Sleep and mental wellbeing
Exploring the links

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Key definitions

Bright light therapy (BLT): The use of light exposure to alter the timing of the circadian rhythm. It can be used to treat delayed sleep wake phase disorder (DSWPD).

Cognitive behaviour therapy for insomnia (CBT-i): Specifically addresses maladaptive cognitions and behaviours related to insomnia. A full CBT-i program involves psychoeducation, sleep hygiene, sleep restriction therapy, stimulus control therapy, relaxation and cognitive therapy.

Cognitive behaviour therapy for depression (CBT-D): Specifically addresses maladaptive cognitions and behaviours related to depression.

Circadian rhythm: A roughly 24-hour internal body rhythm, also known as the body clock, that syncs to light/dark cycles and regulates many body processes, including sleep/wake patterns.

Cohen's d (*d*): an effect size indicating the standardised difference between two means.

Delayed sleep wake phase disorder (DSWPD): A clinically diagnosed circadian rhythm sleep disorder characterised by an inability to initiate sleep and wake-up early enough to meet societal requirements.

Insomnia: A clinically diagnosed sleep disorder characterised by an inability to fall asleep and/or stay sleep. Individuals may wake feeling unrefreshed, experience daytime tiredness, have difficulty concentrating and feel irritable. Symptoms must be present for a minimum of one month for a diagnosis of acute insomnia, and three months for chronic insomnia

Mean (M): The average value

Phase advance: To shift the circadian rhythm earlier – to fall asleep and wake-up earlier.

Phase delay: To shift the circadian rhythm later – to fall asleep and wake-up later

Polysomnography (PSG): Attaching electrodes to the scalp to measure brain waves. This gives an objective measure of when a person is awake or asleep and what stage of sleep they are in.

Randomised control trial (RCT): Randomly allocating participants in an experiment to separate groups. Results of the different groups can then be compared to determine differences in treatment effects.

Rapid eye movement sleep (REM): A stage of sleep where most dreaming occurs.

REM density: Frequency of eye movements during REM sleep (i.e. the higher number of eye movements during REM sleep, the higher the density).

REM latency: The time from sleep onset to when a person first commences REM sleep.

Sleep efficiency (SE): The percentage of time asleep compared to the amount of time spent in bed, with a higher percentage of time in bed asleep indicating more efficient sleep.

Sleep-onset latency (SOL): The time between trying to fall asleep and actually falling asleep at the start of the night.

Wake after sleep onset (WASO): The amount of time, or number of times, a person is awake after initially falling asleep and their final morning wake time.

Wrist actigraphy: A device worn on the wrist that measures movement. It is used in conjunction with algorithms on computer software to objectively measure when a person is awake or asleep.

Abbreviations

BLT	bright light therapy
CBT-D	cognitive behaviour therapy for depression
CBT-i	cognitive behaviour therapy for insomnia
d	Cohen's d
DBT	dialectical behaviour therapy
DSWPD	delayed sleep wake phase disorder
GAD	generalised anxiety disorder
M	mean
MDD	major depressive disorder
N	number (sample size)
OCD	obsessive compulsive disorder
PMR	progressive muscle relaxation
PSG	polysomnography
PTSD	post-traumatic stress disorder
RCT	randomised control trial
REM	rapid eye movement
SE	sleep efficiency
SOL	sleep-onset latency
TST	total sleep time
WASO	wake after sleep onset

Executive summary

Sleep is influenced by a host of biological and lifestyle factors. For example, sleep pressure and the circadian rhythm (i.e. body clock) impact sleep. Sleep need changes as age increases, and adolescents have a biological tendency to go to bed later and sleep in.

Lifestyle factors (e.g. caffeine consumption) are behavioural so they can usually be modified to improve sleep and mental wellbeing. The main focus of this review will be on behavioural factors that can be altered (e.g. not hereditary processes or pharmacological interventions).

The main two sleep disorders discussed will be insomnia (among other criteria, difficulty falling asleep/maintaining sleep) and delayed sleep wake phase disorder (DSWPD; among other criteria, falling asleep and waking up at a later time than meets societal requirements). Sleep disturbance will also be examined; that is, problematic sleep that does not meet criteria for a sleep disorder.

Australian sleep patterns

Adolescents throughout Australia, including Victoria, are often not obtaining the recommended amount of sleep (8–10 hours) during the school week. On average, the amount of sleep varies from 6.5–7.5 hours during the school week but is usually sufficient over the weekend and during holidays.

Australian adults are obtaining closer to sleep recommendations (7–9 hours) but are only meeting minimal requirements, particularly during the working week. Older adults are sleeping close to target sleep amounts (7–8 hours) with less weeknight to weekend discrepancy in the amount of sleep obtained.

Sleep and mental health

Overall, poor sleep across all age groups has been linked to poor current and future mental health. Adolescents may be particularly susceptible to the effects of poor sleep because they often fail to meet suggested sleep requirements during the school week. In adolescents, short sleep is related to a decreased ability to regulate emotions. In adults, acute sleep restriction is not related to increased anxiety; however, across all age groups, an association between depression and poor sleep (e.g. short sleep duration) was found. Many review articles have concluded that poor sleep is related to an increased risk of current and future depressed mood. Although there is less conclusive evidence, it is also suggested that this relationship is bi-directional: poor mental health also leads to poor future sleep.

Lifestyle factors associated with sleep

Most literature assessing lifestyle factors and adolescent sleep links media use, caffeine consumption and sleep. Studies show that pre-bed technology use may be a risk factor for delaying adolescents' bedtimes and decreasing their sleep duration. Adolescents and young adults who use caffeine are likely to have shorter sleep and more daytime tiredness. Conversely, a positive family environment and parent-set bedtimes, as well as exercise, are likely to promote sleep. The timing, intensity and duration of physical activity need to be more rigorously studied to determine the exact effects on sleep. The effects of extracurricular activities on sleep are inconclusive.

Among adults, studies show a trend linking the use of technology with worse sleep outcomes. For both adults and older adults, caffeine consumption is disruptive to sleep, while physical activity is likely to enhance sleep. The sleep of older adults also benefits from social interactions. Sleep medication may be detrimental for the future sleep of older adults.

Across all age groups, more experimental studies are required to investigate casual relationships of protective and risk factors for sleep. Research involving adolescents and young adults is most needed, as many of the studies among this age group are correlational.

Behavioural solutions to improve sleep and mental health in young people

To improve sleep, and thus mental health, among adolescents and young adults, the following treatment options have been successful or partially successful. Each strategy differs in terms of its cost, training required, ease of dissemination and administration mode (e.g. individual, group or internet based) and these should be considered before using them.

Table 1. Summary of effective or partially effective treatments for sleep in adolescents and young adults

Strategy	Description	Summary of evidence
Cognitive behaviour therapy for insomnia (CBT-i)	Combination of sleep psychoeducation, sleep hygiene, sleep restriction therapy, stimulus control therapy, relaxation and cognitive therapy	Improved TST, SE, SOL, WASO, mental health
Bright light therapy (BLT)	Changing a person's body clock through appropriately timed bright light (used for treating DSWPD)	Improved SOL, earlier bedtime, mental health
Sleep hygiene	Education on practices which promote good sleep and practices which may be harmful to sleep	Improved TST, SOL
Other: relaxation, mindfulness	Techniques designed to promote pre-sleep cognitive and physiological de-arousal and/or detachment from unhelpful thoughts	Improved SE, WASO, mental health
School-based interventions	Incorporating various therapies described in this table (Table 1), administered in a school classroom	Improved sleep knowledge, immediate TST. No long-term changes to sleep habits
Pre-bed phone restriction	Restricting phone use in the 1hr before bedtime across the school week	Earlier lights out time, improved TST

Note: SE = sleep efficiency, SOL = sleep-onset latency, TST = total sleep time, WASO = wake after sleep onset

Summary and conclusions

There is a clear link between sleep and mental health: better sleep is associated with better mental health across the lifespan. Adolescents may frequently obtain insufficient weekday sleep and be vulnerable to the effects of chronic sleep deprivation. The following strategies are suggested.

- First, adolescents, their families, other caregivers (e.g. teachers), health professionals and policymakers should be educated on the benefits of sleep for good mental health.
- Second, interventions should be implemented to improve sleep. For clinical sleep problems, CBT-i and BLT provided by trained health care professionals are likely to work best. Young people who do not have a clinical sleep disorder, yet still experience some aspects of poor sleep (e.g. short sleep duration), may benefit from simple, low-intensity interventions such as sleep hygiene practices, phone restriction in the hour before bedtime and relaxation activities (e.g. listening to classical music or mindfulness breath-based audio at bedtime).

Each strategy has benefits and barriers, and must be appropriate to each person's circumstances.

Chapter 1: Introduction

Brief biology of sleep

Sleep is a complex biological process driven by two factors: homeostatic sleep drive (sleep pressure) and the circadian rhythm (body clock). The circadian rhythm is a roughly 24-hour cycle of physiological processes (core body temperature, endogenous melatonin, cortisol etc.), predominately regulated by light and dark cycles (i.e. day and night) via pathways from the eyes to the brain, specifically the suprachiasmatic nuclei (Refinetti & Menaker, 1992).

Bright light (e.g. sunlight) increases core body temperature and suppresses the sleep hormone melatonin, promoting wakefulness. By contrast, dim light or darkness allows core body temperature to decrease and melatonin to increase, which signals to the body that it is time to sleep (Kubota et al., 2002; Scheer et al., 2005; Shanahan & Czeisler, 1991). Adolescents have a biological tendency to delay their circadian rhythm (i.e. core body temperature rhythm, endogenous melatonin secretion), which results in later sleep timing; that is, they go to bed later and sleep in (Carskadon, 2011; Crowley et al., 2007; Roenneberg & Merrow, 2007).

After waking, sleep pressure accumulates exponentially throughout the day, and is alleviated by night-time sleep or naps. From adolescence onwards, adults can postpone the desire to sleep due to slower accumulation of sleep pressure (Crowley et al., 2007; Jenni et al., 2005; Taylor et al., 2005). Thus, they can choose to accomplish other tasks in place of sleeping (e.g. work, watch a movie, do homework, socialise, wake to attend to a child).

The alignment of the circadian rhythm and sleep pressure provides the largest opportunity for sleep in the evening and wakefulness during the day (Crowley et al., 2007).

Sleep over the lifespan

A meta-analysis of objectively measured sleep across the lifespan demonstrates that as people age, they sleep less. Interestingly, although adolescents obtained less sleep than children on school days, on non-school days their sleep duration was no different (Ohayon et al., 2004). These results suggest that adolescents would sleep longer if given the opportunity, such as during school holidays (Ohayon et al., 2004).

Sleep-onset latency (the time it takes to fall asleep) remains relatively stable throughout life. However, sleep efficiency (the percentage of time asleep compared to the amount of time spent in bed, with a higher percentage of time in bed asleep indicating more efficient sleep) decreases with age, thus it makes sense that increased age is related to more awakenings after sleep onset (Ohayon et al., 2004).

The USA National Sleep Foundation made the following recommendations in 2015 for optimal sleep duration (Table 2). It is suggested these recommendations can be applied worldwide.

Table 2: Sleep recommendations by age

Age	Recommended	May be appropriate	Not recommended
Newborns 0–3 months	14–17 hours	11–13 hours 18–19 hours	Less than 11 hours More than 19 hours
Infants 4–11 months	12–15 hours	10 –11 hours 16–18 hours	Less than 10 hours More than 18 hours
Toddlers 1–2 years	11–14 hours	9–10 hours 15–16 hours	Less than 9 hours More than 16 hours
Preschoolers 3–5 years	10–13 hours	8–9 hours 14 hours	Less than 8 hours More than 14 hours
School-aged children 6–13 years	9–11 hours	7–8 hours 12 hours	Less than 7 hours More than 12 hours
Teenagers 14–17 years	8–10 hours	7 hours 11 hours	Less than 7 hours More than 11 hours
Young adults 18–25 years	7–9 hours	6 hours 10–11 hours	Less than 6 hours More than 11 hours
Adults 26–64 years	7–9 hours	6 hours 10 hours	Less than 6 hours More than 10 hours
Older adults ≥ 65 years	7–8 hours	5–6 hours 9 hours	Less than 5 hours More than 9 hours

(National Sleep Foundation, USA, 2015)

Behavioural factors

Environmental factors include those under behavioural control (i.e. that can be altered by an individual). These will be the main focus of the review. It is important to note that behavioural changes can be made by an individual, those surrounding them (e.g. parents), and policy makers. This is empowering for the individual and may be particularly important for adolescents and young adults as they learn to take control of their own health behaviours (Bartel et al., 2016). In contrast, genetic influences cannot be altered.

Two common sleep disorders explained

Insomnia and delayed sleep-wake phase disorder (DSWPD) are two clinical sleep disorders.

Insomnia can include difficulty falling asleep, staying asleep or waking early in the morning without being able to reinitiate sleep (American Academy of Sleep Medicine, 2014). The individual may feel unrefreshed upon waking, experience daytime tiredness, have difficulty concentrating and feel irritable (Thorpy, 2012). These issues cause distress or impairment in the everyday life of the individual. For a diagnosis of acute insomnia, the symptoms must be present for a minimum of one month; for chronic insomnia, they must be present for three months. Prevalence rates of severe clinical insomnia in Australia are: 2% for 14–17 year olds; 11% for 18–24 year olds; 4% for 25–34 year olds; 10% for 35–49 year olds; 7% for 50–64 year olds; and 4% for adults aged 65 years and older (Hillman & Lack 2013).

In contrast, DSWPD is a circadian rhythm disorder. It involves an individual's body clock shifting so they fall asleep and wake up later than societal norms (Thorpy, 2012). It is most prevalent among adolescents (Thorpy, 2012; Carskadon, 2011), with a major consequence being the inability to fall asleep early enough to obtain sufficient sleep on school days, and waking for school becoming difficult or impossible. In Australia, 1% of adolescents experience DSWPD; however, up to 52% meet at least one of the diagnostic criterion (Lovato et al., 2013).

It is worth noting that people can have impaired sleep without meeting diagnostic criteria for a sleep disorder. For example, among adolescents in Adelaide, South Australia, 66% reported at least one symptom of a sleep disorder, yet only 23% believed they had a sleep problem (Short et al., 2013).

Focus of this review

This rapid review will aim to present and discuss evidence about the following issues**:**

- population level sleep/wake patterns for Australians and Victorians
- the extent to which these patterns may have detrimental effects on mental wellbeing as a function of different age groups and life stages, ranging from secondary school to older adults
- whether the mental wellbeing of younger people (specifically those aged 12–25 years) may be particularly at risk as a result of their sleep/wake patterns
- the role of lifestyle and behavioural factors in the perpetuation of sleep/wake patterns that may be impacting on mental health at different ages and life stages
- solutions that may improve the resilience and mental wellbeing of young people in particular, as a result of improved sleep/wake patterns.

