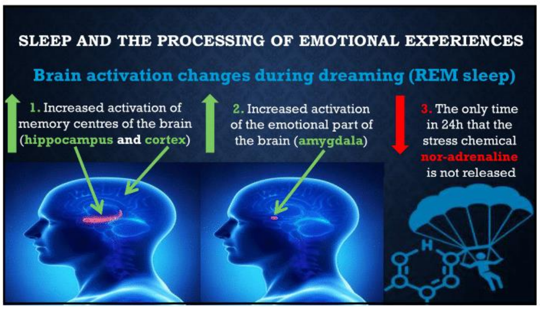
9


SLEEP AND MENTAL HEALTH
Sleep Duration and Depression
Risk of Depression
Normal Sleep Duration
< 6 Hours Sleep
Mental Health
Bidirectional causal relationship
Sleep
Sleep Quality and Social Anxiety Disorder
Risk of Social Anxiety Disorder
Normal Sleep Quality
Poor Sleep Quality

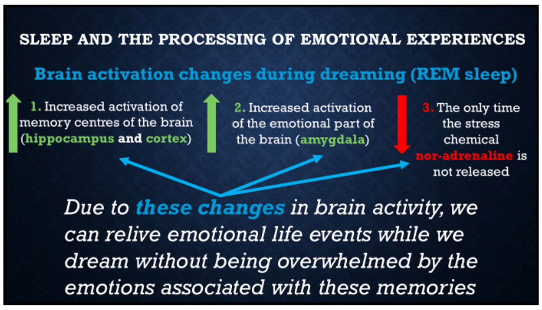
10


SLEEP AND MENTAL HEALTH
Effects of lifestyle changes for people with sleeping difficulties.
Better Sleep
Fewer worries
More Effective than Medication

11


SLEEP AND THE PROCESSING OF EMOTIONAL EXPERIENCES
Brain activation changes during dreaming (REM sleep)
1. Increased activation of memory centres of the brain (hippocampus and cortex)
2. Increased activation of the emotional part of the brain (amygdala)
3. The only time in 24h that the stress chemical nor-adrenaline is not released

12



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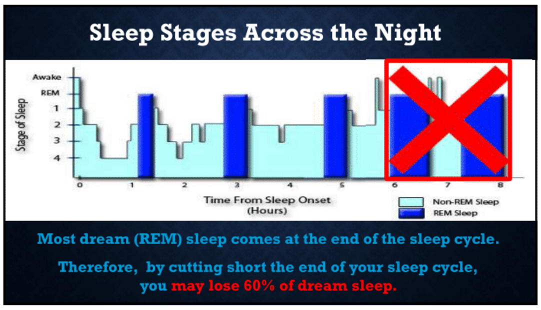

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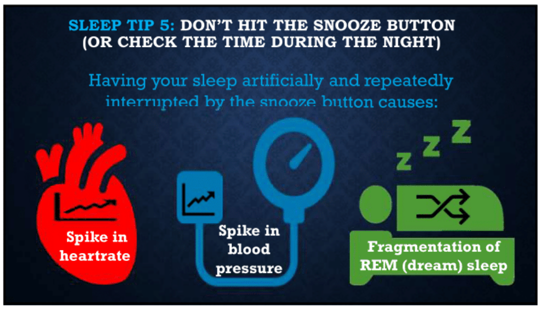

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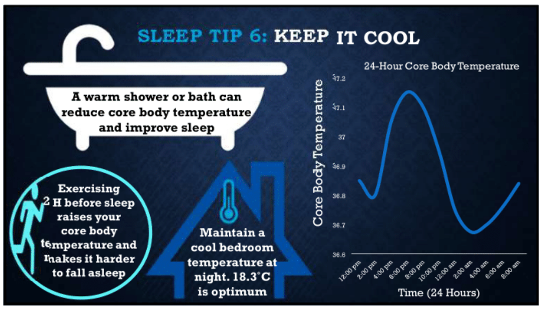

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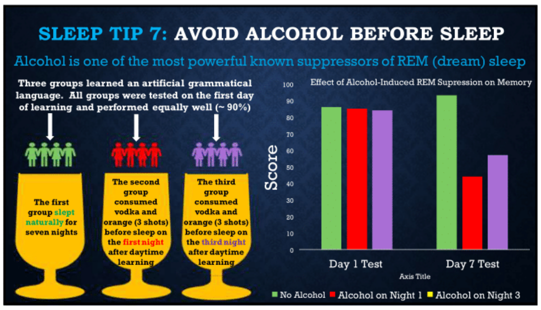

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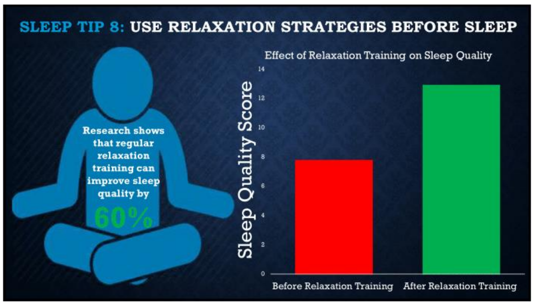
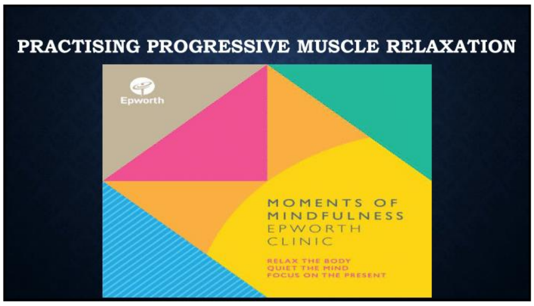
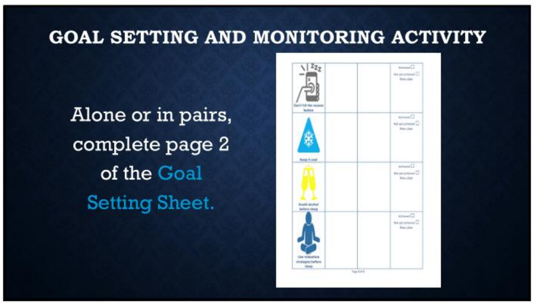

SLEEP TIP 8: USE RELAXATION STRATEGIES BEFORE SLEEP
Research shows that regular relaxation training can improve sleep quality by
60%
Effect of Relaxation Training on Sleep Quality
Sleep Quality Score
0
2
4
6
8
10
12
14
Before Relaxation Training
After Relaxation Training

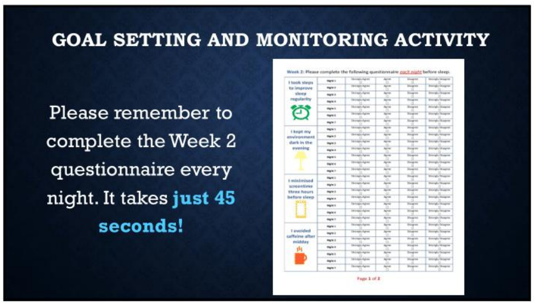
19


PRACTISING PROGRESSIVE MUSCLE RELAXATION
Epworth
MOMENTS OF MINDFULNESS
EPWORTH CLINIC
RELAX THE BODY
QUIET THE MIND
FOCUS ON THE PRESENT

20

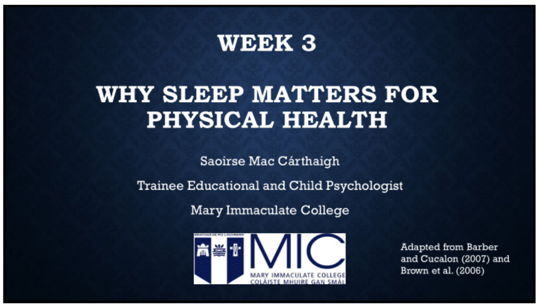

GOAL SETTING AND MONITORING ACTIVITY
Alone or in pairs, complete page 2 of the Goal Setting Sheet.

