MYTH OR SCIENCE?
THE IMPORTANCE OF SLEEP QUALITY:
AN INSIGHT INTO THE RELATIONSHIP BETWEEN SLEEP DURATION AND SLEEP QUALITY

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Critical Appraisal

It is four o'clock in the morning and you are still partying with your friends. Suddenly, you realise that it would be wise to go home and get some sleep. After all, you have an important class tomorrow. Three hours later, your alarm clock goes off, you wake up and you miraculously feel fit. Most students are familiar with such a situation. Students tend to love partying through the night, ultimately skipping many hours of sleep. Despite the short night, some of them manage to feel fit after having been deprived of sleep. An incredible feat as one should sleep between 7 and 9 hours every night, according to the American Academy of Sleep Medicine [1]. This discrepancy questions the relationship between sleep duration and sleep quality, which will be explored in this article.

Introduction

According to the American Academy of Sleep Medicine, the recommended sleep duration to achieve optimal health for adults is between 7 and 9 hours [1]. Adolescents should sleep longer, ideally between 8 and 10 hours [1]. The important role of good sleep in optimal health and well-being has been increasingly recognised [2]. However, many people do not get the sleep they need and are thus likely to suffer from suboptimal health. Interestingly, a lot of people still feel tired despite sleeping a sufficient amount of hours. This phenomenon raises the question of how much total sleep time (TST) contributes to the degree of wakefulness after sleep. In this article, we aim to give perspectives on the role of TST in the wakefulness after sleep. To answer this question, we will first explore the concept of sleep quality by analysing the contributing factors. The article will then discuss ways to measure sleep quality and the influence of circadian rhythms. Finally, possible manners of optimising one's sleep will be considered.

Sleep quality

Sleep quality is a widely used concept in both the clinical and research context. Nonetheless, a clear definition is absent [3]. An approach to defining this concept is to self-rate the quality of sleep [3]. However, people are unable to observe their own sleep, as they lose their consciousness during the process. Another approach is to divide sleep quality into objective, measurable components. In 2017, the National Sleep Foundation (NSF) tried this approach and came up with guidelines for sleep quality [3]. The components they found can be divided into three categories: sleep continuity, sleep architecture and naps.

Sleep continuity is comprised of sleep latency, awakenings of more than 5 minutes, wake after sleep onset (WASO) and sleep efficiency. Sleep latency is the time from trying to sleep until sleep onset, with a latency shorter than 15 minutes indicating good sleep [3, 4]. Fewer than two awakenings longer than 5 minutes is considered good sleep [3]. For adults older than 65 years, two awakenings were also deemed acceptable [3]. WASO is the wake time between sleep onset and final awakening, which should be shorter than 20 minutes in order to be considered good sleep [3, 5]. Lastly, sleep efficiency is commonly defined as either the ratio between TST and time in bed or the ratio between TST and time trying to sleep, the latter generally giving a higher ratio [5]. An efficiency above 85 percent was found as an indicator of good sleep quality [3].

The sleep architecture measurements include the time of the TST a person spends in each of the different stages of sleep: rapid eye movement (REM) and three stages of non-rapid eye movement (N1-3) sleep. For adults, good sleep should be comprised of 21 to 30 percent REM sleep [3]. N1 sleep should be less than 5 percent of TST and N3 sleep should be 16 to 20 percent of TST [3]. N2 sleep is not an indicator of good sleep, but more than 81 percent of N2 sleep indicates bad sleep quality [3]. The percentages differ per age group.

In the third category the naps per 24 hours, nap duration and nap frequency are investigated. Naps are episodes of sleep outside the principal sleep period. For school-children and young adults, no naps indicate good sleep quality but for teens one nap does [3]. For all age groups taking more than four naps a day is not considered good sleep quality [3]. A nap duration shorter than 20 minutes indicates good sleep quality but a duration longer than 100 minutes does not [3]. Naps can be an indicator of bad sleep, but can be present in people with good sleep quality.

Although not mentioned in the NSF recommendations, TST is also often considered as a part of the objective components of sleep quality. Hirshkowitz *et al.* acknowledged the importance of sufficient sleep duration, stating that an adult needs 7-9 hours per night, decreasing with age [6]. The before mentioned recommendation from the American Academy of Sleep Education mentions the same numbers [1]. Importantly, the necessary duration of sleep varies per individual [6]. Alertness during the day indicates sufficient sleep duration [6]. In certain individuals, 6 hours can be enough sleep [6].

Measuring sleep quality

The use of polysomnography (PSG) dates as far back as 1937 when the first sleep recording, using an electroencephalogram (EEG), was published [7]. PSG measures neurophysiologic, cardiopulmonary and other physiologic parameters during sleep. A standard PSG includes EEG, electrooculography, electrocardiography, and electromyography of the chin [7]. In certain diseases such as obstructive sleep apnea, central sleep apnea and periodic limb movement, clinical applications including recordings of airflow, respiratory effort, limb electromyography and oxygen saturation can be measured as well [7]. PSGs are mainly used to diagnose sleep-related breathing disorders, such as obstructive sleep apnea and central sleep apnea [8]. It can also be

used to diagnose sleep-related seizures, periodic limb movement disorder and parasomnias.

The main downside to PSG is its limited use outside of the laboratory, as a sleep technologist is required to set up equipment and apply electrodes to the patient [9]. This limitation led to the development of alternatives. Wrist actigraphy is the most frequently employed alternative for PSG. However, there are also several wearable EEG systems [9]. Actigraphy uses activity trackers containing accelerometers that record movement of the wrist at regular intervals. Using this data, sleep/wake status can be estimated. Kosmadopoulos *et al.* showed that, compared to PSG, wrist actigraphy is more suitable for predicting sleep but not wake [10]. The EEG systems could in theory be more accurate than actigraphy as they can also measure biosignals like heart rate and temperature, along with activity [11]. However, more research is needed to fully adopt these devices [11].