This review will primarily focus on meta-analyses and review articles. However, it will also incorporate relevant studies too recent to be included in published meta-analyses and reviews, and relevant Australian literature not yet been published that is known to the authors. We will include studies that have used subjective measures of sleep (e.g. self-report questionnaires) as well as objective measures of sleep, including polysomnography (PSG) (i.e. electrodes measuring brain activity) and actigraphy (i.e. activity monitoring devices commonly worn on the wrist).

Chapter 2: Australian sleep patterns

Adolescents

A meta-analysis conducted by Olds, Blunden, Petkov and Forchino (2010) summarised sleep duration across international regions, from ages 9 to 18 years. Australian children and adolescents consistently obtained more sleep than their peers in the USA (20–60 minutes/day) and Asia (60–120 minutes/day) during school and non-school days, regardless of age. Across cohorts, sleep patterns were more similar to European children and adolescents. Sleep duration decreased as age increased, at a rate of 12 minutes per year for Australians on school days (Olds et al., 2010).

Studies in Victoria and South Australia found that in older adolescents sleep duration has decreased to approximately 7.5 hours (Bei et al., 2014; Lushington et al., 2015). When the sleep of older adolescents in Victoria (M age = 16.2 years) was measured objectively via a wrist actigraphy that detects sleep/wake patterns, results show only 6.5 hours of sleep is obtained per school night (Bei et al., 2013).

Weekends and holidays create opportunities for adolescents to choose their own sleep timing, as they do not need to rise for school, and catch-up on sleep that was missed throughout the school week. Adolescents sleep approximately 8 hours 40 minutes per weekend night (Lushington et al., 2015). For older adolescents, weekends see later bedtimes and rise times, and sleep duration increased by up to 90 minutes (Lushington et al., 2015). During the school holidays, sleep onset and wake-up times are also later, and Victorian and South Australian adolescents both obtained 40–120 minutes longer sleep (Bei et al., 2013; Lushington et al, 2015), totalling up to 9 hours 40 minutes sleep per night (Lushington et al., 2015).

As adolescents have less external constraints placed upon their sleep during school holidays (i.e. daytime commitments are less likely to truncate sleep duration), these estimates may be a more accurate reflection of adolescent sleep need. Furthermore, a recent laboratory study of 15–17 year olds in Adelaide, South Australia, allowed adolescents to sleep for 10 hours for seven consecutive nights. Adolescents slept an average of 8 hours 17 minutes to 9 hours 19 minutes per night (Short et al., Under review). Overall, 9 hours 19 minutes of sleep was required for optimal performance on an objective sustained-attention reaction-time task, such as a psychomotor vigilance task (Short et al., Under review).

Young adults

The Sleep Health Foundation collected data on the weekday and weekend sleep patterns of Australian adults in 2016 (Adams et al., 2017). Among 18–24 year olds, 7 hours 14 minutes sleep was obtained on weeknights; this extended by 71 minutes on weekend nights (Adams et al., 2017).

These findings were similar to a 2010 Sleep Health Foundation survey. However, the previous survey found that this age group slept the same amount on weeknights and weekends (Hillman & Lack, 2013). Over half of university students are likely to nap once to twice per week (Lovato et al., 2014), which suggests many young adults are not achieving their sleep need during night-time sleep. The most common reason for napping is daytime sleepiness (Lovato et al., 2014), with 56% of first year university students in Armidale, NSW, having felt fatigued or low in energy during the past 6 months (Hussain et al., 2013).

Adults

The Sleep Health Foundation 2016 survey (Adams et al., 2017) found that during weeknights:

- 25–34 year olds slept 7 hours 4 minutes (extended by about 1 hour on weekends)
- 35–44 year olds slept 7 hours 6 minutes (extended by 34 minutes on weekends)
- 45–54 year olds slept 6 hours 49 minutes (extended by 38 minutes on weekends)
- 55–64 year olds slept about 7 hours (extended by 23 minutes on weekends.

Again, results are reasonably consistent with the Sleep Health Foundation 2010 survey, albeit weekend sleep durations did not increase by as much in adults aged 25–49 years (Hillman & Lack, 2013).

Older adults

Both the 2010 and 2016 Sleep Health Foundation surveys found that people aged 65 years or older slept for about 7 hours on both week and weekend nights (Adams et al., 2017; Hillman & Lack, 2013).

Overall, these results suggest that sleep duration decreases across the lifespan.

Key findings of Chapter 2

- Many Australian adolescents are not meeting their sleep need, especially during the school week.
- Some Australian adults may be meeting their sleep need, but only the minimum requirements.
- Many older Australian adults may be meeting their sleep need, or be just below it.

Chapter 3: Sleep and mental health

Adolescents and young adults

Given that many young Australian adolescents fail to meet sleep targets, especially during the school week, how may this be impacting their mental health?

Shochat, Cohen-Zion and Tzischinsky (2014) reviewed the relationship between adolescents' sleep and functional outcomes, including mental health. Overall, prospective studies (i.e. those which looked at sleep and mental health at an initial time point, and then again at a future time point, also known as longitudinal studies) found that sleep disturbances, such as short sleep and insomnia, increased the risk for current and future depression, anxiety, low self-esteem, disturbed mood, fatigue and suicidal ideation (Shochat et al., 2014). Moreover, the relationship between sleep and mental health outcomes was bi-directional: not only can poor sleep lead to poor mental health, but poor mental health can predispose an adolescent to poor sleep (Shochat et al., 2014).

Lovato and Gradisar (2014) used a meta-analytic approach to explore the relationship between depression and sleep in 12–20 year olds. Adolescents experiencing depression took longer to fall asleep and experienced more awakenings during the night than adolescents without depression. In contrast to Shochat and colleagues (2014), when the authors analysed longitudinal studies, sleep disturbances predicted future depression, yet a diagnosis of depression was not a strong precursor for future sleep disturbances (Lovato & Gradisar, 2014). This is consistent with findings from an earlier review also focusing on longitudinal literature (Baglioni et al., 2011). Children and adolescents at baseline, who had insomnia but no depression, were twice as likely to develop depression by follow-up than those without baseline sleep issues (Baglioni et al., 2011).

Another review demonstrated a unidirectional relationship, where sleep problems as a toddler predicted anxiety and depression in adolescence (Becker et al., 2015). In contrast, much of the longitudinal literature reviewed showed that toddler depression did not lead to future sleep problems. A minority of studies showed no association, while some studies revealed that sleep problems in childhood predicted anxiety (but not depression). Becker and colleagues (2015) postulated that hypervigilance that can lead to sleep problems may also lead to later development of anxiety. Their review of the research involving adolescents showed that insomnia symptoms during adolescence predicted a diagnosis of depression in early adulthood. Although limited, there was some support that externalising problems, anxiety and depression predict future sleep issues in this age group. Thus, a bidirectional relationship between mental health and sleep is possible (Becker et al., 2015).

Feeling depressed due to poor sleep may not be surprising, considering sleep restriction and deprivation reduce positive emotions and decrease adolescents' ability to regulate negative emotions (Becker et al., 2015). In fact, both short-term and long-term sleep restriction is likely to disrupt adolescents' ability to regulate their emotions (Tarokh et al., 2016).

Poor sleep is also related to suicidal ideation, attempts and completion, and predicts both internalising and externalising problems (Becker et al., 2015). An earlier review emphasised that for people aged 18 years and under, sleep disturbances (waking after sleep onset, long sleep-onset latency, early morning awakening) were related to suicidal ideation, attempts and completions (Pigeon et al., 2012).

Although not reviews or meta-analyses, the following two studies involve Australian young people and were published recently.

- A study of 741 grade 7–12 students in Melbourne found that adolescents are more likely to develop symptoms of depression as they become older (Raniti et al., 2017). Importantly, this relationship between age and depression was influenced by sleep. That is, shorter weekday sleep duration and poor subjective sleep quality increased the likelihood of depression developing (Raniti et al., 2017). Authors also noted the bi-directional possibility of this relationship, where symptoms of depression mediated the relationship between age and shorter, poorer sleep (Raniti et al., 2017). Of note, adolescents in this study were sleeping an average of 7 hours 42 minutes per school night, which is similar to data from other studies also conducted in Victoria (e.g. Bei et al., 2014).
- A study of Australian university students aged 18–55 years (M age = 30 years) researched self-reported depression, anxiety, stress, help-seeking and poor sleep quality (Zochil & Thorsteinsson, 2017). In this sample, symptoms of depression were found in 38%, anxiety symptoms in 39% and stress in 36%, while 85% reported poor sleep quality. Stress and being female appeared to be driving factors for seeking help. Those most likely to seek help had low depression scores, but high stress. Poor sleep quality was not found to influence a person's intention to seek help (Zochil & Thorsteinsson, 2017).

Moreover, to the authors' knowledge, no review has synthesised the relationship between resilience (or mental toughness) and sleep, perhaps because this is an emerging area of interest (Brand et al., 2016). Mental toughness has been conceptualised as being able to perform well in challenging situations, having commitment and confidence and feeling in control of one's emotions and situations (Brand et al., 2016). Among Swiss adolescents, increased mental toughness was related to fewer sleep disturbances (e.g. difficulties falling/staying asleep, daytime tiredness), and also related positively to other psychological measures (Brand et al., 2014a; Brand et al., 2014b; Brand et al., 2016). For older adolescents (M age = 18 years), increased mental toughness was related to longer sleep duration, short sleep-onset latency, less awakenings after sleep onset, improved mood and concentration, and less daytime tiredness (Brand et al., 2014b). Mental toughness also decreased perceived stress and depressive symptoms, as well as sleep disturbances (Brand et al., 2014b).

Increased mental toughness is related to fewer depressive symptoms, less stress and higher life satisfaction; thus it may be a useful intervention strategy (Gerber et al., 2013). Of note, these were correlational studies. Hence, mental toughness could improve sleep, better sleep could increase mental toughness, or the relationship could be bi-directional. Further research is needed to better elucidate this relationship.

Adults

Multiple reviews have investigated the longitudinal relationship between sleep and mental health among adults. Prospective studies determined that both short (defined as <5 to <7 hours sleep, depending on the study) and long sleep (>8 to >9 hours, depending on the study) were risk factors for developing depression (Zhai et al., 2015). Similarly, adults experiencing insomnia at baseline, but not depression, were twice as likely to develop depression by follow-up than people without baseline sleep issues (Baglioni et al., 2011).

A review of longitudinal studies concluded that there is a bi-directional relationship between insomnia, and anxiety and depression (Alvaro et al., 2013). Nevertheless, insomnia at baseline was a stronger predictor of future depression than depression at baseline was of future insomnia (Alvaro et al., 2013). There were, however, issues with measurement of sleep and mental health, as often sleep measures amalgamated insomnia symptoms, and mental health measures did not adequately differentiate between anxiety and depression (Alvaro et al., 2013). Additionally, studies may not always consider other associated factors (Baglioni et al., 2011). Looking specifically at Australian women, incidence of self-reported depression and anxiety increased over a 9-year period among those with no baseline complaints. However, the risk of developing depression or anxiety was 4.42 times higher and 2.90 times higher, respectively, for women who reported experiencing sleep disturbances, often at baseline (Jackson et al., 2014).

A meta-analysis of sleep architecture variables for healthy controls in comparison to adults with major depressive disorder (MDD) revealed that adults with MDD had shorter total sleep duration, shorter rapid eye movement (REM; involved in mental health and learning; Hobson, 2009) latency, more REM sleep, and higher REM density (Pillai et al., 2011). Their sleep efficiency was poorer and they obtained less deep sleep (i.e. slow-wave sleep for restoration of the brain and body). The severity of depressive symptoms moderated sleep efficiency, sleep duration, REM latency and the amount of REM obtained, yet not slow-wave sleep. Adults with a diagnosis of MDD were also compared to those in remission (Pillai et al., 2011). A similar pattern of results was found: sleep duration was shorter, REM latency was shorter, REM duration increased and sleep efficiency decreased. Compared to healthy controls, adults in remission from MDD had less slow-wave sleep than those with a diagnosis of MDD. Thus, overall, it appears that both sleep duration and sleep architecture (i.e. what happens while a person is asleep) differ between depressed and non-depressed individuals (Pillai et al., 2011).

Sleep issues may also increase thoughts of suicide. A meta-analysis regarding sleep and suicide covered community, inpatient and depression samples, and focused mainly on adults, although children and elderly were also included (Pigeon et al., 2012). Insomnia symptoms were related to suicidal ideation, attempts and suicide. Nightmares were related to suicidal ideation (once statistically adjusted). Other sleep disturbances (e.g. short sleep duration) were not related to insomnia or nightmares, yet were related to suicidal ideation, attempts and suicide (Pigeon et al., 2012).

Other mental health disorders are also likely to be influenced by sleep. Adults experiencing generalised anxiety disorder (GAD), panic disorder or post-traumatic stress disorder (PTSD) have shorter objective sleep duration and longer sleep-onset latency, and more subjective sleep disturbances than healthy adults (Cox & Olatunji, 2016). Furthermore, subjective sleep disturbances predict future GAD. Similarly, sleep disturbances at the time of trauma exposure may predispose an individual to developing PTSD, with subjective sleep disturbances likely to contribute to PTSD maintenance and hindrance of treatment (Cox & Olatunji, 2016). Adults experiencing obsessive-compulsive disorder (OCD) are likely to have objective, yet not subjective, sleep disturbances (Cox & Olatunji, 2016). It has been suggested that sleep disturbances contribute to anxiety and related disorders, not only directly, but also by impairing executive functioning and dysregulating cortisol levels, which further contribute to anxiety symptoms. It is also hypothesised that chronic sleep disturbances put prolonged pressures on the body, which then lead to the formation of an anxiety disorder (Cox & Olatunji, 2016).

Pires, Bezerra, Tufik and Andersen (2016) conducted a meta-analysis on studies that experimentally manipulated sleep length, and the effect this had on acute anxiety (i.e. anxiety that is for a short period of time, not a prolonged disorder or personality trait). Sleep deprivation (i.e. obtaining no sleep for 24–77 hours) was shown to induce state anxiety. However, sleep restriction (limiting sleep to below a set number of hours, such as 3 hours a night for 1–4 consecutive nights) was not found to induce state anxiety (Pires et al., 2016).

Overall, adults experiencing poor sleep, such as short sleep, are at risk of developing mental health problems. Although depression has been a focus of the literature, poor sleep may also predispose adults to other mental health disorders, such as anxiety, panic disorder and PTSD (Cox & Olatunji, 2016). Suicidal ideation and attempts are also likely to be increased in short sleepers and adults experiencing insomnia symptoms (Pigeon et al., 2012). Conversely, sleep restriction alone may not be enough to induce state anxiety (Pires et al., 2016).