21


GOAL SETTING AND MONITORING ACTIVITY
Please remember to complete the Week 2 questionnaire every night. It takes just 45 seconds!

22

Appendix 7.3: Session 3 Slides



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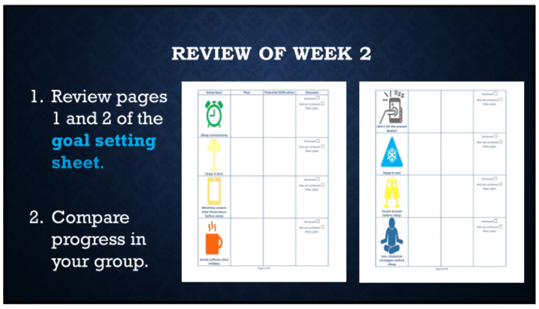

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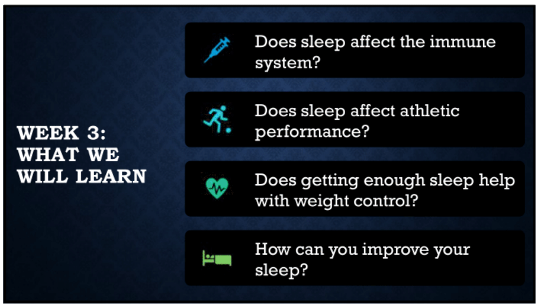

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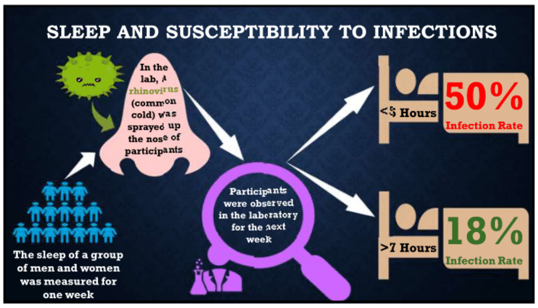

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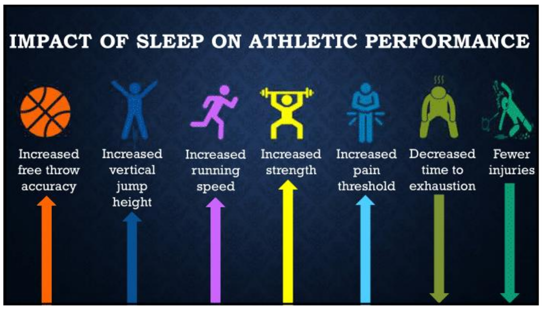
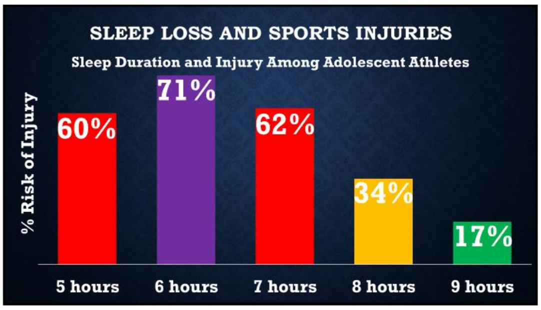
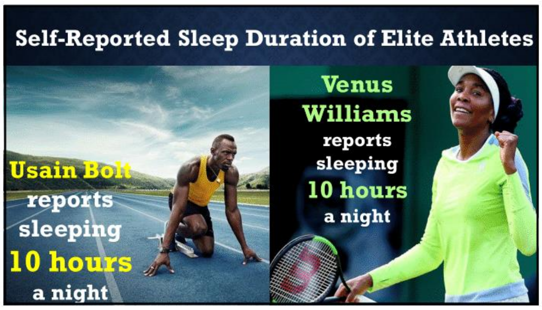

IMPACT OF SLEEP ON ATHLETIC PERFORMANCE
Increased free throw accuracy
Increased vertical jump height
Increased running speed
Increased strength
Increased pain threshold
Decreased time to exhaustion
Fewer injuries

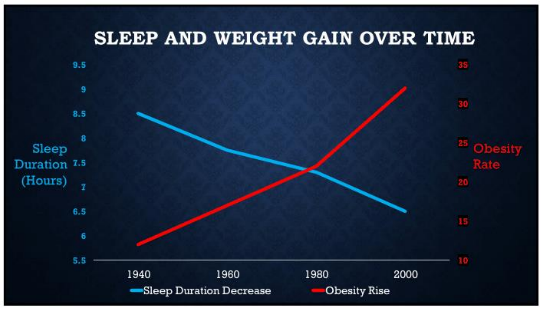
7


SLEEP LOSS AND SPORTS INJURIES
Sleep Duration and Injury Among Adolescent Athletes
% Risk of Injury
60%
71%
62%
34%
17%
5 hours
6 hours
7 hours
8 hours
9 hours

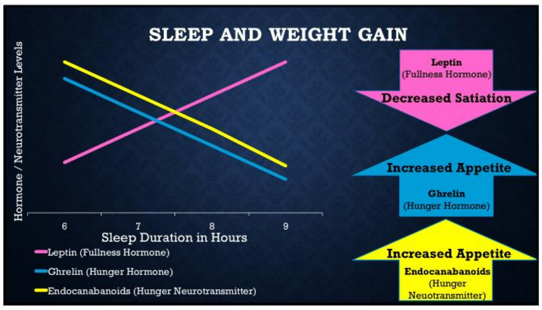
8


Self-Reported Sleep Duration of Elite Athletes
Usain Bolt reports sleeping 10 hours a night
Venus Williams reports sleeping 10 hours a night

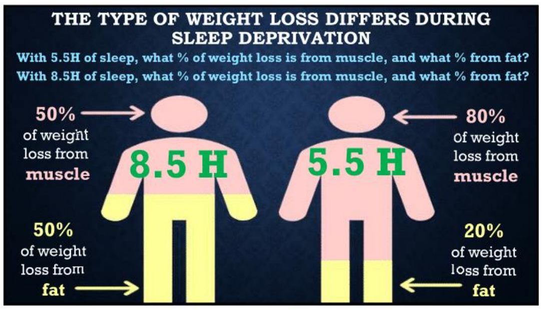
9


SLEEP AND WEIGHT GAIN OVER TIME
Sleep Duration (Hours)
Obesity Rate
1940
1960
1980
2000
Sleep Duration Decrease
Obesity Rise

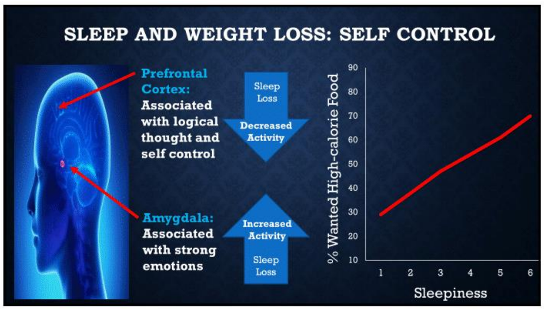
10


SLEEP AND WEIGHT GAIN
Hormone / Neurotransmitter Levels
Sleep Duration in Hours
Leptin (Fullness Hormone)
Ghrelin (Hunger Hormone)
Endocanabanoids (Hunger Neurotransmitter)
Leptin (Fullness Hormone)
Decreased Satiation
Increased Appetite
Ghrelin (Hunger Hormone)
Increased Appetite
Endocanabanoids (Hunger Neotransmitter)

11


THE TYPE OF WEIGHT LOSS DIFFERS DURING SLEEP DEPRIVATION
With 5.5H of sleep, what % of weight loss is from muscle, and what % from fat?
With 8.5H of sleep, what % of weight loss is from muscle, and what % from fat?
50% of weight loss from muscle
8.5 H
50% of weight loss from fat
80% of weight loss from muscle
5.5 H
20% of weight loss from fat