In 1989, Buysse *et al.* developed the Pittsburgh sleep quality index (PSQI) [12]. This self-rated questionnaire, used to assess sleep quality, is comprised of 19 questions for the patient and five questions for the roommate or bed partner. These 19 questions assess a wide variety of sleep quality related factors, including estimates of sleep duration and latency, and the frequency and severity of sleep-related problems [12]. The score of the PSQI ranges from 0 to 21, retrieved by grouping the 19 items into seven component scores, each getting a score from 0 to 3. The lower the score, the better the sleep quality. In their research, Buysse *et al.* showed that the PSQI was easy to use, stable over time and can discriminate patients from controls [12]. A meta-analysis from 2016 acknowledged the PSQI as the only standardised clinical instrument to assess a wide range of factors relevant to sleep quality [13].

Lastly, smartphone applications are increasingly used across the world. In 2014, Sleep Tracker and Alarm Clock were the most downloaded applications on iPhones, with over 500 applications available in the app store [14, 15]. Bhat *et al.* found that these applications are as good as PSG in the detection of sleep time, but are less precise in distinguishing the different stages of sleep [16]. Furthermore, compared to actigraphy, the applications are more sensitive to changes in the environment, such as the presence of a partner or the place of the smartphone on the mattress [15].

Influence of the timing of waking up

The circadian clock plays a crucial role in several processes in the body to ensure appropriate body function during the different hours of the day [17]. The circadian rhythm is regulated by a brain region called the suprachiasmatic nuclei [18]. Sleep is one of the components regulated by this internal clock. Light is the best known external regulator of the rhythm [19]. There is a spectrum of different chronotypes, ranging from early types on the one end to late types on the other end, which varies among individuals [17]. These chronotypes influence our body's ideal bed and wake times and are determined genetically [20]. This can lead to several problems in our 'nine to five society' as the chronotype of the individual might not align with the demands of society. It is possible to shift the circadian rhythm by regulating one's exposure to light and can be severely disrupted by changes in light exposure [17]. Low light levels in nursing homes, severe eye damage such as blindness and working night shifts are a few examples [21-23].

Creating conditions for optimal sleep

The recent guidelines from the NSF suggest that sleep quality can be improved at all ages by improving sleep continuity (decreasing sleep latency, nighttime awakenings and WASO) and sleep efficiency [3]. In contrast, the influence of sleep architecture and naps on sleep quality is less clear [3]. Healthy sleep habits (Figure 1) are of value in optimising good sleep quality [24]. The sleep environment should be cool, dark and comfortable [25, 26]. A regular sleep/wake schedule, in which consistent

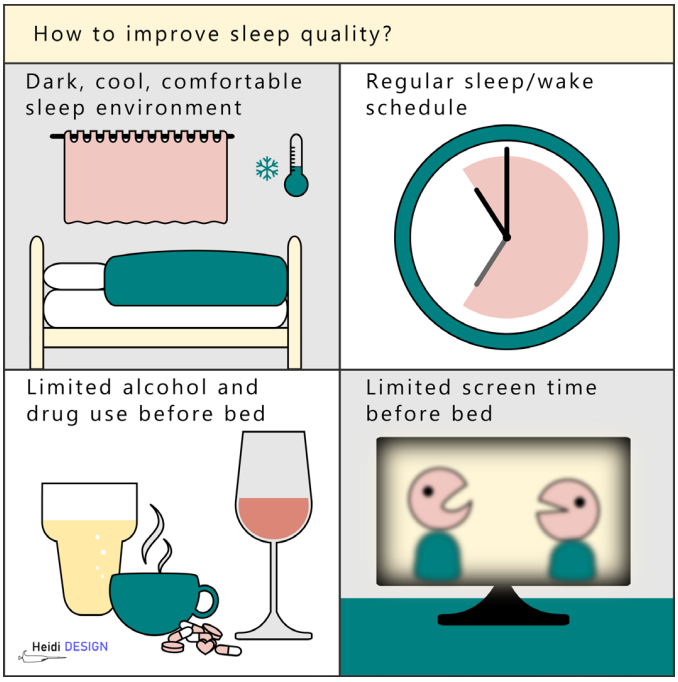

Figure 1: Factors that improve sleep quality
Sleep quality can be improved by changing one's sleep habits. The conditions for healthy sleep include: a dark, cool and comfortable sleep environment; a regular sleep/wake schedule; limited use of alcohol and drugs before bed; and limited screen time before bed.

wake times is the most important, aids to good sleep quality [24, 27]. Substance use, such as caffeine and alcohol, should be limited some hours before bed (3-7 hours for caffeine and 3-4 hours for alcohol), as they can interfere with sleep [28, 29]. Screen use 1-2 hours before bed can influence melatonin release and should thus be avoided [30]. Improvements in sleep duration and quality appear to improve reaction time, accuracy, and endurance performance [31]. In contrast, poor sleep may increase the risk of injury and illness, and may undermine overall health [31].

Conclusion

To conclude, sleep duration is an important part of good sleep and one should aim for around 7 to 9 hours per night. However, sleep quality is more than that. Sleep continuity, sleep architecture and the number of naps are important indicators as well. Sleep can be measured objectively via PSG and actigraphy and subjectively via the PSQI. Smartphone applications are very popular for measuring sleep, but are not yet as accurate as the other methods. Wakefulness can also be influenced by disruptions in the circadian rhythm, which is the internal clock of the body. Sleep quality can be increased by improving sleep continuity and efficiency as well as by adopting healthy sleep habits. Thus, to feel awake in the morning, one should take into account more than just sleeping for 8 hours each night.

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