Older adults

Objective sleep duration and sleep efficiency decrease in older age (Ohayon et al., 2004). The following studies are meta-analyses that have explored the link between depression and sleep in elderly populations.

Becker, Jesus, João, Viseu and Martins (2017) included studies with average participant ages of 65–85 years, with all included studies using self-report measures of sleep quality. As sleep quality decreased, depressive symptoms increased (Becker at el., 2017). In agreement with these findings, Bao and colleagues (2017) investigated this link in adults aged 60 years or older living in the community. The prevalence of depression and depression symptoms was found to be higher in adults with sleep disturbances than those without. Longitudinal studies revealed that older adults with subjective sleep disturbances at baseline had a 1.9 times higher risk of developing depression 1–2 years later, than those who did not report baseline sleep disturbances. The likelihood was even higher (at 3.9 times) when older adults had persistent baseline sleep disturbances. Persistent baseline sleep disturbances also increased the chance of a depressive episode re-occurring, and worse future depressive symptoms. Regarding objective sleep, however, neither lower sleep efficiency (<70%), sleep-onset latency longer than 60 minutes, nor sleep duration increased the likelihood that depression would develop 3–5 years later.

Similarly, longitudinal studies of older adults who had insomnia at baseline, but not depression, were twice as likely to have developed depression at follow-up than people without baseline sleep issues (Baglioni et al., 2011). Looking at the reverse relationship, baseline symptoms of depression predicted future poor sleep (Bao et al., 2017). Cole and Dendukuri (2003) conducted a meta-analysis of prospective studies in adults over 50 years of age to determine factors predicting depression. Five factors were most likely to predict future depression: being female; having a disability; sleep disturbance; bereavement; and a prior history of depression (Cole & Dendukuri, 2003).

One cross-sectional study published after these meta-analyses investigated self-reported sleep and health in females aged 65 years and older, living in the USA. Mental health issues were 66% more common among adults sleeping 5 or less hours per day, and 26% more common among adults sleeping 9 or more hours per day, than among adults sleeping 6–8 hours per day (Thomas et al., 2017).

Overall, this suggests that older adults who experience poor subjective sleep are at increased risk of current and future depression. There is also evidence to suggest that sleeping too short or too long increases the incidence of depression. It should be kept in mind, however, that sleep is but one factor contributing to depression, and other life events, such as having a disability (Cole & Dendukuri, 2003) are also contributors.

Are young people at risk due to sleep/wake patterns?

Adolescents are not meeting their sleep requirements (8–10 hours), especially on school nights. Short sleep is related to increased risk of current and future mental health problems, such as depression. The risk of depression increases with age throughout adolescence, especially for those with short sleep or self-reported poor sleep quality (Raniti et al., 2017). Short sleep also decreases emotion regulation (Becker et al., 2015; Tarokh et al., 2016) and increases the risk of suicidal thoughts and actions (Becker et al., 2015; Pigeon et al., 2012).

It is also possible that short sleep, or disrupted sleep, decreases mental toughness, whereas increased mental toughness is related to more favourable psychological outcomes and sleep measures (Brand et al., 2014a; Brand et al., 2014b; Brand et al., 2016).

Thus, it would appear that adolescents are vulnerable to poor mental health, either presently or in the future, if they experience sleep problems such as short or disrupted sleep.

Key findings of Chapter 3

- Poor sleep is linked to increased mental health problems across age groups.
- Short sleep is related to decreased emotional regulation in adolescents.
- Acute anxiety is not related to sleep restriction in adults.
- Poor sleep predisposes an individual to future risk of poor mental health across the lifespan.
- Adolescents may be particularly vulnerable to mental health issues resulting from poor sleep, considering they often fail to obtain minimum sleep duration requirements during the school week.

Chapter 4: Lifestyle factors associated with sleep

Adolescents and young adults

It appears that both genetics and the environment contribute to sleep disturbances among adolescents and young adults. This section of the review will largely focus on factors that can be changed – such as lifestyle factors under behavioural control – rather than genetic components of sleep and mental health. This empowers individuals, families, communities, health organisations and the government to be able to make behavioural changes that improve sleep.

Nonetheless, the genetic component of sleep cannot be ignored. Monozygotic (identical) and dizygotic (fraternal) twin pairs have been used to study the heritability of sleep and mood disturbances. Furthermore, it is likely that insomnia genes also share variance with depression and anxiety (Barclay & Gregory, 2013). Yet, environmental influences also play a role, and these will be the focus for the remainder of Chapter 4.

Media use

Technology use is frequently claimed to impair the sleep of adolescents, often without considering the quantity of the effect (Bartel et al., 2015). Technology use is undoubtedly high among this population (Johansson et al., 2016). Results from the 2011 National Sleep Foundation 'Sleep in America' poll showed that 97% of 13–21 year olds used technology before sleep (Johansson et al., 2016). Adolescents in this study had a mean sleep duration of 7 hours 20 minutes per night and self-reported inadequate sleep was associated with increased pre-bed technology use, feeling unrefreshed when waking and tiredness during the day (Johansson et al., 2016). Yet, when multiple studies are synthesised in a review or meta-analysis, what does the collective evidence say?

A recent meta-analysis synthesised studies published between 2011 and 2015 concerning portable screens and their impact on the sleep of 6–19 year olds (Carter et al., 2016). The review included three studies from Australasia. Children and adolescents who used a media device at least three times per week had inadequate sleep duration (i.e. <10 hours/night for children and <9 hours/night for adolescents) and poor sleep quality (difficulty falling or staying asleep, or feeling unrefreshed from sleep), compared to children who did not have access to a portable screen. Children who had access to a portable screen were more also likely to have inadequate sleep duration, poor sleep quality and excessive daytime sleepiness, compared to children who did not have access to a device (Carter et al., 2016).

Another systematic review looked at technology use beyond that of portable screens, updating Cain and Gradisar's 2010 review on technology use and paediatric sleep (Hale & Guan, 2015). The relationships between television watching, computer use, video gaming and use of mobile devices on children and adolescents' (5–17 years) sleep were explored, including five studies from Australia (7% of studies). Although inconsistent, watching television was generally associated with later bedtime or shorter sleep duration. One study used an objective measure of sleep (actigraphy) and found no association between sleep duration and television watching. Over 50% of studies found no relationship between television viewing and sleep-onset latency. Overall, watching television was the least likely media device to be related to detrimental sleep outcomes. Computer use was associated with shorter sleep duration and later bedtimes. Inconclusive results were found for sleep-onset latency, although a majority, but not all, studies found that increased computer use was associated with greater daytime tiredness. Regarding video gaming, 81% of studies showed a relationship with later bedtime or less sleep. However, as video gaming was only related to shorter sleep on weekends, and among older adolescents, it is likely other factors influenced these relationships. Measurement of video gaming was also an issue, as some studies included it in computer use, whereas other studies separated it. Results for sleep-onset latency were also inconsistent. Similar to Carter and colleagues' (2016) meta-analysis, mobile devices were related to shorter sleep by as much as 45 minutes, and were also associated with later bedtimes and daytime sleepiness. No consistent association was found between mobile phones and sleep-onset latency (Hale & Guan, 2015). When screen type was not specified, the general finding was that the sleep duration decreased (Hale & Guan, 2015).

A meta-analysis of protective and risk factors for adolescent sleep showed that video gaming, phone use, computer use and internet use, yet not television use, were related to later bedtimes (Bartel et al., 2015). No technology variables were related to sleep-onset latency, and only computer use was related to less sleep (Bartel et al., 2015). These findings are further substantiated by a review finding that among cross-sectional studies, media use was associated with less sleep, and later bedtimes (Becker et al., 2015). Longitudinal studies demonstrated that early technology use predicts future sleep difficulties. Yet, authors also noted that technology use may be used to facilitate sleep, and among college students, may be used to cope with sleep problems (Becker et al., 2015). For example, if difficulty initiating sleep is an issue, students may use technology to pass time until they feel sleepy.

A less comprehensive narrative review determined that technology use was related to poorer sleep outcomes (Owens et al., 2014). Having bedroom television access was related to later weekday bedtimes, and higher daytime sleepiness. Pre-bed computer use lengthened sleep-onset latency and disrupted sleep. Using multiple devices before bed also related to shorter sleep duration, and increased daytime tiredness (Owens et al., 2014).

Much of the literature included in these reviews and meta-analyses were cross-sectional – that is, data collected at a single point in time measuring the relationship between variables, without the ability to determine cause and effect. Moreover, different means of measuring variables poses challenges for accurate assessment of outcomes (Bartel et al., 2015; Hale & Gaun, 2015) and there is a possibility that results are more likely to be published if they have interesting findings (i.e. that technology use disrupts sleep; Hale & Gaun, 2015).

The following study is not a meta-analysis or review, yet is recently published Australian literature adding to the story regarding technology use and sleep. A study of Melbourne high school students in years 10–12 assessed pre-bed behaviours (e.g. technology use, exercise, reading) as well as sleep-wake variables (Harbard et al., 2016). Similar to a previous meta-analysis (Bartel et al., 2015), on school nights no pre-bed behaviour was related to sleep-onset latency.

On school nights, the following pre-bed behaviours were related to sleep variables:

- bedtime: video gaming (+12 minutes), snacking (+14 minutes), family time (–15 minutes)
- sleep duration: video gaming (–14 minutes), family time (+14 minutes).

During school holidays the following pre-bed behaviours were related to sleep variables:

- bedtime: video gaming (+14 minutes)

- sleep-onset latency: more frequent online chatting (+3 min), social networking (+3 min), listening to music (+4 minutes).

No pre-bed behaviour was related to sleep duration during the holidays (Harbad et al., 2016). Pre-sleep cognitive arousal mediated the relationship between socialising online and sleep-onset latency during holidays. That is, increased social media use before bed was related to higher levels of pre-sleep cognitive arousal (e.g. repetitive negative thinking), which then led to longer sleep-onset latency.

These findings are similar to other recent international studies. Using media devices in the hour before bed was found to negatively impact American first year university students' sleep (Orzech et al., 2016), and smartphone ownership among Swiss high school students predicted decreased sleep duration and increased sleep problems (Schweizer et al., 2017).

Together, it appears that media use among adolescents and young adults is extremely prevalent (Johansson et al., 2016), particularly before bedtime, and leads to later bedtimes, and possibly shorter sleep duration. Sleep-onset latency is less likely to be affected by using technology prior to sleeping. Ownership of interactive, mobile devices likely contributes to shorter sleep (Carter et al., 2016; Schweizer et al., 2017). Thus, although technology use prior to bed does not seem to benefit adolescents' sleep, there are likely other important contributing factors to shortened sleep during the school week. Considering the field of technology use and sleep lacks experimentally manipulated literature, future research is needed to determine causal relationships.

Evening light

Evening light (e.g. room lighting, screen light) is related to later bedtimes and less sleep (Bartel et al., 2015). Adolescents with more evening media use, and those who live in urban rather than rural areas, have later sleep timing (Bedrosian & Nelson, 2017). Authors hypothesis that light pollution may contribute to this delay in sleep timing (Bedrosian & Nelson, 2017).

Caffeine

Caffeine consumption is increasing among adolescents (Owens et al., 2014). One systematic review has been conducted exclusively on adolescent caffeine use and bedtime, sleep-onset latency and sleep duration (Bonnar & Gradisar, 2015). Increased caffeine consumption was related to decreased sleep duration. However, inconsistent results were found concerning bedtime and sleep-onset latency. These findings replicate a meta-analysis by Bartel, Gradisar and Williamson (2015). A closer look at types of adolescent caffeine use revealed that only evening caffeine consumption shortened sleep duration, whereas tea and coffee drinkers had a variable relationship, and drinking energy drinks or caffeinated soda was not related to total sleep time (Bartel et al., 2015). Alternatively, review articles have stated that increased caffeine consumption is related to shorter sleep, more awakenings after sleep onset, increased daytime tiredness (Clark & Landolt, 2017; Owens et al., 2014; Roehrs & Roth, 2008) and sleepiness (Temple et al., 2017). College students consumed 3.6 times more caffeine each day if they obtained less than 6 hours sleep per night, compared to longer than 8 hours (Clark & Landolt, 2017).

Caffeine may inhibit sleep by blocking the sleep-promoting hormone adenosine in the brain (Urade & Hayaishi, 2011). This may be why caffeine is used by adolescents to maintain a wakeful state (Temple et al., 2017). However, high doses of caffeine may induce nervousness, restlessness and sleeplessness (Temple et al., 2017). One major issue in the field of caffeine research and adolescent sleep is the lack of experimental studies. Consequently, it is unknown whether adolescents who sleep less and are more tired use caffeine to promote alertness, or whether sleep is disrupted as a direct result of caffeine consumption (Bartel et al., 2015; Bonnar & Gradisar, 2015; Clark & Landolt, 2017; Owens et al., 2014; Roehrs & Roth, 2008). Thus, in order to promote better sleep it would be recommended not to use caffeine, particularly in the evenings. Yet, the exact effects of caffeine on adolescent sleep need to be experimentally tested to discover the extent to which caffeine effects sleep and subsequent daytime functioning.

Although differing in intent, a qualitative study of university students in Wollongong, NSW, aged 18–25 years old found that students who drank energy drinks (often containing caffeine and other alerting substances) mixed with alcohol would sometimes find it difficult to sleep later that night (Jones et al., 2012). Thus, alerting substances are being consumed by at least some Australian university students late in the evening, and are likely to decrease the ability to sleep, although this evidence was only qualitative (i.e. prevalence rates were not measured).

Family factors

A good home environment has been linked with improved sleep quality (Becker et al., 2015), earlier bedtime, shorter sleep-onset latency and longer sleep duration (Bartel et al., 2015). As with caffeine, this association may be bi-directional. Greater conflict in late childhood is related to early adolescent sleep problems, and when older children have sleep problems their mothers are less likely to display closeness and sensitivity by early adolescence (Becker et al., 2015). The same authors found that insecure attachment is related to poorer sleep among college students, and postulated that feeling safe leads to good attachment, as well as the ability to relax in order to obtain good sleep (Becker et al., 2015). A study of Melbourne secondary school students also supported the value of family time, in that during the school week family time was related to 15 minutes earlier bedtimes, and 15 minutes extended sleep duration (Harbad et al., 2016). During school holidays, no specific pre-bed behaviour was related to sleep duration (Harbad et al., 2016).