12



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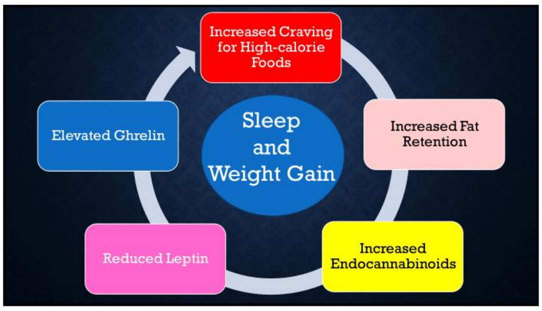

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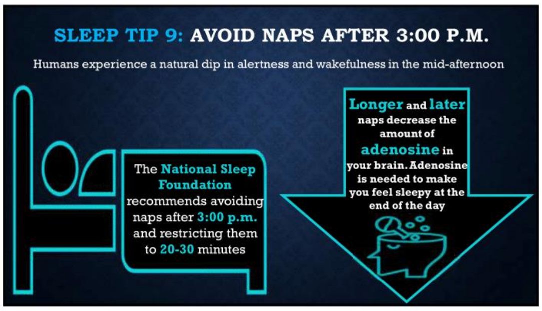

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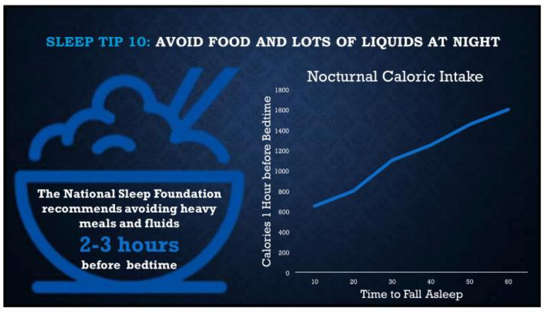

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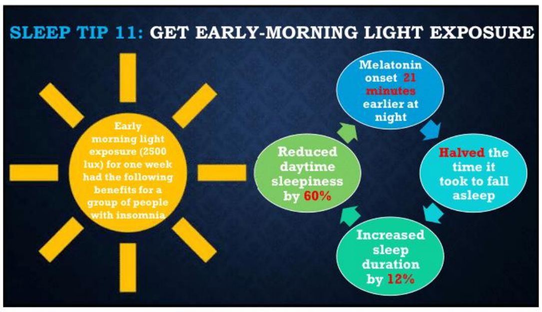
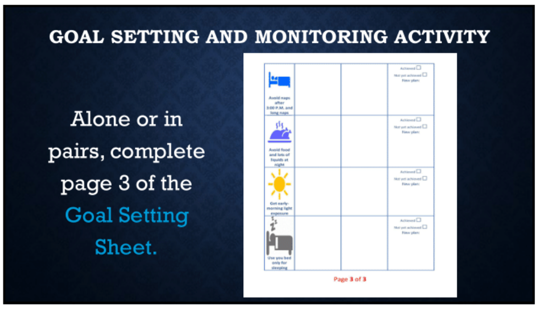


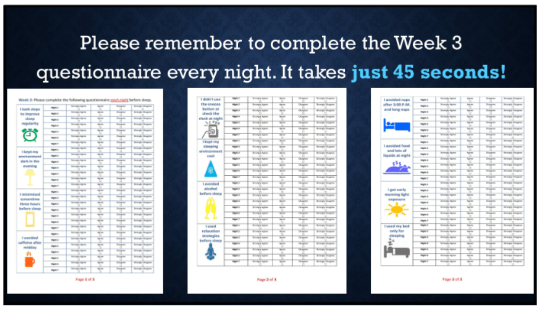
18


SLEEP TIP 12: USE YOUR BED ONLY FOR SLEEP
Sleeping Difficulties
A group of people who had difficulty sleeping made lifestyle changes over 8 weeks including using their bed only for sleep.
20
18
16
14
12
10
8
6
4
2
0
Before Behaviour Change
After Behaviour Change

19


GOAL SETTING AND MONITORING ACTIVITY
Alone or in pairs, complete page 3 of the Goal Setting Sheet.
Page 3 of 3

20


Please remember to complete the Week 3 questionnaire every night. It takes just 45 seconds!

21

Appendix 8: Session Overviews

Appendix 8.1: Session One Overview

Session One Components	Recommended Duration
1. Using the think-pair-share strategy (Bamiro, 2015), participants reflect on what they believe the purpose to sleep to be.	10 minutes
2. In pairs or groups of three, participants complete a pre-lecture true-or-false quiz on the relationship between sleep and academic performance (Narloch et al., 2006).	10 minutes
3. The facilitator delivers an interactive psychoeducational presentation on the importance of sleep for academic performance adapted from Barber and Cucalon (2017) and Brown et al. (2006). The evidence-based active student responding technique (Randolph, 2007) is used throughout this presentation. The contents of the presentation include: ➢ Sleep duration recommendations for adults and adolescents from the national sleep foundation (Hirshkowitz et al., 2015). ➢ Information on the prevalence of sleep insufficiency among adolescents (Peltzer & Pengpid, 2016; Wheaton et al., 2018). ➢ Changes in sleeping patterns over the past century (Matricciani et al., 2012). ➢ Information on circadian rhythms and the homeostatic process. A video with an in-video quiz (Cummins et al., 2015) is presented to consolidate learning: https://www.youtube.com/watch?v=tDWKGnjWkAg ➢ Information on the cause of the higher rate of sleep insufficiency among adolescents (Carskadon et al, 2019; Crowley et al., 2014; Jenni & Carskadon, 2007; Wright Jr et al., 2012). ➢ Information on the importance of sleep before learning	30 minutes

(Mander et al., 2011).

- Information on the importance of sleep after learning (Ellenbogen et al., 2009).

- Information on the relationship between sleep and academic performance (Curcio et al., 2006; Okano et al., 2019).

- Sleep hygiene recommendations (sleep regularity, light levels, screen time and caffeine) (Chang et al., 2015; Cho et al. 2013; Drake et al., 2013) Gradisar et al., 2013; Grosso & Bracken, 2005; Irish et al., 2015).

- A video explaining the link between evening caffeine consumption and sleep disruption: https://www.youtube.com/watch?v=4YOwEqGykDM

4. Participants complete a goal setting activity (Harkin et al., 2016) using page one of the goal setting and review document (Appendix 11).	10 minutes
5. Participants are assigned a homework task of completing the week one progress monitoring questionnaire each night before sleep (Appendix 12.1) (Harkin et al., 2016).	
6. An abridged video version of session one is sent to parent(s) and/or guardian(s) (Appendix 10). In addition, a letter is sent to parent(s) and/or guardians to explain how the learning from session one may be generalised to the home context (Appendix 9.1). This is based on the recommendations of several systematic reviews of school-based sleep promotion interventions (Blunden, Chapman, & Rigney, 2012; Blunden & Rigney, 2015; Cassoff, Knäuper, Michaelsen, & Gruber, 2013; Gruber, 2017; Sheldon, 2015).	

Appendix 8.2: Session Two Overview

Session Two Components	Recommended Duration
1. Using the think-pair-share strategy (Bamiro, 2015), participants reflect on how sleep can affect mental health.	5 minutes
2. Participants complete a paced breathing activity (Ma et al., 2017; O'Reilly et al., 2016; Tsai et al., 2015) with video guidance: https://www.youtube.com/watch?v=QWJtWfSSTi4	5 minutes
3. Participants complete a goal setting and review activity (Harkin et al., 2016) using page one of the goal setting and review document (Appendix 11).	5 minutes
4. In pairs or groups of three, participants complete a pre-lecture true-or-false quiz on the relationship between sleep and mental and emotional health (Narloch et al., 2006).	5 minutes
5. The facilitator delivers an interactive psychoeducational presentation on the importance of sleep for mental and emotional health adapted from Barber and Cucalon (2017) and Brown et al., (2006). The evidence-based active student responding technique (Randolph, 2007) is used throughout this presentation. The contents of the presentation include: ➢ Information on sleep debt (Carskadon & Dement, 2005; Endo et al., 1998). ➢ Information on the impact of sleep insufficiency on brain activation (Dahl & Lewin, 2002; Gruber & Cassoff, 2014; Yoo et al, 2007b; Yoo et al., 2007a). ➢ Information on the link between sleep and the ability to identify facial expressions (Mayer et al., 1990; Van Der Helm et al, 2010). This included a facial expression identification activity adapted from Dehning et al. (2014) (Appendix 21). ➢ Information on the link between mental health conditions and sleep (Ramsawh et al., 2009; Roberts &	30 minutes

Duong, 2014; Strine & Chapman, 2005).