Moreover, parent limit setting (i.e. parent-set bedtimes) may also benefit sleep, including increasing total sleep time, and decreasing daytime tiredness (Bartel et al., 2015; Becker et al., 2015). These results are further supported by another recent cross-sectional study. A Canadian research team used parent report to ascertain whether children (5–13 years) and adolescents (14–17 years) were obtaining recommended sleep (9–11 hours for children, 8–10 hours for adolescents; Pyper et al., 2017). A child was 1.6 times more likely to meet sleep guidelines during the week if parents enforced a set bedtime, yet a set bedtime did not have an effect on weekend sleep (Pyper et al., 2017). Furthermore, a positive home environment may encourage good sleep hygiene. Good sleep hygiene includes having a regular bedtime, relaxing before bed, avoiding evening stimulants and having a comfortable sleep environment. Good sleep hygiene is related to earlier bedtimes, shorter sleep-onset latency and longer sleep (Bartel et al., 2015). Thus, a positive home environment, a consistent parent-set bedtime, and good sleep hygiene are likely to benefit adolescents' sleep, especially on school nights.

Peer factors

Peers are an important component of an adolescent's life and their network increases in size during this stage of life (Wrzus et al., 2013), so it could be expected that friends may influence adolescent sleep patterns. Increased loneliness and difficulty interacting with peers is associated with increased sleep problems, yet positive peer interactions may benefit sleep, such as increasing sleep duration (Becker et al., 2015). Spending time with peers was not related to sleep duration; however, only two studies were available for inclusion in data-analysis, hence this result should be interpreted with caution (Bartel et al., 2015). As detailed above, socialising with friends online is associated with a small increase in school-holiday sleep-onset latency (Harbad et al., 2016).

Extracurricular activities and homework

A review has suggested that increased homework is related to less total sleep (Becker et al., 2015). However, a meta-analysis showed no relationship between homework and bedtime, sleep-onset latency or sleep duration (Bartel et al., 2015). Likewise, working part-time during adolescence or in college has been suggested to decrease sleep length and quality, and increase daytime sleepiness (Becker et al., 2015), yet meta-analytic data determined no relationship between working and bedtime, sleep-onset latency or sleep duration (Bartel et al., 2015). Overall, no relationship has been found between extracurricular activities and bedtime, sleep-onset latency or total sleep time (Bartel et al., 2015; Becker et al., 2015). Yet, in some circumstances they may either be protective or unhelpful for sleep (Becker et al., 2015). Hence, it appears that other factors may influence the relationship between extracurricular activities and sleep.

Physical activity in adolescents may also be related to earlier bedtimes (Bartel et al., 2015), with shorter sleep related to less exercise (Tremblay et al., 2007). Regardless of the measurement type (objective or subjective), increased exercise is associated with better sleep quality and quantity (Lang et al., 2016). It is likely that the timing of physical activity is crucial, as exercise just before bed is likely to delay bedtime and rise time (Richardson et al., 2017). The exact timing to help advance bedtimes and wake times is unknown, but morning exercise may be beneficial in achieving this goal (Richardson et al., 2017). This finding is similar for young adults, as acute exercise earlier in the day may be better for improving sleep, yet resistance training may be beneficial regardless of the time of day it is performed (Dolezal et al., 2017). Although effects for the most efficacious timing of exercise are mixed, it does appear that physical activity decreases sleep-onset latency and night awakenings in young adults. Conversely, regular cardiovascular exercise for 15 weeks improved sleep quality in young adults, but only in those who were overweight or obese at baseline. Hence, results could reflect improved sleep due to a decrease in body fat (Dolezal et al., 2017).

Overall, it appears that physical activity is likely to benefit sleep, yet it may be that a limit exists regarding homework and extracurricular activities in general. Potentially, a certain amount of out-of-school activity is useful for sleep; with detrimental effects occurring after this threshold is crossed. However, there is a need for experimental studies to clarify relationships (Becker et al., 2015). The timing of these activities may also be a critical factor concerning their influence on sleep (Richardson et al., 2017).

Mixed protective and risk factors measured simultaneously

A study of Australian, Canadian and Dutch adolescents aged 12–19 years old compared protective and risk factors for weekday bedtime, sleep-onset latency and sleep duration within and across countries (Bartel et al., 2016). Age and gender were controlled. The later the time an adolescent stopped using their mobile phone or the computer on weekdays, the later their bedtime and the shorter their sleep, in all countries. No other technology use was studied. Playing after school sports was protective for Australian adolescents, but not for adolescents in other countries. Good sleep hygiene promoted shorter sleep-onset latency across all countries, and was also related to longer sleep in Australia and Canada. Parent-set bedtimes were only beneficial for lengthening sleep in Australian adolescents (Bartel et al., 2016). Overall, it appeared that many similarities between countries existed, yet some differences also occurred between countries.

Summary

In conclusion, it appears that adolescents' technology use before bed is a risk factor for later bedtimes, and possibly shorter sleep. Caffeine use is also likely related to shorter sleep and daytime tiredness. A positive family environment, including good sleep hygiene, and positive peer relationships are likely to support good sleep. Physical activity is related to enhanced sleep quality, yet there are likely to be many factors which contribute to when physical activity will have the most benefits on sleep (e.g. timing). Results regarding the effects of other extracurricular activities on sleep are mixed.

The field of protective and risk factors for adolescent sleep is hampered by a lack of experimental studies (Bartel et al., 2015). Thus, is should be kept in mind that for a majority of the research discussed above, results provided are associative, as opposed to the effect of one manipulated variable on another.

Adults

A review article has demonstrated that there is likely to be a genetic component of insomnia, as there is for other sleep disorders (Harvey et al., 2014). Insomnia can be inherited and is related to anxiety, depression and stress-reactivity (i.e. one may have a low threshold for developing a stress reaction to a given trigger). Individuals may also be predisposed to hyperarousal (Harvey et al., 2014). This then increases the odds of future sleep disruptions, including insomnia, which subsequently leads to vulnerability to depression. Subjective, cognitive and somatic arousal all contribute to sleep distribution and insomnia, thus insomnia is a combination of physiological and psychological processes (Harvey et al., 2014).

Regarding personality factors, it is likely that neuroticism (a negative emotional state) contributes to both depression, and poor sleep and daytime consequences. Yet, conscientiousness (e.g. being principled, well-organised) may improve sleep, and allow individuals to see their daytime sleepiness in a less negative light, which in turn improves sleep. Neuroticism, on the other hand, leads to an increase in perceived stress, thus increasing arousal, decreasing sleep and also increasing negative interpretation of obtaining less sleep (Harvey et al., 2014).

Sleep disruption is a strong predictor of insomnia, as after disrupted sleep, negative emotions regarding the sleeping environment may form. This then leads to future difficulties sleeping, and thus the cycle continues (Harvey et al., 2014).

A longitudinal study investigated the predictive factors for insomnia symptoms and diagnosis by assessing adults who were good sleepers at baseline, then at 6 months and 12 months (LeBlanc et al., 2009). During the year, 31% of adults experienced symptoms of insomnia and 7% met diagnostic criteria. Those who developed insomnia were also more likely to have more symptoms of depression and anxiety, and poorer baseline mental health, low extraversion, higher arousability, poor general health and physical pain. Those with insomnia were more likely to have had a previous episode of insomnia, a family history of insomnia, be easily arousable, and experience poorer self-perceived general health and physical pain (LeBlanc et al., 2009).

Adults diagnosed with insomnia (rather than just presenting with symptoms) were more likely to have a higher increase in perceived stress, have experienced more negative life events in the previous 6 months, and have higher depreciation in mental health. Depression and anxiety symptoms were also more likely to have increased over the past 6 months (LeBlanc et al., 2009). The type of coping methods used – body mass index, number of glasses of alcohol per week, and number of days of physical activity per week – did not differ between those who did not develop insomnia, those with symptoms and those meeting diagnostic criteria (LeBlanc et al., 2009).

Electronic media and evening light

Use of electronic media before bed (e.g. for 4 hours, 30–50 lux) increases the time is takes to fall asleep, as it suppresses the sleep hormone melatonin, and using a night light (40 lux) increases awakenings after sleep onset, (Bedrosian & Nelson, 2017). Despite multiple reviews and meta-analyses incorporating media use in adolescents, such reviews could not be found in the adult literature, with most literature focussing on younger users (Saling & Haire, 2016).

Exelmans and Van den Bulck (2016) performed a cross-sectional study in 18–94 year olds, investigating the relationship between mobile phone use and sleep. Approximately 50% of participants owned a smartphone, 46% owned a phone without internet capabilities and 4% did not own a phone. Sixty per cent of participants took their phone to their bedroom at night, frequently using the phone after lights out. Increased phone use after lights out was related to more daytime tiredness, insomnia and a later rise time. Of note, phone use after lights out was more common among younger adults. Those who used their phone after lights out were 2.2 times more likely to take longer than 30 minutes to fall asleep, compared to less than 15 minutes for those who never used their phone after lights out. They were also more likely to experience sleep disturbances (Exelmans & Van den Bulck, 2016).

Recently, mobile phone use after lights out was the subject of an Australian online study (Saling & Haire, 2016). Seventy-five per cent of respondents (M age = 34 years) used their phone after lights out. Higher frequency of sending and receiving text messages and calls over a 1-month period was related to increased tiredness, as well as depression, anxiety and stress. Those who were less willing to turn their phone off when it could distract them (e.g. when sleeping) also experienced more tiredness. People who were more frequently woken by someone else's phone were also more tired and stressed. Being tired and a higher frequency of phone use after lights out predicted combined depression, anxiety and stress scores, whereas tiredness was predicted by frequency of use and whether a person was willing to turn off their phone (Saling & Haire, 2016).

Outdoor light pollution (i.e. artificial outdoor lighting, such as street lights) can also decrease sleep quality and increase symptoms of insomnia (Bedrosian & Nelson, 2017). Appropriately timed light exposure is important, as getting daytime light helps regulate the body clock – promoting healthy sleep and mood (Bedrosian & Nelson, 2017). In polar regions, where seasonal variation causes extremely long or short days, disruption to mood occurs (Bedrosian & Nelson, 2017). Moreover, correlational literature shows that as the amount of electric lighting has increased, so have depression rates, yet these are not present in societies that have not adopted electrical lighting (Bedrosian & Nelson, 2017).

Thus, evening technology use and light late into the evening pose a risk to the sleep and mental health of adults. However, experimental studies regarding media use in adults are needed.

Caffeine

Two review articles have focused on caffeine and sleep, including in the adult population (Clarke & Landolt, 2017; Roehrs & Roth, 2008). Both articles concluded that in laboratory studies (i.e. studies where the experimenter can choose the time and dose of caffeine, and other factors such as bedtime) caffeine prior to bed affects sleep. Caffeine lengthened sleep-onset latency, reduced sleep duration, and increased the frequency and duration of awakenings during the night (Clarke & Landolt, 2017; Roehrs & Roth, 2008).

The influence of caffeine on sleep was not as apparent in self-report studies, possibly as people are not aware of all the awakenings during the night, which are both longer and more frequent when measured using PSG (Clarke & Landolt, 2017). Slow-wave sleep, which is most prominent at the start of the night, is decreased when measured by PSG (Clarke & Landolt, 2017; Roehrs & Roth, 2008). Furthermore, a timing-dose response exists (Clarke & Landolt, 2017; Roehrs & Roth, 2008). Higher doses of caffeine close to bedtime cause greater disruptions to deep sleep, and increase wakefulness in the first 6 hours of sleep. Most laboratory studies have administered caffeine within the hour before bedtime, producing the largest disruption (Clark & Landolt, 2017).

Subjective reports of caffeine and sleep often describe decreased sleep quality with high consumption, along with shorter sleep (Clark & Landolt, 2017). A consistent finding among survey studies is that caffeine consumption is associated with daytime sleepiness, hence may be used in an attempt to promote wakefulness during the day (Clarke & Landolt, 2017; Roehrs & Roth, 2008). Moreover, people who self-report caffeine sensitivity are also more likely to report taking longer than 20 minutes to fall asleep and waking more frequently after consuming caffeine, than those who do not report such sensitivity (Clark & Landolt, 2017).

Therefore, the consumption of caffeine does influence sleep, with higher doses resulting in greater impairments. Yet, people who use caffeine may be trying to compensate for fatigue (Clarke & Landolt, 2017; Roehrs & Roth, 2008).

Physical activity

The notion that exercise should be prescribed to enhance sleep is not novel (Youngstedt, 1997). An early review stated that both acute and chronic exercise increased deep sleep and total sleep time, with decreased sleep-onset latency and REM sleep also occurring (Kubitz et al., 1996). Conversely, a meta-analysis suggested that acute exercise decreased sleep-onset latency, but only if performed 4–8 hours before bedtime (Youngstedt et al., 1997), with the largest decreases in awakenings after sleep onset also occurring when performed 4–8 hours before bedtime. Deep sleep also increased, and the largest benefits to total sleep time increases followed acute exercise of longer duration (>2 hours; Youngstedt et al., 1997).

These views are still held 20 years later, with a 2017 review concluding that acute exercise leads to small improvements in sleep duration, deep sleep and sleep-onset latency (Dolezal et al., 2017). Yet, stronger results are found when adults partake in regular exercise (Dolezal et al., 2017; ZubiaVeqar, 2012). Moderate to strong effects are found on sleep quality, increased sleep duration and sleep efficiency, whereas smaller effects are found on sleep-onset latency (Dolezal et al., 2017). Improving cardiovascular fitness improves sleep quality and decreases symptoms of insomnia. This may be due to improved body composition, which also enhances sleep quality and decreases insomnia risk (Dolezal et al., 2017).

Adults with a higher fitness level achieve longer sleep, fall asleep faster and have more deep sleep. These effects can also be induced by participation in 4 weeks of exercise, yet the addition of exercise into the lifestyle of adults who are already good sleepers may be of little benefit to sleep (Driver & Taylor, 2000). One review suggested that exercise increases total sleep time by an average of 10min, often among people who already sleep well (Driver & Taylor, 2000).

The timing, type (e.g. aerobic, resistance) and duration of exercise all contribute to its interaction with sleep. In reasonably fit individuals, increased sleep duration is seen when exercise is performed for at least 1 hour per day. Effects of intensity have ranged between increasing deep sleep after moderate intensity exercise, to no effect on deep sleep after varied or normal intensity exercise. Aerobic exercise may have larger benefits on sleep than weight lifting (Driver & Taylor, 2000). However, another review suggested resistance training (i.e. weightlifting) improves self-reported sleep quality to a larger extent when performed three times per week, and at high (rather than low–moderate) intensity (Kovacevic, et al., 2017).

Cross-sectional studies have found that exercise improves sleep quality in adults and older adults. Over the course of a week, it is suggested that a minimum of 150 minutes of moderate intensity exercise, or 75 minutes of vigorous exercise, needs to be achieved for sleep to be enhanced (Buman & King, 2010). Exercise meeting these requirements, and performed consistently over the long term, may yield the largest benefits to sleep. Furthermore, adults who are usually active sleep better following a day where exercise was performed (Buman & King, 2010). Importantly, improvements to sleep are likely to be enhanced when combined with morning bright light (Driver & Taylor, 2000).