- Information on the impact that lifestyle changes can have on sleep quality (Omvik et al., 2008).

- Information on how sleep helps individuals to process emotional experiences (Goldstein & Walker, 2014; Raskind et al., 2003; Walker & van Der Helm, 2009).

- Information on sleep staging (Carskadon, 1993).

- Sleep hygiene recommendations (avoiding sleep disruption, cool sleeping environment, avoiding alcohol and using relaxation strategies) (Aksu et al., 2018; Barrett et al., 1993; Brower, 2001; Jacobson, 1938; Kaida et al., 2003; Kaida et al., 2005; Kanda et al., 1999; Manzoni et al., 2008; Raymann & Someren, 2008; Saeedi et al., 2012; Smith & Smith, 2003).

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6. Participants complete a video-guided progressive muscle relaxation activity: https://www.youtube.com/watch?v=pyxvL1O2duk (Saeedi et al, 2012).	5 minutes
7. Participants complete a goal setting activity (Harkin et al., 2016) using page two of the goal setting and review document (Appendix 11).	5 minutes
8. Participants are assigned a homework task of completing the week two progress monitoring questionnaire each night before sleep (Appendix 12.2) (Harkin et al., 2016).	
9. An abridged video version of session two is sent to parent(s) and/or guardian(s) (Appendix 10). In addition, a letter is sent to parent(s) and/or guardians to explain how the learning from session two may be generalised to the home context (Appendix 9.2). This is based on the recommendations of several systematic reviews of school-based sleep promotion interventions (Blunden, Chapman, & Rigney, 2012; Blunden & Rigney, 2015; Cassoff, Knäuper, Michaelsen, & Gruber, 2013; Gruber, 2017; Sheldon, 2015).	

Appendix 8.3: Session Three Overview

Session Three Components	Recommended Duration
1. Using the think-pair-share strategy (Bamiro, 2015), participants reflect on how sleep can affect physical health.	5 minutes
2. Participants complete a paced breathing activity (Ma et al., 2017; O'Reilly et al., 2016; Tsai et al., 2015) with video guidance: https://www.youtube.com/watch?v=QWJtWfSSTi4	5 minutes
3. Participants complete a goal setting and review activity (Harkin et al., 2016) using pages one and two of the goal setting and review document (Appendix 11).	5 minutes
4. In pairs or groups of three, participants complete a pre-lecture true-or-false quiz on the relationship between sleep and physical health (Narloch et al., 2006).	5 minutes
5. The facilitator delivers an interactive psychoeducational presentation on the importance of sleep for physical health adapted from Barber and Cucalon (2017) and Brown et al. (2006). The evidence-based active student responding technique (Randolph, 2007) is used throughout this presentation. The contents of the presentation include: ➢ Information on how sleep can affect susceptibility to infections (Prather et al., 2015). ➢ Information on how sleep can affect athletic performance (Azboy & Kaygisiz, 2009; Gao et al., 2019; Mah et al., 2011; Milewski et al., 2014; Onen et al., 2001; Orzel-Gryglewska, 2010; Reilly & Piercy, 1994; Skein et al., 2011; Takeuchi et al., 1985; Van Cauter & Copinschi, 2000). ➢ The self-reported sleep duration of elite athletes (Brown & Basil, 1995; Chawla, 2016; Dix et al., 2010). ➢ Information on the relationship between sleep and	30 minutes

weight gain (Greer et al., 2013; Hanlon et al., 2016; Magee & Hale, 2012; Nedeltcheva et al., 2010; Taheri et al., 2004; Van Cauter & Knutson, 2008).

- Sleep hygiene recommendations (minimising daytime napping, avoiding heavy meals and liquids late at night, getting early morning sunlight exposure and using bed only for sleep) (Brown et al, 2017; Crispim et al., 2011; Dhand & Sohal, 2006; Figueiro et al., 2017; Fujiwara et al., 2012; Harvey et al., 2014; Lack et al., 2007; Marinkovic et al., 2004; Peschke et al., 2013).

6. Participants complete a goal setting activity (Harkin et al., 2016) using page three of the goal setting and review document (Appendix 11).	10 minutes
7. Participants are assigned a homework task of completing the week three progress monitoring questionnaire each night before sleep (Appendix 12.3) (Harkin et al., 2016).	
8. An abridged video version of session three is sent to parent(s) and/or guardian(s) (Appendix 10). In addition, a letter is sent to parent(s) and/or guardians to explain how the learning from session three may be generalised to the home context (Appendix 9.3). This is based on the recommendations of several systematic reviews of school-based sleep promotion interventions (Blunden, Chapman, & Rigney, 2012; Blunden & Rigney, 2015; Cassoff, Knäuper, Michaelsen, & Gruber, 2013; Gruber, 2017; Sheldon, 2015).	

Appendix 9: Letters to Parent(s) and/or Guardian(s)

Appendix 9.1: Session 1 Letter

06/11/2020

Dear parent(s) / guardian(s),

I am writing to outline the content of Session 1 of the Sleep Education Programme.
There were several aims of Session 1:

- The first aim was to provide information about the recommended sleep duration for adolescents aged 14–17. The National Sleep Foundation recommends a sleep duration **between 8 and 10 hours.**
- Second, information was provided regarding the prevalence of sleep insufficiency. The Centres for Disease Control, for instance, found that **just 28% of secondary school students sleep sufficiently**.
- Third, the processes which control sleep were examined: the homeostatic process and the circadian rhythm. We discussed how these processes contribute to sleep disruption among adolescents.
- Fourth, we discussed **the impact of sleep on cognition, learning and academic performance**. For instance, we discussed research which demonstrated that sleep duration is associated with school grades. We also discussed experimental research which sheds light on this association.
- Finally, advice was offered to help students to improve sleeping patterns. These tips are enclosed.

During Session 1, we explored the scientific research supporting recommendations 1-4. The science behind the remaining 8 recommendations will be discussed during Sessions 2 and 3.

Tip 1: Research shows that one of the most effective ways to improve sleep quality is to **improve sleep regularity:** going to bed and getting up at the same time every day, even on weekends. Strategies to do this include, first, choosing a bedtime which gives 8-10 hours of sleep opportunity, second, setting a bedtime alarm and, third, using a phone wallpaper as a reminder to sleep.

Tip 2: Research has demonstrated that a **low light environment** in the evening improves sleep quality. This is because light supresses the release of the hormone melatonin which promotes sleep. To achieve this, some tips include, first, turning off overhead lighting and using low-wattage lamp lighting instead, second, using a spotlight to illuminate the working area instead of lighting up the entire room and, third, drawing the curtains at night to eliminate street lighting.

Tip 3: The third sleep tip is to **minimise screen time before sleep**. The rationale for this recommendation is that blue light emitted from screens suppresses melatonin and interferes with sleep.

Tip 4: The final sleep tip is to **avoid caffeine after midday.** Research has shown that consumption of caffeine in the evening doubles the time it takes to fall asleep and reduces sleep duration.

Finally, students were asked to monitor their progress with the above recommendations. The reason for this is that research has found that **behavioural change is much more likely to occur with goal setting and progress monitoring.** Students were asked to complete the 45-second questionnaire **each night** before sleep.

To allow parent(s) / guardian(s) to learn more about the science of sleep, and to see the content of Session 1, **an abridged version of session 1** of the sleep education programme is available through this link:

Session 1: Sleep and Academic Performance

https://youtu.be/sJIr83ehNH8

Kind regards,

Saoirse Mac Cárthaigh (Trainee Educational and Child Psychologist)

Saoirse Mac Cárthaigh

Appendix 9.2: Session 2 Letter

10/11/2020

Dear parent(s) / guardian(s),

I am writing to outline the content of Session 2 of the Sleep Education Programme.

There were several aims of Session 2:

- The first aim was to demonstrate how getting enough sleep is good for mental and emotional health. For instance, we discussed evidence which shows that sleep is a protective factor against the development of depression and anxiety.
- Secondly, we discussed the importance of sleep for emotional intelligence. For instance, studies have found that getting sufficient sleep helps us to accurately interpret facial expressions.
- Third, we discussed and practiced relaxation strategies which have been shown not only to improve sleep quality, but also to reduce worry and rumination. We covered two of these strategies during Session 2: paced breathing and progressive muscle relaxation.

During Session 2, we reviewed the students' progress with sleep tips 1-4 from Session 1. We also explored the science supporting sleep tips 5-8:

Tip 5: **Avoid hitting the snooze button or checking the clock during the night.** Multiple abrupt awakenings have been shown to cause a spike in blood pressure and fragmentation of REM sleep.

Tip 6: Research has demonstrated that **a cool environment promotes better sleep quality**. This is because the core body temperature falls by approximately 1˚C during sleep. The optimum bedroom temperature is 18.3˚C.

Tip 7: The third sleep tip is to **avoid evening consumption of alcohol.** Alcohol is one of the most powerful known suppressors of REM sleep.

Tip 8: The fourth sleep tip is to **use relaxation strategies before sleep.** Research has shown that using relaxation strategies can improve sleep quality by up to 60%.

Finally, students were asked to monitor their progress with the above recommendations. The reason for this is that research has found that **behavioural change is much more likely to occur with goal setting and progress monitoring.** Students were asked to complete the 45-second questionnaire **each night** before sleep.

To allow parent(s) / guardian(s) to learn more about the science of sleep, and to see the content of Session 2, an **abridged version of Session 2 of the Sleep Education Programme** is available through this link:

Session 2: Sleep and Emotional and Mental Health

youtube.com/watch?v=hY_a2aJOEd0

Kind regards,

Saoirse Mac Cárthaigh (Trainee Educational and Child Psychologist)

Saoirse Mac Cárthaigh

Appendix 9.3: Session 3 Letter

23/11/2020

Dear parent(s) / guardian(s),

I am writing to outline the content of the third and final session of the Sleep Education Programme.

There were several aims of Session 3:

- The first aim was to demonstrate how getting enough sleep promotes physical health. For instance, getting enough sleep has been shown to be a protective factor against viral infections such as the common cold. Sleep has also been shown to be important for injury avoidance and maintaining a healthy body mass index.
- Secondly, we continued to practice the relaxation strategies which had been covered in Session 2. These strategies have been shown to improve sleep quality and reduce symptoms of anxiety.
- Finally, students were supported to continue developing a plan to improve sleeping habits.

During Session 3, we reviewed the students' progress with sleep tips 1-8. We also explored the science supporting sleep tips 9-12:

Tip 9: Avoid naps after 3:00 p.m. and naps longer than 30 minutes. Research has shown that doing so improves sleep quality and increases sleep duration.

Tip 10: Avoid heavy meals and lots of fluids in the hours before sleep. There are three reasons for this recommendation. First, late night food consumption causes blood to rush to the gut. This keeps the core body temperature high and interferes with the ability to fall asleep. Second, when food is consumed late at night, the stomach releases acid to digest the food. This can lead to acid reflux and can fragment sleep. Finally, when food is consumed, insulin is released by the pancreas to help absorb blood sugar. However, insulin has been shown to suppress the effect of melatonin. Lower levels of melatonin make it more difficult to fall asleep.

Tip 11: Get early-morning light exposure. Doing so has been shown to improve sleep quality and lengthen sleep duration. This can be achieved by going for a morning walk, having breakfast by a large window or opening the curtains immediately in the morning.

Tip 12: Use your bed only for sleep, rather than for relaxing or engaging in activities such as watching TV. By using your bed only for sleep, the brain quickly makes the association that bed is a place for sleeping and the time it takes to fall asleep reduces. Research has shown that following this sleep tip improves sleep quality.

Finally, students were asked to monitor their progress with the above recommendations. The reason for this is that research has found that **behavioural change is much more likely to occur with goal setting and progress monitoring.** Students were asked to complete the 45-second questionnaire **each night** before sleep.

To allow parent(s) / guardian(s) to learn more about the science of sleep, and to see the content of Session 3, an **abridged version of Session 3** of the Sleep Education Programme is available through this link:

Session 3: Sleep and Physical Health

youtube.com/watch?v=jopA-9XypfU

Kind regards,

Saoirse Mac Cárthaigh (Trainee Educational and Child Psychologist)

Saoirse Mac Cárthaigh

Appendix 10: Videos for Parent(s) and/or Guardian(s)

Session 1:

Sleep and Academic Performance

https://youtu.be/sJIr83ehNH8

Session 2:

Sleep and Mental and Emotional Health

youtube.com/watch?v=hY_a2aJOEd0

Session 3:

Sleep and Physical Health

youtube.com/watch?v=jopA-9XypfU

Appendix 11: Goal Setting and Review Document

Sleep Goal	Plan	Potential Difficulties	Outcome
 **Sleep Consistently**			Achieved ☐ Not yet achieved ☐ New plan:
Keep it dark			Achieved ☐ Not yet achieved ☐ New plan:
Minimise screen-time three hours before sleep			Achieved ☐ Not yet achieved ☐ New plan:
 **Avoid caffeine after midday**			Achieved ☐ Not yet achieved ☐ New plan:

Page **1** of **3**

 Don't hit the snooze button or check the clock at night			Achieved ☐ Not yet achieved ☐ New plan:
 Keep it cool			Achieved ☐ Not yet achieved ☐ New plan:
Avoid alcohol before sleep			Achieved ☐ Not yet achieved ☐ New plan:
 Use relaxation strategies before sleep			Achieved ☐ Not yet achieved ☐ New plan:

 **Avoid naps after 3:00 P.M. and long naps**			Achieved ☐ Not yet achieved ☐ New plan:
 **Avoid food and lots of liquids at night**			Achieved ☐ Not yet achieved ☐ New plan:
 **Get early-morning light exposure**			Achieved ☐ Not yet achieved ☐ New plan:
 **Use you bed only for sleeping**			Achieved ☐ Not yet achieved ☐ New plan:

Appendix 12: Progress Monitoring Questionnaire

Appendix 12.1: Week 1 Progress Monitoring Questionnaire

Week 1: Please complete the following questionnaire *each night* before sleep.

I took steps to improve sleep regularity 	Night 1	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I kept my environment dark in the evening	Night 1	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I minimised screentime three hours before sleep	Night 1	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I avoided caffeine after midday 	Night 1	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐

Appendix 12.2: Week 2 Progress Monitoring Questionnaire

Week 2: Please complete the following questionnaire *each night* before sleep.

I took steps to improve sleep regularity 	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I kept my environment dark in the evening	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I minimised screentime three hours before sleep	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I avoided caffeine after midday 	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐

Page **1** of **2**

I didn't use the snooze button or check the clock at night 	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I kept my sleeping environment cool 	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I avoided alcohol before sleep	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I used relaxation strategies before sleep 	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐

Appendix 12.3: Week 3 Progress Monitoring Questionnaire

Week 3: Please complete the following questionnaire ***each night*** before sleep.

I took steps to improve sleep regularity	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I kept my environment dark in the evening	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I minimised screentime three hours before sleep	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I avoided caffeine after midday	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐

I didn't use the snooze button or check the clock at night 	Night 1	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I kept my sleeping environment cool 	Night 1	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I avoided alcohol before sleep	Night 1	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I used relaxation strategies before sleep 	Night 1	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐

I avoided naps after 3:00 P.M. and long naps 	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I avoided food and lots of liquids at night 	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I got early morning light exposure 	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
I used my bed only for sleeping 	**Night 1**	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 2	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 3	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 4	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 5	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 6	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐
	Night 7	Strongly Agree ☐	Agree ☐	Disagree ☐	Strongly Disagree ☐

Appendix 13: Visual Prompt

Please keep this folder by your bedside.