Reviews have provided mixed results as to the effectiveness of exercise for improving insomnia. Among middle-aged women, scheduled cardiovascular physical activity had benefits on sleep quality, as did yoga to a lesser extent. Duration ranged from 1.5–3 hours per week, and was completed for 12–16 weeks. However, despite improving sleep, insomnia severity was not significantly altered by exercise (Rubio-Arias et al., 2017).

Exercise may also act to improve sleep in adults and older adults experiencing depression. As poor sleep is a common symptom of depression, improving sleep through exercise may alleviate depressive symptoms (Buman & King, 2010; Driver & Taylor, 2000). Both short-term and long-term exercise have also been shown to improve anxiety, which may in turn reduce insomnia (Buman & King, 2010; Stathopoulou et al., 2006). Increases in exercise over a 3-month period are reported to improve sleep among people experiencing depression, with the reverse relationship also true (Driver & Taylor, 2000). Of note, higher intensity exercise proves superior to lower intensity exercise for decreasing rates of depressed mood. In general, higher intensity exercise improves sleep quality above low intensity exercise (Stathopoulou et al., 2006).

The relationship between sleep and exercise may be reciprocal (Chennaoui et al., 2015). For example, sleep deprivation for one night appears to have little effect on strength the next day. However, 30–100 hours of wakefulness may impact performance. Adults with shorter sleep are more likely to obtain an injury. Reductions in sleep also increase the risk of pain. Both of these factors may influence future likelihood of exercising. Sleep extension improves mood, as well as resilience during subsequent sleep restriction. Authors have concluded that regular, moderate-intensity exercise may be prescribed to individuals, both as a preventative measure and as a treatment for sleep disorders (Chennaoui et al., 2015).

All reviews consistently conclude that more rigorous studies investigating the effects of exercise on sleep – including timing, duration and intensity – are needed. One frequently cited issue in the area is the use of good sleepers when exploring the impact of exercise on sleep; hence, the ability for sleep to improve may be limited. Overall though, it appears that exercise, especially if performed regularly, improves subjective and objective sleep quality, increases total sleep time, decrease sleep-onset latency and increases deep sleep.

Summary

It may be premature to draw conclusions on the influence of technology use and sleep, yet a trend appears towards the harmful relationship between the two. Caffeine use disrupts sleep, yet physical activity can be considered a protective factor for adult sleep.

Older adults

A systematic review of prospective studies with a 1–20 year follow-up period investigated risk factors for sleep disturbance in older adults (Smagula et al., 2016). A majority of studies indicated that being female increased the risk of future sleep disturbances, with age also predicting future sleep disturbances. Eighty per cent of studies linked depression with sleep outcomes, with depression linked to future poor sleep quality. Conversely, psychological wellbeing was related to fewer sleep disturbances. Although medication may be used in an attempt to enhance sleep, it may actually lead to a decline in both sleep quality and the likelihood of sleep improving over time. Poor physical health, including self-reported health status, number of reported medical conditions and chronic medical conditions, predicted future sleep disturbances (Smagula et al., 2016). The exposure to light during the night in elderly people has also been linked to fragmented sleep and depressed mood (Bedrosian & Nelson, 2017).

Caffeine

Among older adults, 200 milligrams of caffeine consumed 1–3 hours before bedtime slightly increased sleep-onset latency and decreased sleep duration. However, a higher dose of caffeine (300 mg) was found to increase sleep-onset latency by over 1 hour, and decrease sleep by 2 hours. Night awakening also increased and deep sleep decreased (Clark & Landolt, 2017). These doses of caffeine could easily be consumed within a day, or possibly even before bed, as 200 milligrams of caffeine can be found in two cups of brewed coffee (Roehrs & Roth, 2008).

Peer factors

Choi, Irwin and Cho (2015) reviewed social interactions and sleep in studies containing samples with a mean age greater than 60 years, although in two studies, people were as young as 51 years. Subjective social isolation was related to more sleep disturbances. Previous feelings of loneliness were related to increased insomnia severity, while higher social interaction and better quality relationships were associated with faster sleep-onset latency and better sleep quality (Choi et al., 2015). Low social support was also linked with fatigue. Furthermore, older adults with low social engagement and higher loneliness also experienced more symptoms of depression (Choi et al., 2015).

Physical activity

The effects of age on sleep are greater than the effects physical exercise on sleep (Driver & Taylor, 2000). However, this is not to say that the effects of exercise on older adults' sleep are negligible. In fact, regular daily exercise and acute exercise improves sleep quality, regardless of whether it is aerobic, resistance training, yoga or tai chi (Driver & Taylor, 2000). Resistance training performed three times per week for 10 weeks improved self-reported sleep quality, as well depression symptoms (Driver & Taylor, 2000).

Physical activity may also be a protective factor for future sleep patterns; however, studies are limited in number and provide inconclusive results (Smagula et al., 2016). One 10-year follow-up study of Taiwanese adults aged 65 years and older showed that older adults who maintained a higher frequency of leisurely physical activity were less likely to develop insomnia than those who engaged in low-level physical activity at either time points (Chen et al., 2014).

In a meta-analysis of adults aged 50–72 years, high resistance or moderate cardio training were compared to control groups (e.g. control groups received health information sessions; Yang et al., 2012). Training lasted 10–16 weeks, with each session's duration ranging from 40–60 min. Exercise improved subjective sleep quality, and decreased sleep-onset latency as well as medication used to assist sleeping. However, there were no differences between groups for total sleep time, sleep efficiency, disrupted sleep or daytime functioning (Yang et al., 2012).

Alternatively, adults aged 65 years and older who displayed baseline sleep problems showed improved sleep quality, sleep-onset latency, sleep duration, sleep efficiency and daytime dysfunction, after performing up to 6 months of tai chi, for 20–60 minutes, 2–5 times per week (Du et al., 2015). This finding has been replicated in another review, where meditative movement (tai chi, qi gong, yoga) improved the sleep quality, quality of life and depressive symptoms in middle-aged to older adults (Wang et al., 2016). However, most of the included studies were lacking experimental rigour, hence results need to be interpreted with caution (Wang et al., 2016).

Randomised control trials (RCTs) have almost exclusively concluded that exercise in older adults improves self-reported sleep-onset latency, sleep quality and sleep duration (Buman & King, 2010). Moreover, daytime sleepiness is associated with less physical activity, whereas increased physical activity is related to improved wellbeing, less restless sleep and lower incidence of insomnia (Tremblay et al., 2007). Hence, encouraging physical activity among older adults may be a relatively easy means to facilitate improved sleep.

Summary

In older adults, social interactions are beneficial for sleep, as is physical activity. An added benefit of physical activity is that it may improve overall health, which would in turn also promote good sleep. Caffeine is disruptive for sleep, especially if consumed just prior to bedtime. Contrary to its intention, sleep medication may be harmful for future sleep.

Key findings of Chapter 4

- Media use and caffeine use likely have negative effects on sleep in adolescents and adults.
- Physical activity is likely beneficial to sleep quality across all age groups.
- Positive social interactions likely benefit sleep.

- Across all age groups, rigorous experimental studies are required to determine causal relationships, and the extent of benefits or risk factors associated with sleep. This is particularly true in the adolescent and young adult age group.

Chapter 5: Behavioural solutions to improve sleep and mental health in young people

The final section of this rapid review will focus on improving the sleep of adolescents and young adults, primarily through behavioural change. This section outlines the effectiveness of clinical interventions and school-based trials, as well as more low-intensity cognitive and behavioural interventions.

Clinical interventions

Cognitive behavioural therapy for insomnia (CBT-i)

Cognitive behavioural therapy for insomnia (CBT-i) is the most common treatment for insomnia in young people (Blake, Sheeber et al., 2017). As discussed in Two common sleep disorders explained (Chapter 1), it is estimated that 2% of 14–17 year olds and 11% of 18–24 year olds experience severe clinical insomnia (Hillman and Lack, 2013), although many more (up to 66%) experience symptoms of insomnia (Short et al., 2013).

In lay terms, CBT-i involves modifying peoples' sleep behaviours and the way they think about their sleep problem. CBT-i encompasses a number of different treatment components, many of which can be administered in non-clinical and school-based interventions. CBT-i typically involves a combination of psychoeducation about sleep; sleep hygiene; sleep-restriction therapy; stimulus control therapy; relaxation; and cognitive therapy (i.e. cognitive restructuring) – see Table 3 for a description of each strategy. Given the emergence of 'third wave' psychotherapies, these core treatment components have more recently been supplemented with mindfulness-based strategies, including mindfulness-based cognitive therapy and mindfulness-based stress reduction (Blake, Sheeber et al., 2017).

Table 3. Cognitive behavioural therapy strategies for insomnia

CBT-i strategy	Description
Psychoeducation	Education to increase the client's basic understanding of sleep and how disorder-specific treatment may improve sleep
Sleep hygiene	Education on practices which promote good sleep and practices which may be harmful to sleep
Sleep-restriction therapy	Altering the time spent in bed to increase sleepiness and reduce the time taken to fall asleep and time spent awake across the night
Stimulus-control therapy	Going to bed when sleepy, getting out of bed if unable to fall asleep within 15–20 mins, waking up at the same time every day regardless, keeping the bed/ bedroom only for sleep
Relaxation	Techniques (i.e. progressive muscle relaxation) designed to promote pre-sleep cognitive and physiological de-arousal
Cognitive therapy	Identifying and challenging maladaptive sleep-related beliefs and unhelpful thoughts through cognitive restructuring and behavioural experiments, etc.

Mindfulness strategy	Description
Mindfulness-based cognitive therapy	Cognitive therapy whereby clients are taught to disengage from unhelpful thinking (i.e. rather than challenging thoughts)
Mindfulness-based stress reduction	Mindfulness meditation (i.e. body scan) promoting non-judgemental awareness of cognitions and physical sensations

Adapted from Tang (2009)

Chronobiological treatment for DSWPD

Treatment for delayed sleep-wake phase disorder (DSWPD) takes a similar treatment approach; however, compared to insomnia, chronobiological treatment takes precedence over sleep restriction therapy or stimulus control therapy (Gradisar et al., 2014). As discussed above, in Two common sleep disorders explained (Chapter 1), 1% of Australian adolescents experience DSWPD, yet up to 52% meet at least one of the diagnostic criterion (Lovato et al., 2013). As DSWPD is theorised to occur due to a misalignment between circadian (i.e. body clock) timing and the 24–hour social world, chronobiological treatments primarily aim to correct (i.e. phase advance) adolescents' circadian rhythm (Gradisar & Crowley, 2013). As timing of the human circadian rhythm is most sensitive to light and melatonin, these chronobiological agents are most commonly used in treatment.

Bright light therapy

Light is the primary timekeeper for our body clock; therefore, circadian timing can be altered through manipulation of light/dark exposure. Importantly, bright light administered in the evening phase delays circadian timing, pushing sleep timing later, and bright light administered in the morning phase advances the circadian rhythm, pushing sleep timing earlier (Crowley & Eastman, 2017).

Assessment for DSWPD in young people should include sleep recording via sleep diaries and/ or wrist actigraphy for 1–2 weeks, over both school nights and weekend nights (American Academy of Sleep Medicine, 2014). Adolescents' circadian timing is typically masked throughout the school term, as school start times curtail sleep duration. Therefore, measuring sleep across the school week and weekend will likely capture sleep restriction across the school week and more natural sleep timing (i.e. later bedtimes and wake up times, longer sleep duration) on weekends, when young people are typically free from morning commitments. This assessment of baseline sleep helps to guide clinicians regarding the best time to commence morning light therapy.

Bright light therapy (BLT) for DSWPD typically requires the young person to sleep in on the first day of treatment (Gradisar, Smits, & Bjorvatn, 2014). Consequently, sleeping-in provides insight into when adolescents' would naturally wake if allowed to sleep in line with their circadian rhythm. Baseline sleep diaries and actigraphy recording assist the clinician to estimate when young people are likely to wake on the first morning of therapy. Following this initial sleep-in, young people are typically instructed to seek 30–60 mins of bright light immediately after awakening (Bjorvatn & Pallesen, 2009; Gradisar et al., 2014). Natural ambient light is the preferred light source; however, specialised light boxes and lamps are also clinically endorsed (Auger et al., 2015) and can be used when ambient light is limited (i.e. during reduced daylight hours in winter). Wake-up times (and light exposure) are then advanced by 30 minutes each day, until the required wake up time is attained. As evening light can phase delay the circadian rhythm, evening light restriction is also recommended alongside BLT (Crowley & Eastman, 2017). In particular, young people are advised to minimise light in the 2–3 hours prior to bedtime (Appleman et al., 2013). This can be achieved by avoiding particular activities (i.e. computer use, video gaming) or minimising light exposure (i.e. dimming house lighting, dimming light from technological devices and/or using blue-light blocking filters on devices, such as Night Shift on Apple devices).

Exogenous melatonin

Melatonin is a sleep-promoting hormone endogenously secreted by the pineal gland in dim light. This process occurs when photic information (i.e. light) is detected by melanopsin receptors, which are situated within ganglion cells in the eye. This information is then transmitted to the suprachiasmatic nucleus (SCN) via the retinohypothalamic tract (Freedman et al., 1999; Morin, 1994; Morin & Allen, 2006).

Although evening light restriction inherently encourages the onset of melatonin to become earlier, exogenous melatonin can also be administered as an additional chronobiological agent, alongside BLT (Gradisar et al., 2014). The onset of endogenous melatonin secretion occurs approximately 2 hours prior to bedtime (Revell et al., 2006; Saxvig et al., 2013), therefore administration of exogenous melatonin prior to this time encourages a phase advance of the circadian rhythm.

There is some consensus within the field that 1–3mg of compound melatonin should be administered 3 hours before bedtime and advanced by 30 minutes each subsequent night until ideal sleep timing is reached (and melatonin is ceased) (Gradisar et al., 2014). In Australia, the use of exogenous melatonin would require young people to obtain a prescription for compound melatonin from a general practitioner (GP). Prolonged release preparations (e.g. Circadin) are also available; however, this form of melatonin may maintain or worsen delayed-sleep timing in young people with DSWPD and, therefore, should be avoided (see Gradisar et al., 2014).

Cognitive behavioural therapy for DSWPD

Although DSWPD is assumed to have primarily physiological causes (i.e. circadian delay), there is growing evidence that cognitive processes are also implicated (Richardson et al., 2016). In particular, young people with DSWPD report difficulty initiating sleep (American Academy of Sleep Medicine, 2014) and prolonged sleep onset provides the opportunity for repetitive negative thinking, which can worsen pre-sleep hyperarousal and sleep-onset difficulties (Gradisar & Crowley, 2013; Harvey, 2002). In this regard, DSWPD and insomnia have similar phenomenology (Richardson et al., 2016). Unsurprisingly then, CBT-i strategies have also been combined with chronobiological agents in the treatment of DSWPD in young people. CBT-i components for DSWPD have included psychoeducation, sleep hygiene, cognitive restructuring, motivational interviewing, stimulus control and progressive muscle relaxation (Danielsson et al., 2016; Gradisar et al., 2011).