Remember to complete the questionnaire each night.

Appendix 14: Mi-Band Usage Instructions

This device will track your sleep over the next few weeks 

- Please set it up using the **Mi Fit** app
- Please be sure to **charge** the device today 
- Remember, the device is **waterproof**, so you can wear it in the shower or when swimming. 
- It is recommended that you keep the device on your wrist at **all times**, except when charging. 

Appendix 15: Questionnaire

Questionnaire

Please enter the last four digits of your phone number:

4th Last Digit	3rd Last Digit	2nd Last digit	Last Digit

What is your gender?

Male ☐

Female ☐

Prefer not to say ☐

What is your age?

____________ years

What is your ethnicity?

Caucasian ☐

Traveller ☐

Black ☐

Asian ☐

Other (please state): ____________________

Have you been diagnosed with a sleep disorder?

No ☐

Yes ☐ (specify the disorder) ______________________

Instructions: The following questions relate to your usual sleep habits *during the past month only*. Your answers should indicate the most accurate reply *for the majority* of days and nights in the ***past month***. **Please answer all questions.**

During the past month…				
1. What time have you usually gone to bed?	**____:____ am ☐ pm ☐**			
2. How long (in minutes) has it taken you to fall asleep each night?	**____ minutes**			
3. What time have you usually gotten up in the morning?	**____:____ am ☐ pm ☐**			
4. How many hours of actual sleep did you get at night? (This may be different than the number of hours you spend in bed)	**____hours____ minutes**			
5. During the past month, how often have you had trouble sleeping because you…	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
a. Cannot get to sleep within 30 minutes	☐	☐	☐	☐
b. Wake up in the middle of the night or early morning	☐	☐	☐	☐
c. Have to get up to use the bathroom	☐	☐	☐	☐
d. Cannot breathe comfortably	☐	☐	☐	☐
e. Cough or snore loudly	☐	☐	☐	☐
f. Feel too cold	☐	☐	☐	☐
g. Feel too hot	☐	☐	☐	☐
h. Have bad dreams	☐	☐	☐	☐
i. Have pain	☐	☐	☐	☐
j. Other reason(s), please describe, including how often you have had trouble sleeping because of this reason(s):	☐	☐	☐	☐
6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?	☐	☐	☐	☐
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?	☐	☐	☐	☐
	No problem at all	Only a very slight problem	Some-what of a problem	A very big problem
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?	☐	☐	☐	☐
	Very good	Fairly good	Fairly bad	Very bad
9. During the past month, how would you rate your sleep quality overall?	☐	☐	☐	☐

Instructions: Using the choices below, circle ***how often*** the following things have happened ***<u>during the past month</u>***.

							Always (100%)
						Frequently, if not always (80%)	
					Quite often (60%)		
				Sometimes (40%)			
			Once in a while (20%)				
		Never (0%)					
During the day…							
1	…I take a nap that lasts ***more than*** 1 hour.	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
After 6:00 in the evening…							
2	…I have drinks with caffeine (for example: cola, energy drinks, iced tea, coffee).	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
3	…I take a nap.	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
4	…I smoke or chew tobacco.	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
5	…I drink beer (or some other drinks with alcohol).	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
During the 1 hour before bedtime…							
6	…things happen that make me feel ***strong emotions*** (sadness, anger, excitement).	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
7	…I am ***very active*** (for example: playing outside, running, wrestling).	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
8	…I do things that make me feel ***very awake*** (for example: playing video games, watching TV, talking on the telephone).	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
9	…I drink ***more than*** 4 glasses of water (or some other liquid).	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
I go to bed…							
10	…and do things in my bed that keep me awake (for example: watching TV, reading).	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
11	…and think about things I ***need*** to do.	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
12	…feeling upset.	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
13	…and replay the day's events over and over in my mind.	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
14	…and worry about things happening at home or at school.	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
15	…with a stomach-ache.	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**
16	…feeling hungry.	Never **0%**	Once in a while **20%**	Some-times **40%**	Quite often **60%**	Freque ntly **80%**	Always **100%**

		Never (0%)	Once in a while (20%)	Sometimes (40%)	Quite often (60%)	Frequently, if not always (80%)	Always (100%)
I fall asleep…							
17	…while listening to loud music.	Never 0%	Once in a while 20%	Some-times 40%	Quite often 60%	Freque ntly 80%	Always 100%
18	…while watching TV.	Never 0%	Once in a while 20%	Some-times 40%	Quite often 60%	Freque ntly 80%	Always 100%
19	…in a ***brightly*** lit room (for example: the overhead light is on).	Never 0%	Once in a while 20%	Some-times 40%	Quite often 60%	Freque ntly 80%	Always 100%
20	…in ***one place*** and then move to ***another place*** during the night.	Never 0%	Once in a while 20%	Some-times 40%	Quite often 60%	Freque ntly 80%	Always 100%
21	…in a room that feels ***too hot*** or ***too cold***.	Never 0%	Once in a while 20%	Some-times 40%	Quite often 60%	Freque ntly 80%	Always 100%
I…							
22	…use a bedtime routine (for example: bathing, brushing teeth, reading).	Never 0%	Once in a while 20%	Some-times 40%	Quite often 60%	Freque ntly 80%	Always 100%
23	…use my bed for things ***other than sleep*** (for example: talking on the telephone, watching TV, playing video games, doing homework).	Never 0%	Once in a while 20%	Some-times 40%	Quite often 60%	Freque ntly 80%	Always 100%
24	…check my clock several times during the night.	Never 0%	Once in a while 20%	Some-times 40%	Quite often 60%	Freque ntly 80%	Always 100%
During the school week, I…							
25	...stay up ***more than 1 hour*** past my ***usual*** bedtime. My usual ***school night*** bedtime is: **____:____ am ☐ pm ☐**	Never 0%	Once in a while 20%	Some-times 40%	Quite often 60%	Freque ntly 80%	Always 100%
26	..."sleep in" ***more than 1 hour*** past my ***usual*** wake time. My usual ***school day*** wake time is: **____:____am ☐ pm ☐**	Never 0%	Once in a while 20%	Some-times 40%	Quite often 60%	Freque ntly 80%	Always 100%
On weekends, I…							
27	…stay up ***more than 1 hour*** past my ***usual*** bedtime. My usual ***weekend*** bedtime is: **___:___ am ☐ pm ☐**	Never 0%	Once in a while 20%	Some-times 40%	Quite often 60%	Freque ntly 80%	Always 100%
28	…"sleep in" ***more than 1 hour*** past my ***usual*** wake time. My usual ***weekend*** wake time is: **____:____am ☐ pm ☐**	Never 0%	Once in a while 20%	Some-times 40%	Quite often 60%	Freque ntly 80%	Always 100%

Instructions: Please indicate your response to the following items by **circling one** of the numbers, which have the following meaning:

1 = strongly disagree; **2** = disagree; **3** = neither agree nor disagree; **4** = agree; **5** = strongly agree

Please answer these items carefully, **thinking about how you have been generally, over the past month**. Do not spend too much time on any one item.

	Disagree				**Agree**
1) Even when under considerable pressure I usually remain calm	1	2	3	4	5
2) I like the idea that I can set and beat goals and targets for myself	1	2	3	4	5
3) I usually enjoy a challenge	1	2	3	4	5
4) I am generally confident in my own abilities	1	2	3	4	5
5) I generally feel in control	1	2	3	4	5
6) I can normally sustain high levels of mental effort for long periods	1	2	3	4	5
7) I am generally able to react quickly when something unexpected happens	1	2	3	4	5
8) I don't usually give up under pressure	1	2	3	4	5
9) I generally look on the bright side of life	1	2	3	4	5
10) I usually find myself just going through the motions	1	2	3	4	5
11) I don’t mind taking risks to achieve things	1	2	3	4	5
12) I generally try to give 100%	1	2	3	4	5
13) I am comfortable telling people what to do	1	2	3	4	5
14) Sometimes I just can’t hold my emotions inside	1	2	3	4	5
15) I don’t mind setbacks, there’s always something to learn from them	1	2	3	4	5
16) I generally feel that I am in control of what happens in my own life	1	2	3	4	5
17) If I feel somebody is wrong, I am not afraid to argue with them	1	2	3	4	5
18) I can generally be relied upon to complete the tasks I am given	1	2	3	4	5
19) I like pushing myself out of my comfort zone	1	2	3	4	5
20) I am good at focusing on the task at hand	1	2	3	4	5
21) I often feel intimidated in social gatherings	1	2	3	4	5
22) I can usually adapt myself to challenges that come my way	1	2	3	4	5
23) I can modify my emotions to suit the situation	1	2	3	4	5
24) I do not usually criticise myself even when things go wrong	1	2	3	4	5

Instructions:

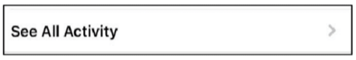
For each question, please tick the box which most describes yourself.

1. Missing planned work due to smartphone use	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
2. Having a hard time concentrating in class, while doing assignments, or while working due to smartphone use	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
3. Feeling pain in the wrists or at the back of the neck while using a smartphone	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
4. Won't be able to stand not having a smartphone	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
5. Feeling impatient and fretful when I am not holding my smartphone	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
6. Having my smartphone in my mind even when I am not using it	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
7. I will never give up using my smartphone even when my daily life is already greatly affected by it.	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
8. Constantly checking my smartphone so as not to miss conversations between other people on social media.	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
9. Using my smartphone longer than I had intended	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
10. The people around me tell me that I use my smartphone too much.	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
11. Smartphone use interferes with my sleep.	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐

If you use iOS , follow the instructions on this page.

If you use Android , follow the instructions on page 8.

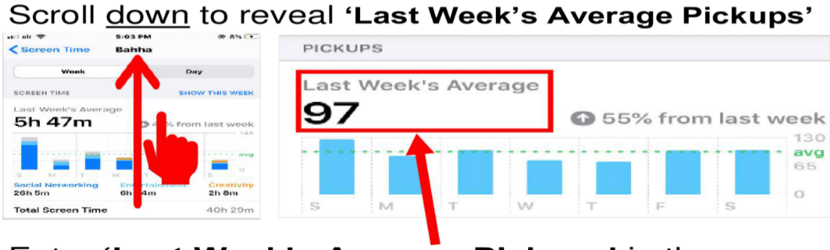
1. Open **Settings**
2. Scroll down and press **Screen Time**
3. Select **'See All Activity'**



4. Ensure **'Week'** is selected at the top of the screen

5. Scroll sideways on **'Daily Average'** to reveal **'Last Week's Average'**

6. Enter **Last Week's Average** screentime in the grey boxes below
7. Scroll down to reveal **'Last Week's Average Pickups'**

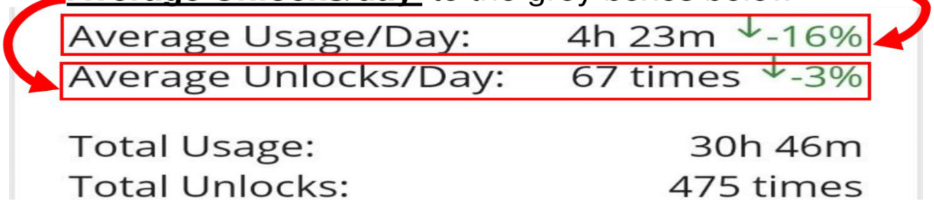


8. Enter **'Last Week's Average Pickups'** in the grey box below.

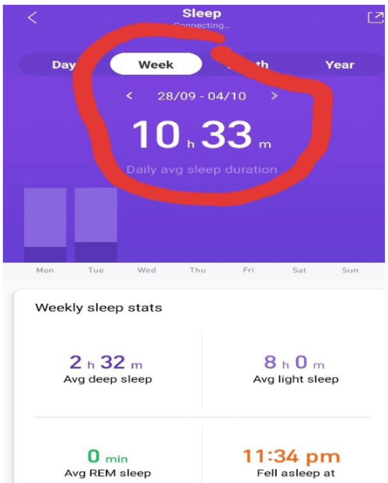
Last Week's Average Screentime:	________**hours**	_______**minutes**
Last Week's Average Pickups:	_______ **pickups**	

1. Open **Play Store**
2. Type '**YourHour**' in the search bar
3. Press INSTALL, and after download and press OPEN
4. Press Let's get started and select language English
5. Press Give Permission
6. Scroll <u>down</u> to 'YourHour' and select it. Then allow usage tracking
7. Press back twice
8. Press NEXT 6 times and then press DONE
9. Scroll <u>down</u> and **press** **'This month's average usage'**
   (you may have to watch an advert to access the data)

10. Transfer your data for **'<u>Average Usage/Day</u>'** and **'<u>Average Unlocks/day</u>'** to the grey boxes below

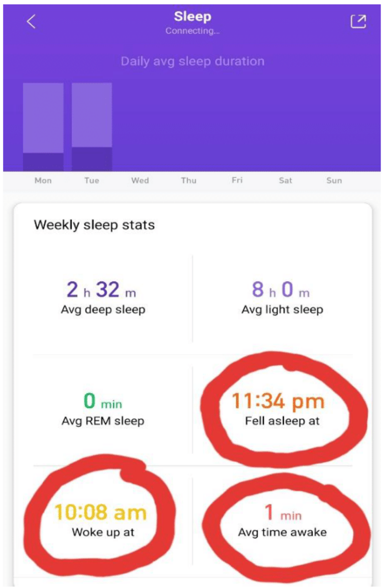


Average Usage / Day:	________**hours**	_______**minutes**
Average Unlocks /Day: **(Not total unlocks)**	_______ **times**	



Input your average **weekly** sleep duration between **28/09/ and 04/10**

________ Hours	________Min.



Input **weekly** average fall asleep time, wake up time and average time awake between **28/09/ and 04/10**

Fell asleep at:	________Hours	________Min.
Woke up at:	________Hours	________Min.
Avg. time awake:	________Hours	________Min.

Appendix 16: Scale of Engagement

Please enter the last four digits of your phone number:

4th Last Digit	3rd Last Digit	2nd Last digit	Last Digit

Do you agree with the following statement?

"I felt engaged in learning during the Sleep Education Programme."

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

Appendix 17: Exit Survey

Please answer the following questions. Your answers will help to improve the programme.

I enjoyed the sleep programme.	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
The sleep programme was suitable for people my age.	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
I think the programme will result in changes in my sleep.	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
I learned a lot about sleep.	Strongly disagree ☐	Disagree ☐	Weakly disagree ☐	Weakly agree ☐	Agree ☐	Strongly agree ☐
Is there anything else about the sleep programme that you would like us to know?						