Current evidence for clinical sleep interventions for young people

Sleep disturbance

Many young people report symptoms of sleep disturbance, but may not have a diagnosable sleep problem. Regardless, clinical sleep interventions are often the primary treatment administered. Five studies have evaluated clinical interventions for the treatment of sleep disturbance in young people: two were conducted in Victoria, one in South Australia, and two were conducted internationally

(Bartel, Huang et al., 2018; Blake, Sheeber, et al., 2017; Friedrich & Schlarb, 2017); 502 young people aged 12–22 years participated in the trials.

Two trials evaluated CBT-i combined with mindfulness-based cognitive therapy (Bei et al., 2013, Blake et al., 2016), one administered CBT-i combined with mindfulness-based stress reduction (Bootzin & Stevens, 2005) and the most recent study compared simple CBT and mindfulness components administered before bed (i.e. body scan, constructive worry; Bartel, Huang et al., 2018). The final study compared the effectiveness of CBT-i with dialectical behaviour therapy (DBT) combined with mindfulness-based stress reduction (Trockel et al., 2011). DBT is similar to CBT but focuses on mindfulness and acceptance rather than thought challenging. Relative to CBT, DBT also focuses more on skill learning (O'Connell & Dowling, 2014). In three of the five studies, a psychologist administered treatment to groups of 2–9 young people over 6–8 weekly, 90-minute sessions. The other two studies administered treatment via email, with participants in the first study encouraged to engage with the treatment materials for 30 minutes each week for 8 weeks (Trockel et al., 2011). The other classroom-based, 2 week intervention asked participants to either listen to a 15-minute body-scan audio clip each night before bed, or complete a brief constructive worry exercise nightly from 6–8 pm(Bartel, Huang et al., 2018).

The Victorian group-based interventions administering CBT-i and mindfulness-based cognitive therapy showed objective (i.e. via wrist actigraphy) decreases in the time it took young people to fall asleep post-treatment. The initial pilot trial (N=9) showed objective increases in total sleep time at post treatment (i.e. 7 hours 33 minutes, relative to 7 hours 13 minutes pre-treatment; Bei et al., 2013). However, this finding was not replicated in the larger trial (N=123; Blake et al., 2016). Subjectively, adolescents reported reduced sleep-onset latency and earlier sleep timing, with less day-to-day variation, which suggests adolescents' body-clock timing better aligned with their school-week schedule. Perceived sleep quality also improved and daytime sleepiness reduced. Overall, these findings suggest that CBT-i combined with mindfulness-based cognitive therapy may be an effective intervention for adolescent sleep (Bei et al., 2013; Blake et al., 2016).

Similar results were seen in the trial evaluating CBT-i combined with mindfulness-based stress reduction (Bootzin & Stevens, 2005). Those who regularly attended the intervention reported increases in subjective and objective total sleep time and reduced subjective sleep-onset latency. Importantly, adolescents who completed mindfulness meditation more frequently at home had greater increases in total sleep time, which suggests that treatment compliance and home practice are important elements of treatment.

In terms of the internet-delivered treatments, university students' sleep quality benefited more from CBT-i, relative to DBT combined with mindfulness stress reduction. These results add to the evidence base for CBT-i; however, further research comparing internet-based versus therapist-delivered CBT-i is needed. In terms of the school-based interventions, neither constructive worry nor the mindfulness body scan reduced sleep-onset latency across two weeks of treatment. However, analyses performed on a subgroup of adolescents who had a baseline sleep-onset latency of 30 minutes or longer (i.e. criterion for insomnia) and who completed the intervention for a minimum of three nights for at least one week, showed mindfulness reduced sleep-onset latency over the 2 week period by 30 minutes. As such, a pre-recorded breath-based mindfulness body scan could be a simple, effective and easily disseminated tool to address sleep onset difficulties in adolescents, provided adolescents use the recording (Bartel, Huang et al., 2018).

Insomnia

To date, there have been three pilot trials and one RCT investigating CBT-i for adolescent insomnia (Blake, Sheeber, et al., 2017), and two trials and two RCTs investigating CBT-i for university students (Friedrich & Schlarb, 2017). All these trials have been conducted internationally, meaning Australian and Victorian data are not yet available. Studies with an adolescent focus recruited participants aged 11–19 and those recruiting university students had an age range from 17–44 years. In total, 348 young people participated in these studies. Multimodal CBT-i programs were primarily evaluated; however, two studies investigated standalone CBT-i techniques (i.e. stimulus control: Funderburk et al., 2015, and progressive muscle relaxation: Means et al., 2000). Treatment for adolescents was administered over six weekly 90–100 minute sessions. One study in university students administered CBT-i similarly, over six weekly sessions; however, generally treatment length in most studies was more brief (e.g. just one session, or three weekly sessions of 15–20 minutes duration). Treatment was administered to groups of young people in four studies, one-on-one in two studies, and group-based versus internet-delivered treatment was directly compared in two studies.

Group-delivered CBT-i for adolescent insomnia appears to be effective. The three pilot trials showed significant improvement in subjective sleep-onset latency and total sleep time (Roeser et al., 2016, Schlarb et al., 2011), and a higher percentage of time spent asleep in bed (i.e. sleep efficiency) post-treatment (de Bruin et al., 2014). Other benefits included reduced insomnia symptoms, chronic sleep reduction and sleepiness (de Bruin et al., 2014). Schlarb and colleagues (2011) also showed improvements were durable at 12 months post treatment.

In the pilot trial (N=26) comparing group-based to internet-delivered treatment, similar improvements were seen for the adolescents who received internet-delivered treatment. However, generally, there was greater improvement for the group therapy condition. Importantly, as the internet therapy group had lower scores at baseline, this may have limited the scope for improvement (de Bruin et al., 2014); therefore, it was important to replicate the study with a larger, more balanced sample.

The subsequent larger trial (N=116) also extended findings by including a waitlist control group (de Bruin et al., 2015). In terms of results, both the internet-delivered and group-based treatment groups showed significantly reduced sleep onset latencies (both objectively and subjectively). However, only the internet-delivered treatment group showed significant improvements in objective total sleep time (i.e. 7 hours 16 minutes, relative to 6 hours 59 minutes pre-treatment). Overall, results from these studies suggest CBT-i is effective for the treatment of adolescent insomnia. Additionally, internet-delivered CBT-i appears to be a viable alternative to face-to-face group therapy, which may have flow-on effects for the dissemination of sleep treatment to adolescents and young people.

University students have benefited similarly from CBT-i. In particular, university students who underwent group treatment had reduced subjective sleep-onset latency and a trend for increased total sleep time following treatment, compared to a waitlist control condition. The CBT-i group also reported significantly lower insomnia severity and better sleep quality at post-treatment, relative to the control condition (Taylor et al., 2014).

More simple and/or brief CBT-i interventions have also shown promise for university students. More specifically, one session of CBT-i has resulted in a significant reduction in insomnia symptoms two weeks post treatment (Petrov et al., 2014). One week of stimulus control therapy, a standalone component of CBT-i, also resulted in a significant decrease in insomnia severity (Funderburk et al., 2015). However, as the Insomnia Severity Index was the only sleep measure included in both studies, and both studies lacked randomisation and a control condition, results need to be interpreted with caution. Progressive muscle relaxation (PMR), as another standalone component of CBT-i, appears promising for university students with insomnia (Means et al., 2000). PMR did not have an effect on sleep-onset latency; however, pre-treatment sleep-onset latency was below the clinical cut-off for insomnia (Buysse et al., 2006), which may have limited the scope for improvement. Improvement in sleep quality for the PMR group was statistically significant, whereas sleep quality for the control group remained stable. Taken together, these results suggest further research into the efficacy of standalone CBT-i components is warranted, particularly as simple, standalone components of CBT-i could be disseminated to young people easily and affordably.

Delayed sleep-wake phase disorder

Bright light therapy (BLT)

Relative to adolescent Insomnia, more well-designed studies have investigated treatments for adolescent DSWPD. To date, four RCTs have investigated the efficacy of BLT for the treatment of adolescent DSWPD (Danielsson et al., 2016; Gradisar et al., 2011; Richardson et al., 2018; Saxvig et al., 2014 / Wilhelmsen-Langeland, Saxvig, Pallesen, Nordhus, Vedaa et al., 2013), with two of these studies being conducted in Australia (South Australia). Given DSWPD is most common in adolescents and young adults, these studies have collectively recruited 206 participants aged 11–26 years. Three studies have compared light therapy as a standalone treatment, with light therapy combined with other treatment modalities (i.e. CBT-i, melatonin); and one directly compared light therapy plus CBT-i with a waitlist control condition. Two studies have also compared the efficacy of different wavelength of light (i.e. bright broad-spectrum white light with dim red light [placebo], and green light with red light [placebo]). Light therapy was administered between 2 weeks to 3 months, following between two and six 50–90 minute sessions with a psychologist.

Overall these studies have shown light therapy to be an effective treatment for DSWPD in young people. Generally, young people have taken less time to fall asleep post treatment (10–56 minutes less post treatment), had earlier sleep-onset times (49–111 minutes earlier post treatment) and gained more sleep across the night (29–60 minutes more post treatment) (Danielsson et al., 2016; Gradisar et al., 2011; Richardson et al., 2018; Saxvig et al., 2014; Wilhelmsen-Langeland et al., 2013). One study also measured circadian timing and showed earlier body clock timing post-treatment (Saxvig et al., 2014; Wilhelmsen-Langeland et al., 2013). The daytime functioning of young people has also improved, including measures of morning alertness, daytime sleepiness, fatigue and functional impairment.

In terms of adding and refining components to light therapy, results have been modest. Young people's sleep benefited similarly, regardless of whether CBT-i was added to light therapy or not (Danielsson et al., 2016). Additionally, two studies have not found any difference in the efficacy of light therapy, based on the wavelength of light administered (Richardson et al., 2018; Saxvig et al., 2014; Wilhelmsen-Langeland et al., 2013). Further research is required to determine whether current applications of light therapy can be further improved, particularly as long-term relapse of symptoms is common (Richardson et al., 2018; Saxvig et al., 2014). Regardless, these collective results suggest that 2–3 weeks of light therapy may be sufficient to improve the sleep of young people with DSWPD, which is particularly significant given the chronicity of the condition (e.g. 3.5 years; Richardson et al., 2018).

Melatonin

Fewer well-designed studies have evaluated the efficacy of exogenous melatonin for the treatment of DSWPD in adolescents. One retrospective study with 33 adolescents aged 10–18 years showed improvements in sleep-onset timing (131 minutes earlier post treatment) and sleep duration (155 minutes more post treatment) following approximately 6 months of melatonin treatment (Szeinberg et al., 2006). A limitation of this study is that a control condition was not included, so results should be interpreted with caution.

Another small study (N=13, aged 22–42, mean=28 years) investigated whether four weeks of melatonin treatment improved the sleep of young adults with DSWPD (Mundey et al., 2005). Participants cited the onset of DSWPD as during childhood, adolescence or young adulthood. Participants who received exogenous melatonin had earlier circadian timing (i.e. 90 minutes earlier dim-light melatonin onset, core body temperature minimum) post treatment. However, having earlier circadian timing did not translate to improvements in sleep. That is, there were no significant changes in sleep-onset latency, sleep-onset time, wake-up time or total sleep time.

More recently, a RCT compared the efficacy of 3 milligrams of evening melatonin to a placebo over 2 weeks of treatment (Saxvig et al., 2014; Wilhelmsen-Langeland et al., 2013). Both the melatonin and placebo groups advanced their bedtime across two weeks of treatment (74 minutes and 49 minutes earlier, respectively). However, no between-group differences were observed. Sleep-onset latency also showed signs of improvement across treatment, albeit not statistically significant and there was no impact on total sleep time.

The same trial also investigated whether treatment combining light therapy and melatonin was more effective than either approach separately (Saxvig et al., 2014). There were no significant differences in outcomes across the two weeks of treatment. However, adolescents who maintained light therapy and melatonin treatment for three months continued to advance sleep timing and further reduced sleep-onset latency. Alternatively, adolescents who received no additional treatment had returned to pre-treatment levels by the 3-month follow-up.

To date, there is limited evidence supporting the efficacy of melatonin for adolescent DSWPD. In addition, there is some concern about the safety of melatonin when used in paediatric samples (Kennaway, 2015), with adverse outcomes including excessive sedation, increased risk of type 2 diabetes and influence on reproductive development (Burgess & Emens, 2016; Kennaway, 2015). However, it has also been argued that there is no evidence for harmful effects of melatonin in paediatric samples, either immediately, or after a 3-year follow-up period (Bruni et al., 2015). Given this controversy, compared to melatonin, light therapy may be a preferable first-line treatment for DSWPD in adolescents and young adults.

School-based and non-clinical interventions

A review of psychological interventions for sleep problems in university student populations determined that CBT-i (such as the studies above) was superior to other treatments for improving sleep and mental health (Friedrich & Schlarb, 2017). Nonetheless, three other categories of interventions were found to be useful for sleep and mental health in this population: sleep hygiene, relaxation/mindfulness and other therapies.

Sleep hygiene

The review included four RCTs and five controlled trials of sleep hygiene, with follow-up periods up to 12 months. All studies recruited healthy samples. Interventions varied between mixtures of information sessions and/or lectures on sleep hygiene, to group discussions (in person and/or online), to one-on-one discussions. The majority of interventions were provided as a one-off session. Overall, sleep hygiene interventions increased sleep duration to a small extent and decreased sleep-onset latency to a medium extent. Dysfunctional beliefs about sleep decreased. Thus, overall, it appears that sleep hygiene can be a useful technique for improving sleep in university students. However, the effects were smaller than those seen in the other intervention types (Friedrich & Schlarb, 2017).

Studies involving relaxation, mindfulness and hypnotherapy

Studies involving relaxation, mindfulness and hypnotherapy were analysed together. Regarding RCTs, two were of healthy samples, two included sleep-impaired samples, and one trial recruited sleep-disorder students. The one control trial used a healthy sample. Sleep intervention strategies were mixed, ranging from four 75-minute mindfulness sessions (involving abdominal breathing, guided imagery and insight meditation) to muscle relaxation, listening to classical music and hypnosis (Friedrich & Schlarb, 2017).

Oxtoby and colleagues (2013) prescribed listening to classical/meditative music for a minimum of 20 minutes per night, after 6pm, to Brisbane-based university students. The control group was instructed to continue their night-time habits as usual. After 2 weeks, improvements were found in the music group for anxiety and depression symptom scores, stress, pre-sleep arousal, sleep related behaviour and attention. Dysfunctional beliefs about sleep and insomnia scores did not alter. The control group showed no change to any of the measures over time (Oxtoby et al., 2013).

Overall, relaxation interventions provided small effects for sleep efficiency and medium effects for waking after sleep onset, sleep quality and sleep problems (Friedrich & Schlarb, 2017).

Other interventions

Interventions to improve sleep in the ‘other’ category included implosive therapy (a behavioural therapy where exposure to a stressful stimulus occurs without progressive steps) or listening to ocean sounds; cognitive refocusing; and a gratitude intervention compared to constructive worry (Friedrich & Schlarb, 2017).

Although benefits of the gratitude intervention (explained below) and constructive worry were found on pre-sleep arousal and anxiety, few benefits were found on sleep, other than for sleep quality (Digdon & Koble, 2011). Training people with insomnia to refocus their attention on non-sleep related stimuli decreased pre-sleep arousal after 4 weeks, and decreased insomnia scores (Gellis et al., 2013). Implosive therapy and listening to ocean sounds both decreased sleep-onset latency after 4 weeks, compared to a waitlist control group (Carrera & Elenewski, 1980). The sum of these results suggests medium impacts on sleep quality and sleep problems (Friedrich & Schlarb, 2017).

Thus, sleep hygiene, relaxation, mindfulness and other strategies may be effective treatments, although less so than CBT-i (Friedrich & Schlarb, 2017). It should be noted that the majority of the samples were healthy students (63%) not experiencing sleep problems or sleep disorders. Importantly, some strategies (e.g. sleep hygiene, listening to classical music) require less specialised training and knowledge in the area of sleep in order to administer them. Hence, they represent a hopeful path for assisting the sleep of young adults without the need to employ clinicians. This may be pertinent in Australia, whereby psychological services can be provided for sleep issues under the Better Access to mental health care initiative, but students without sleep issues requesting practical support would not be able to use these Medicare benefits.

School-based interventions

School-based sleep interventions are a feasible and acceptable platform from which to modify adolescent sleep (Blunden & Rigney, 2015; Gruber, 2016), although setting up intervention programs in schools is not without administrative barriers (Perfect, 2014). Despite the appeal of school-based programs, their success for change in sleep has been unconvincing (Cassoff et al., 2013; Gruber, 2016).

Blunden, Chapman and Rigney (2012), Blunden and Rigney (2015) and Gruber (2016) reviewed 12[1], 13 and 15 school-based intervention studies provided to secondary school students, respectively. Some programs sought mainly to impart sleep knowledge information, with others aimed to change behaviours (Blunden et al., 2012; Blunden & Rigney, 2015). Sleep programs often incorporated some or all of the following content: importance of sleep, what sleep is, reasons for sleep, sleep need, changes to sleep for adolescents, sleep hygiene and ways to change sleep patterns (Blunden et al., 2012; Gruber, 2016). Lessons were generally 50 minutes long; however, the number of lessons ranged from one to twelve, with four to six lessons being most common (Blunden et al., 2012; Blunden & Rigney, 2015; Gruber, 2016). Of these, style of delivery was either instructional or interactive, with student feedback indicating that interactive classes were preferred (Blunden & Rigney, 2015).

The most common type of sleep measurement was self-report (questionnaire or sleep diary). Some studies included parent involvement or school community engagement to increase the likelihood of sleep change. Follow-up periods ranged from 5 days to 18 weeks (Blunden & Rigney, 2015; Gruber, 2016). Results for the efficacy of these interventions for sleep patterns, sleep knowledge and health were mixed (Blunden et al., 2012; Gruber, 2016). In a majority of the studies, sleep knowledge increased, yet changes to sleep and health were often limited, and not maintained at follow-up (Gruber, 2016). Two studies that incorporated sleep hygiene found decreases in sleep-onset latency, and two studies found small increases sleep duration (Blunden et al., 2012).

Another review of school-based interventions assessed their effectiveness at decreasing adolescent sleep restriction (Cassoff et al., 2013). It was found that sleep knowledge improved from interventions, yet behavioural changes to sleep were not maintained by follow-up. This was regardless of whether the sleep program included only sleep education, or whether it included elements of CBT-i. To combat this issue, authors suggested motivational interviewing to enhance the likelihood of adolescent adherence to sleep change (Cassoff et al., 2013). Motivational interviewing

[1] Eight of the 12 studies in Blunden and colleagues' 2012 review were included in Bluden and Rigney's 2015 review.

includes empathising with the client, encouraging the client to make their own decisions, being non-confrontational towards client resistance to change, and assisting the client to realise the discrepancy between their current behaviours and future goals. It was also suggested to tailor the intervention to the individual, as much as was feasible (Cassoff et al., 2013).

One meta-analysis of RCTs for school-based interventions has been performed (Chung et al., 2017); seven studies were included (four from Australia). As with the review articles described above, most commonly, four 50-minute lessons were taught. Immediately post treatment, both weekday and weekend sleep duration increased in the treatment group, compared to class-as-usual. There was no difference in sleep-onset latency. Interestingly, and in contrast to the conclusions of the reviews discussed above, there was no difference in sleep knowledge between groups. Follow-up periods ranged from 6 weeks to 1 year. Regardless of follow-up time frame, no differences in sleep behaviours, sleep knowledge or sleep hygiene (for the two studies measuring this outcome) were observed between groups (Chung et al., 2017). Thus, similarly to review articles, Chung and colleagues (2017) concluded that school sleep programs promote short-term benefits, but do not create long-term change.

Overall, school-based sleep programs provide a feasible means to educate adolescents about sleep and provide interventions. According to review articles, these programs consistently increase sleep knowledge, although one meta-analysis disagrees with this (Chung et al., 2017). School-based sleep programs have had limited success in altering sleep/wake patterns. Although some success has been found for short-term change, the benefits of the program are often not maintained into the future.

Gratitude interventions

One meta-analysis investigated the effects of gratitude interventions (i.e. writing down things you are thankful for) on outcomes that include sleep (Dickens, 2017). The two studies measuring sleep outcomes targeted university students. One of these studies, included in the review by Friedrich and Schlarb (2017), requested students to complete a gratitude intervention, imagery distraction or constructive worry for 1 week. In the other study, students were allocated one of three interventions (Emmons & McCullough, 2003). One group was instructed to write down hassles, the other to write down what they were grateful for, and a third to write down how they were better than others, for nearly 2 weeks (Emmons & McCullough, 2003). Consistent with findings from Friedrich and Schlarb (2017) combining the results from the above two studies, no benefits of gratitude intervention were found on self-report sleep duration, regardless of the comparison group (Dickens, 2017).

Media use

As reported above in Adolescents and young adults: Caffeine (Chapter 4), no interventions have been conducted regarding the use of caffeine in adolescents, although previous interventions have instructed caffeine restriction as part of good sleep hygiene (see Friedrich & Schlarb (2017) review of sleep hygiene interventions in university students). Despite the plethora of correlational literature linking technology use and sleep issues in adolescents (Hale & Guan, 2015), experimental studies and interventions pertaining to media use are scarce.

One recent South Australian study experimentally manipulated the time adolescents stop using their mobile phone on school nights (Bartel, Scheeren & Gradisar, 2018). After a week of sleep habits as usual, adolescents were asked to stop using their phone 1 hour before bedtime. Adolescents maintained the same bedtime during the intervention week, yet they turned their lights out 17 minutes earlier. That is, although they went to bed at a similar time both weeks, they turned their lights out and attempted to sleep earlier. Consistent with review and meta-analytic findings above in Adolescents and young adults: Media use (Chapter 4), sleep-onset latency was not affected by the earlier mobile phone stop time. Adolescents obtained 21 minutes more sleep per night, which equates to an extra 1 hour 45 minutes sleep over the course of the school week (Bartel, Scheeren & Gradisar, 2018). Thus, this experimental study displays the benefits of harm minimisation among adolescents.

Rather than completely prohibiting the use of phones among adolescents, encouraging them to learn healthier sleep habits by setting a bedtime for their phone, 1 hour before their normal bedtime, will benefit their sleep (Bartel, Scheeren & Gradisar, 2018). Future experiments are needed to determine the implications this has on mental health.

The effect of clinical sleep interventions on young people's mental health

As mentioned in Two common sleep disorders explained (Chapter 1), adolescents may experience symptoms of a sleep disorder without meeting diagnosis criteria (e.g. Lovato et al., (2013). As such, we will discuss studies relating to sleep disturbance and those aimed at treating clinical sleep disorders separately.

Sleep disturbance

Four studies evaluating clinical sleep interventions for sub-clinical sleep disturbance included secondary measures of mental health. Following a 6-week multimodal (CBT-i, mindfulness-based cognitive therapy) intervention, adolescent girls showed a small reduction in symptoms of panic/ agoraphobia and separation anxiety (Bei et al., 2013). However, there was a small deteriorating effect on the general anxiety subscale and overall anxiety remained consistent. A more recent RCT of a 7-week CBT-i and mindfulness-based cognitive therapy intervention found a small reduction in overall anxiety, relative to the control condition (Blake et al., 2016). However, between groups there were no differences in symptoms of depression. This may be because the adolescents had low levels of depression pre-treatment (i.e. major depression was an exclusion criteria). In terms of other mental health outcomes, improvements in social and attentional problems and aggression were driven by improvements in self-reported sleep quality (Blake, Snoep et al., 2017).

It is important to conduct treatment studies with adolescents who experience comorbid conditions, as this helps to increase the generalisability of findings. To this end, adolescents with substance abuse problems had significantly less mental distress (i.e. depression, anxiety, somatic and behavioural problems) following six sessions of CBT-i and mindfulness-based stress reduction (Britton et al., 2010). There was a trend for treatment completers to have better mental health outcomes, which again reinforces the importance of treatment attendance and engagement. In terms of the interrelationship between sleep and mental health, there was some evidence that worry, self-efficacy and substance use were related to total sleep time, with increases in total sleep time linked with better mental health outcomes. These results suggest adolescents with comorbid psychological conditions may also benefit from sleep intervention.

In investigating the effect of sleep interventions on the mental health of university students, Trockel and colleagues (2011) found young adults with poor sleep quality had reduced depressive symptoms after receiving CBT-i over eight weeks, relative to university students who received a treatment combining dialectical behaviour therapy (DBT) and mindfulness-based stress reduction. The change in average depression scores moved participants from above to below the cut-off score for clinically significant depression.

Effects of sleep hygiene interventions, relaxation strategies and school-based interventions were not comprehensive (See Table 4 below for a summary of results of all strategies). Nonetheless, among university students, sleep hygiene interventions benefited mental health, and relaxation strategies improved mental health to a large extent (Friedrich & Schlarb, 2017). Gratitude interventions and constructive worry were found to decrease pre-sleep arousal and anxiety, yet, overall, the use of 'other' therapies suggested medium impacts on mental health (Friedrich & Schlarb, 2017). School based interventions in high school students lead to improved mood in the treatment group compared to class-as-usual, immediately post treatment (Chung et al., 2017).

Table 4: Effect of sleep interventions on mental health in adolescents and young adults

Authors (year)	Intervention	Population	Effect size
Blake, Sheeber et al., (2017)	CBT-i	High school students	+ large depression + small anxiety
Friedrich & Schlarb (2017)	CBT-i	University students	+ medium
Friedrich & Schlarb (2017)	Sleep hygiene	University students	+ small
Friedrich & Schlarb (2017)	Relaxation	University students	+ large
Friedrich & Schlarb (2017)	'other' (e.g. gratitude intervention, constructive worry)	University students	+ medium
Gradisar et al., (2011)	BLT	High school students	+ medium
Danielsson et al., (2016)	BLT	Adolescents and young adults	+ small
Richardson et al., (2018)	BLT	Adolescents and young adults	+ small to medium
Chung et al., 2017	School-based interventions	High school students	+ large

Note: + indicates improvement.

Insomnia

Of the three pilot trials and one RCT protocol investigating treatment for adolescent insomnia, two of these studies measured outcomes relating to mental wellbeing. In a pilot trial, adolescents with insomnia who received six weeks of CBT-i reported a significant improvement in emotional wellbeing (i.e. withdrawal, somatic complaints, anxiety, depression, social problems, thought problems, attention problems, aggression and delinquent behaviour) post-treatment (Schlarb et al., 2011). However, as a control condition was not included, results should be interpreted with caution. A study comparing 6 weeks of internet-delivered or group-based CBT-i to a waitlist condition – sleep outcomes described above in Clinical interventions (Chapter 5) – found both treatments improved mental health (de Bruin et al., 2017). A reduction in insomnia symptoms for the group therapy condition resulted in decreased affective, anxiety, somatic and oppositional defiant problems. A reduction in insomnia symptoms for the internet group lead to decreased affective and oppositional defiant problems (de Bruin et al., 2017). This increases our confidence that CBT-i is effective at improving insomnia, and also mental health. However, more RCTs are needed to better understand the effect of CBT-i on adolescents' mental wellbeing.

One study investigating CBT-i for insomnia in university students included measures of mental health (Taylor et al., 2014). As part of a RCT of CBT-i, university students showed signs of improved quality of life (d=0.67) and reduced depressive symptoms (d=0.61), alongside improvements in subjective sleep. However, as there were no statistically significant differences between the CBT-i and waitlist control conditions, it is uncertain how clinically meaningful these improvements were.

As described in Chapter 3 above, young people with sleep disturbance often experience comorbid psychological conditions (Roane & Taylor, 2008; Sivertsen et al., 2015). Importantly, sleep disturbance may precede the development of depression (Lovato & Gradisar, 2014). Both conditions warrant treatment; however, treatment targeting each condition separately (i.e. independently) may result in poorer outcomes (i.e. sleep disturbance may reduce adolescents' ability to engage in treatment for depression). Consequently, Clarke and colleagues (2015) investigated whether the inclusion of CBT-i enhances treatment for depression in adolescents (12–20yrs). Forty-one adolescents with both insomnia and unipolar depression received either three or four sessions of CBT-i (i.e. psychoeducation, stimulus control, sleep restriction, cognitive therapy, savouring) or sleep hygiene education (control), before going on to receive four to six sessions of CBT-D. Most sleep outcomes and depression scores on the Child Depression Rating Scale did not differ between the two conditions. However, adolescents who received CBT-i had better depression outcomes, in terms of the percentage of participants determined to be recovered (see Figure 1), and time to recovery, relative to those who received sleep hygiene education prior to treatment for depression (Clarke et al., 2015). Although CBT-i appears to improve mental wellbeing outcomes for adolescents and young adults with insomnia and depression, more research is needed to increase confidence in this effect.