Appendix 18: Correlation Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	**T1 MT**																				
2	**T2 MT**	.67**																			
3	**T3 MT**	.67**	.62**																		
4	**T1 PSU**	-.29*	-.27*	-.11																	
5	**T2 PSU**	-.25*	-.27*	-.26	.80**																
6	**T3 PSU**	-.04	-.12	-.02	.85**	.85**															
7	**T1 ASHS**	.27*	.15	.40*	-.40**	-.18	.34														
8	**T2 ASHS**	.22	.18	.22	-.24*	-.24	.18	.75**													
9	**T3 ASHS**	.15	.08	-.02	-.23	-.11	-.21	.36	.59**												
10	**T1 PSQI**	-.23	.03	-.02	.19	.06	-.24	-.57**	-.62**	-.24											
11	**T2 PSQI**	-.2	-.04	.2	.36**	.30*	-.09	-.48**	-.65**	-.37	.76**										
12	**T3 PSQI**	-.1	-.21	-.07	-.05	-.19	-.18	-.35	-.76**	-.59**	.52*	.71**									
13	**T1 PU**	-.14	.23	.32	.22	.28*	.36	-.05	-.17	.08	.11	.28*	-.09								
14	**T2 PU**	-.16	.11	.26	.31*	.39**	.19	-.08	-.1	.29	.12	.31*	-.34	.55**							
15	**T3 PU**	-.02	-.06	.21	.41*	.26	.49*	.53**	.23	.02	-.40*	-.15	-.1	.75**	.61**						
16	**T1 ST**	-.27*	-.14	-.41*	.18	.32*	.25	-.21	-.29*	.06	.22	.16	.05	.16	.09	.26					
17	**T2 ST**	-.45**	-.38**	-.04	.42**	.30*	.03	-.28*	-.23	-.08	.19	.27*	.22	.16	.16	.3	.63**				
18	**T3 ST**	-.64**	-.63**	-.32	.27	.27	.06	-.49*	-.58**	-.34	.22	.26	.46*	.27	-.04	.16	.73**	.62**			
19	**T1 OS**	.1	.03	.17	-.21	-.26*	-.32	.04	.18	.09	-.23	-.21	-.08	-.31*	-.06	-.27	-.24	-.1	-.71**		
20	**T2 OS**	-.01	-.12	-.27	-.18	-.09	-.33	.13	.18	.32	-.29*	-.44**	-.07	-.33*	-.22	-.3	-.04	-.17	-.3	.39**	
21	**T3 OS**	-.53**	-.26	-.26	-.05	-.06	-.13	-.53*	-.26	-.23	.24	-.09	.39	.04	-.04	-.05	.42*	.38	.39	.15	.35

**. Correlation is significant at the .01 level (1-tailed).

*. Correlation is significant at the .05 level (1-tailed).

Appendix 19: WoE A Quality Assessment Checklist (Current Study)

Quality Criterion	Yes	No	Unclear	Not applicable
1. Is it clear in the study what is the ‘cause’ and what is the ‘effect’ (i.e., there is no confusion about which variable comes first)?	☒	☐	☐	☐
2. Were the participants included in any comparisons similar?	☒	☐	☐	☐
3. Were the participants included in any comparisons not receiving similar treatment/care, other than the exposure or intervention of interest?	☐	☒	☐	☐
4. Was there a control group?	☒	☐	☐	☐
5. Were there multiple measurements of the outcome both pre and post the intervention/exposure?	☐	☒	☐	☐
6. Was follow up completed and if not, were differences between groups in terms of their follow up adequately described and analysed?	☒	☐	☐	☐
7. Were the outcomes of participants included in any comparisons measured in the same way?	☒	☐	☐	☐
8. Were outcomes measured in a reliable way?	☒	☐	☐	☐
9. Was appropriate statistical analysis used?	☒	☐	☐	☐

Appendix 20: Ethical Approval

Appendix 20.1 Approval for Sleep Promotion Intervention

Mary Immaculate College
Research Ethics Committee
MIREC-4: MIREC Chair Decision Form

APPLICATION NO. A19-054 - FINAL

1. PROJECT TITLE

Sleep, Smartphone Addiction and Mental Toughness: an exploration of the Effectiveness of a School-based Sleep Promotion Intervention with a Cohort of Post-primary Students in Ireland.

2. APPLICANT

Name:	Saoirse Mac Cárthaigh
Department / Centre / Other:	Dept of Psychology
Position:	Postgraduate Researcher

3. DECISION OF MIREC CHAIR

☐	Ethical clearance through MIREC is required.
☐	Ethical clearance through MIREC is not required and therefore the researcher need take no further action in this regard.
✓	Ethical clearance is required and granted. Referral to MIREC is not necessary.
☐	Ethical clearance is required but the full MIREC process is not. Ethical clearance is therefore granted if required for external funding applications and the researcher need take no further action in this regard.
☐	Insufficient information provided by applicant / Amendments required.

4. REASON(S) FOR DECISION

A19-054: Sleep, Smartphone Addiction and Mental Toughness: an exploration of the Effectiveness of a School-based Sleep Promotion Intervention with a Cohort of Post-primary Students in Ireland.

I have reviewed A19-054 - Saoirse Mac Carthaigh, and I believed it satisfies MIREC requirements. It is, therefore, approved.

5. DECLARATION (MIREC CHAIR)

Name (Print):	Dr Áine Lawlor
Signature:	Áine Lawlor
Date:	6th December 2019

Appendix 20.2: Approval for Contingency Study

BRIATHAR DÉ MO LÓCHRANN
MIC
MARY IMMACULATE COLLEGE
COLÁISTE MHUIRE GAN SMÁL

Mary Immaculate College
Research Ethics Committee
MIREC-4: MIREC Chair Decision Form

APPLICATION NO. A20-036 FINAL

1. PROJECT TITLE

The relationship between sleep, problematic smartphone use and mental toughness among adolescents and young adults

2. APPLICANT

Name:	Saoirse Mac Cárthaigh
Department / Centre / Other:	EPISE
Position:	Postgraduate Researcher

3. DECISION OF MIREC CHAIR

☐	Ethical clearance through MIREC is required.
☐	Ethical clearance through MIREC is not required and therefore the researcher need take no further action in this regard.
✓	Ethical clearance is required and granted. Referral to MIREC is not necessary.
☐	Ethical clearance is required but the full MIREC process is not. Ethical clearance is therefore granted if required for external funding applications and the researcher need take no further action in this regard.
☐	Insufficient information provided by applicant / Amendments required.

4. REASON(S) FOR DECISION

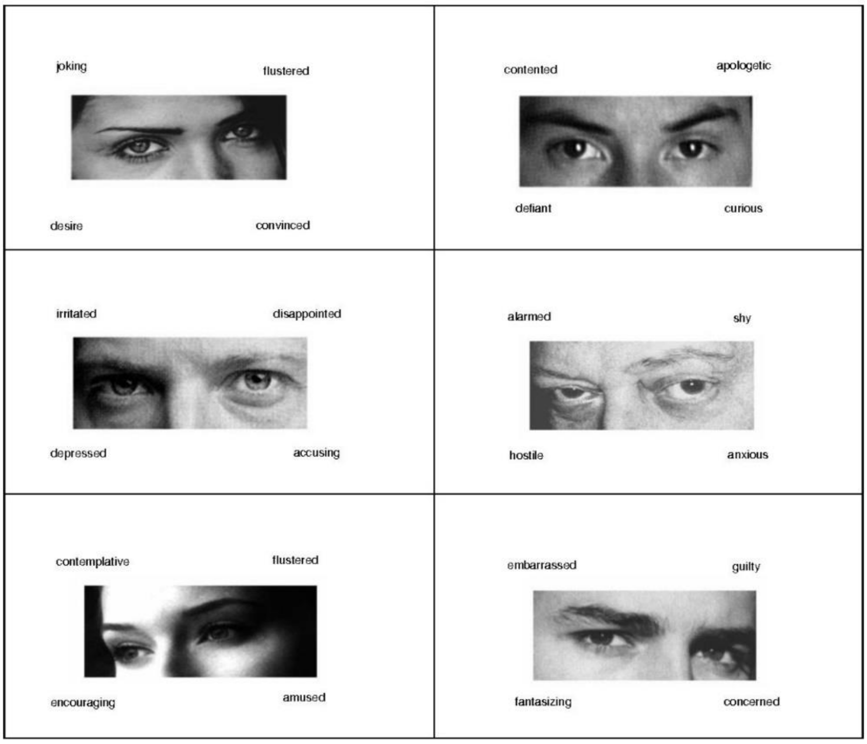
A20-036 – Saoirse Mac Cárthaigh - *The relationship between sleep, problematic smartphone use and mental toughness among adolescents*

I have reviewed this application and I believe it satisfies MIREC requirements. It is, therefore, approved.

5. DECLARATION (MIREC CHAIR)

Name (Print):	Dr Áine Lawlor
Signature:	Áine Lawlor
Date:	15th June 2020

Appendix 21: Facial Expression Identification Activity



Answers: The six mental states are, 1 ''desire,'' 2 ''defiant,'' 3 ''accusing,'' 4 ''hostile,'' 5 ''contemplative,'' and 6 ''concerned''.

Source: Dehning et al. (2014).