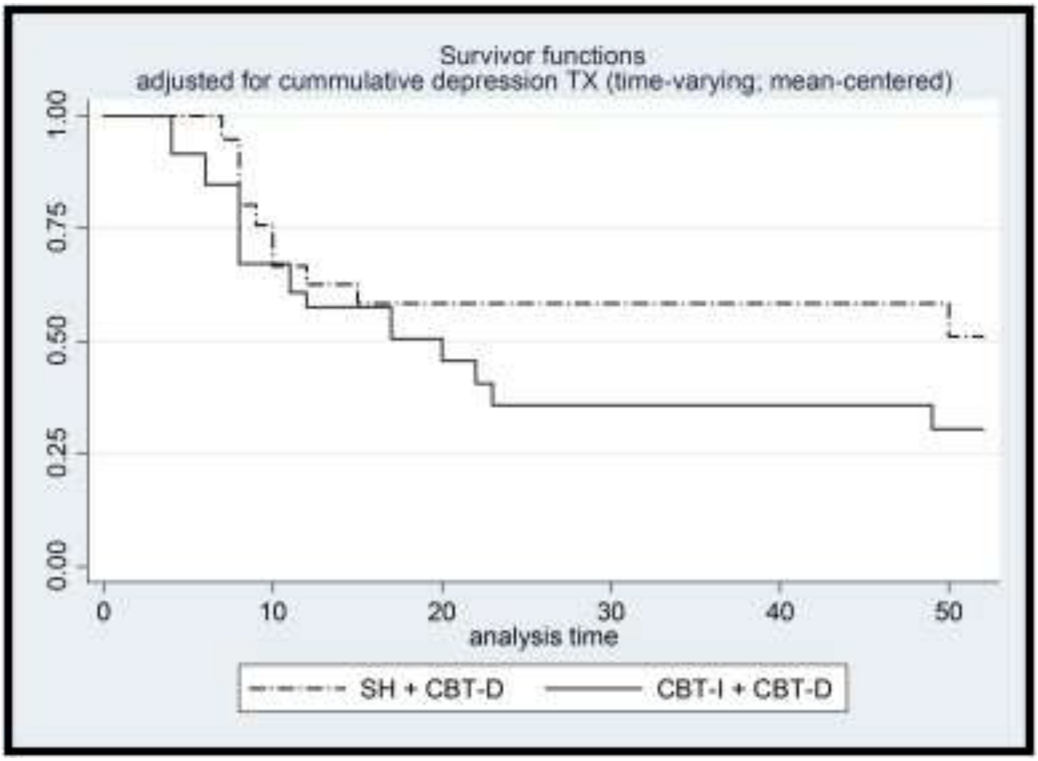
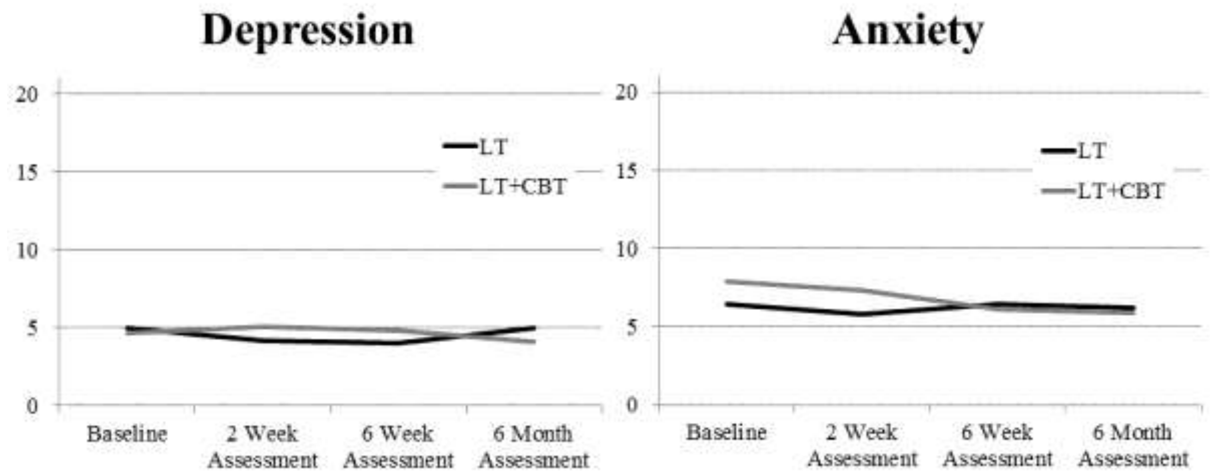


Figure 1. Recovery from depression from baseline, for sleep hygiene (SH) + CBT-D and CBT-i + CBT-D treatment groups (Clarke et al., 2015)

Delayed sleep-wake phase disorder

In terms of treatment for adolescent delayed sleep-wake phase disorder (DSWPD), three of the four RCTs of BLT measured outcomes relating to mental wellbeing. In the first RCT for adolescent DSWPD, six sessions of BLT plus CBT-i resulted in moderate decreases (d=0.71) in depressive symptoms, relative to the waitlist control condition (Gradisar et al., 2011). However, the interaction between group and time did not reach statistical significance. In teasing apart whether the inclusion of CBT-i improved the efficacy of bright light therapy, Danielsson and colleagues (2016) found that CBT-i did not further improve sleep outcomes for adolescents with DSWPD. However, the inclusion of CBT-i did result in better outcomes relating to depression and anxiety. The group who received additional CBT-i had a larger decrease in symptoms of depression and anxiety from the two week assessment to the 6-week and 6-month assessments, compared to the group who received bright light alone (see Figure 2). This is particularly important given the high rate of psychological comorbidity within DSWPD (Reid et al., 2012; Sivertsen et al., 2015) and that psychological comorbidity could lead to an increased risk of relapse (i.e. depression leading to withdrawal, sleeping in and circadian delay).



CBT = cognitive behaviour therapy; LT = light therapy

Figure 2. Change in depression and anxiety symptoms across treatment and follow-up, by treatment group, using LT vs LT + CBT-i (Danielsson et al., 2016)

In the most recent trial of BLT, three weeks of light therapy resulted in a small decrease in depressive symptoms (d=0.23), albeit not statistically significant (Richardson et al., 2018). However, mood continued to improve post-treatment, with a moderate (d=0.62) and statistically significant decrease in depression observed at the 3-month follow-up, relative to pre-treatment (Richardson et al., 2018).

Only one study evaluating melatonin for adolescents with DSWPD included measures of mental wellbeing. Adolescents who received melatonin for 6 months reported less behavioural and social difficulties during treatment (28%), relative to pre-treatment (86%) (Szeinberg et al., 2006). However, other mental health outcomes (e.g. anxiety, depression) were not measured.

Key findings of Chapter 5

To improve sleep, and thus mental health, among adolescents and young adults, the treatment options outlined in Table 5 have been successful or partially successful.

Table 5. Summary of effective or partially effective treatments for sleep in adolescents and young adults

Strategy	Description	Summary of evidence
Cognitive behaviour therapy for insomnia (CBT-i)	Combination of sleep psychoeducation, sleep hygiene, sleep restriction therapy, stimulus control therapy, relaxation and cognitive therapy	Improved TST, SE, SOL WASO, mental health
Bright light therapy (BLT)	Changing a person's body clock through appropriately timed bright light (used for treating DSWPD)	Improved SOL, earlier bedtime, mental health
Sleep hygiene	Education on practices that promote good sleep and practices that may be harmful to sleep.	Improved TST, SOL

Other: relaxation, mindfulness	Techniques designed to promote pre-sleep cognitive and physiological de-arousal and/or detach from unhelpful thoughts	Improved SE, WASO, mental health
School-based interventions	Incorporating various therapies described in this table (Table 5), administered in a school classroom	Improved sleep knowledge, immediate TST. No long-term changes to sleep habits
Pre-bed phone restriction	Restricting phone use 1 hour before bedtime across the school week	Earlier lights out time, improved TST

Note: DSWPD = Delayed sleep wake phase disorder, TST = total sleep time, SOL = sleep-onset latency, WASO = wake after sleep onset,

Overall, the following was found regarding intervention strategies for the sleep, and thus mental health, of adolescents and young adults.

- CBT-i is a highly effective strategy for improving the sleep and mental health of adolescents and young adults.
- BLT is an effective treatment for adolescents experiencing DSWPD.
- Sleep hygiene, relaxation and mindfulness strategies are beneficial to the sleep and mental health of young adults.
- Listening to a mindfulness body-scan audio clip for 15 minutes at bedtime can decrease sleep-onset latency for adolescents with sleep-onset latency of 30 minutes or longer.
- School-based sleep programs provide a promising platform to disseminate sleep interventions, yet further research is needed to turn student knowledge into sustained sleep habits.
- Gratitude interventions may not be a useful standalone technique to help young adults sleep better.
- Adolescents who stop using their mobile phone 1 hour before bedtime turn their lights out earlier and sleep longer.

Chapter 6: Summary and conclusions

Overview of Chapter 1: Introduction

Sleep is influenced by a host of biological and lifestyle factors. For example, sleep pressure and the circadian rhythm (i.e. body clock), impact sleep, and sleep need changes decreases across the lifespan. Of note, adolescents have a biological tendency to go to bed later and sleep-in, which conflicts with school start times.

Lifestyle factors are behavioural, and thus usually under an individual's control (e.g. caffeine consumption). Thus, an individual can modify their lifestyle factors to influence their sleep and mental wellbeing. This review focused on behavioural factors, thus empowering individuals, and those who support them, to make changes that benefit their sleep and mental health.

Overview of Chapter 2: Australian sleep patterns

Adolescents throughout Australia, including Victoria, are often not obtaining the recommended amount of sleep (8–10 hours) during the school week. On average, sleep acquired ranges from 6.5–7.5 hours during the school week, but is usually sufficient over the weekend and holidays.

Australian adults are obtaining closer to sleep recommendations (7–9 hours), yet are only meeting minimal requirements, particularly during the work week. Likewise, older adults are sleeping close to target sleep amounts (7–8 hours), yet with less weeknight to weekend discrepancy in the amount of sleep obtained.

Overview of Chapter 3: Sleep and mental health

Overall, poor sleep across all age groups has been linked to poor present and future mental health. Adolescents may be particularly susceptible to the effects of poor sleep, considering the often fail to meet suggested sleep requirements during the school week. In adolescents, short sleep is related to decreased ability to regulate emotions, however, in adults, acute sleep restriction in not related to increased anxiety. Across all age groups, an association between depression and poor sleep (e.g. short sleep duration) was found. That is, many review articles have concluded that poor sleep is related to increased risk of current and future depressed mood. Although there is less conclusive evidence, it is also suggested that this relationship is bi-directional, that is, that poor mental health also leads to poor future sleep.

Overview of Chapter 4: Lifestyle factors associated with sleep

The majority of the literature assessing lifestyle factors and adolescent sleep is correlational, with links between media use, caffeine consumption and sleep. Despite this flaw, pre-bed technology use may be a risk factor for delaying adolescents' bedtimes and decreasing their sleep duration. Similarly, adolescents and young adults who use caffeine are likely to have shorter sleep and more daytime tiredness. Conversely, a positive family environment and parent-set bedtimes are likely to promote sleep, as does exercise. The timing, intensity and duration of physical activity need to be more rigorously studied to determine its exact effects on sleep. The effects of extracurricular activities on sleep are inconclusive.

Among adults there is a trend towards the use of technology and worse sleep outcomes. For both adults and older adults, caffeine consumption is disruptive to sleep, yet physical activity is likely to enhance sleep. The sleep of older adults also benefits from social interactions. Sleep medication may be detrimental for the future sleep of older adults.

Across all age groups, more experimental studies are required to investigate casual relationships of protective and risk factors for sleep. Adolescents and young adults are in most need of these studies, as many of the studies among this age group are correlational.

Overview of Chapter 5: Behavioural solutions to improve sleep and mental health in young people

CBT-i and bright light therapies are proven to be efficacious in treating sleep disorders (insomnia and DSWPD, respectively) among adolescents. Sleep hygiene, relaxation therapies and mindfulness may also benefit sleep in young adults. School based interventions, although useful in their ability to reach many students simultaneously, require further development before they are able to consistently alter sleep and mental health in adolescents. Regarding media use, having a bedtime for phones, 1hr before habitual bedtime, increases adolescents' sleep duration. Yet, more studies are warranted in the areas of technology use (and caffeine use) and adolescent sleep and mental health.

A summary of findings for effective strategies is found in Table 5 above.

Implementation of strategies

It is also useful to consider the practical aspects of implementing strategies that have shown to effectively improve sleep. There are benefits and limitations to each strategy (described in Table 2) regarding their implementation, as described below in Table 7.

Table 6: Benefits and barriers for implementing interventions that assist sleep and mental health in adolescents and young adults

Strategy	Training required to administer	Easy to disseminate	Cost	Administration type	Other notes
Cognitive behaviour therapy for insomnia (CBT-i)	+	#	#	Individ./grp /internet	Effective treatment for insomnia/sleep disturbance
Bright light therapy (BLT)	+		#	Individ./grp	Effective for DSWPD
Sleep hygiene	+*	+	Low	Individ./grp /internet	
Other: relaxation, mindfulness	+/–, #	#	#	Individ./grp /internet	Large variation in techniques available
School-based interventions	+	+ (pending school administration/	#	Group	Reach a large number of students simultaneously,

		training of administrator)			capture students who are unaware of sleep problem
Pre-bed phone restriction	–	+	Low	Individ./grp /internet	Low desire to restrict phone use

Notes: DSWPD = delayed sleep-wake phase disorder, Individ. = individual, grp = group, * indicates minimal training required, # indicates dependence on setting/exact techniques implemented, - indicates not present/not required, + indicates present/required

Due to the benefits and pitfalls of each strategy, the circumstances of each situation need to be taken into account before the most appropriate intervention for that situation is administered.

Conclusions

There is a clear link between sleep and mental health: better sleep is generally associated with better mental health. Adolescents may frequently obtain insufficient weekday sleep and may be vulnerable to the effects of chronic sleep deprivation.

Recommendations

1. Adolescents, their families, other caregivers (e.g. teachers), health professionals and policy makers should be educated on the benefits of sleep for good mental health.

2. Interventions should be implemented to improve sleep. For clinical sleep problems, CBT-i and BLT provided by trained health care professionals are likely to be the most efficacious. Yet, other simple, low-intensity interventions may ameliorate these treatments, and may also improve the sleep of young people who do not experience a clinical sleep disorder, yet still experience some aspects of poor sleep (e.g. short sleep duration). These strategies include sleep hygiene, listening to a mindfulness breath-based audio at bedtime, relaxation or listening to classical music, and phone restriction in the hour before bedtime.

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