

Editorial

Adolescents and Emerging Adults' Sleep Patterns: New Developments

Over the last three decades, researchers have established an increasingly more nuanced understanding of adolescents' sleep demands, circadian timing, underlying bioregulatory processes, and environmental constraints [1–5]. Studies have also documented the clear consequences of insufficient and inconsistent sleep for developing adolescents, such as poor academic performance and school absenteeism, drowsy-driving accidents, substance abuse, and emotion regulation difficulties [6–10]. This critical area of adolescent health research has also started to inform policy from school start times to drivers' education programs [11–15]. Yet, at this juncture, additional and new questions arise. In this issue of the *Journal of Adolescent Health*, researchers investigate two understudied areas—predictors of sleep difficulties in older adolescents or emerging adults, and teenage athletes' sleep patterns and daytime functioning [16,17].

As Lund *et al* point out, few carefully designed studies have captured and articulated college-age adolescents or emerging adults' changing sleep patterns [16]. The end of adolescence is defined and/or measured by a complexity of physical, psychological, social, and cognitive measures. One developmental aspect of adolescence involves the capacity to stay up late and to sleep in or delay wake time. Roenneberg *et al* queried a large sample of 8–90-year olds regarding their sleep/wake schedules and calculated the average “mid-point” of each person's sleep duration, or the time half way between when they go to sleep and when they wake up [18]. They found that children and adolescents slept increasingly later until the age of approximately 20, when there is an abrupt shift in sleep schedules. After age 20, Roenneberg *et al* found that the mid-point times became increasingly earlier again [18]. Although this is cross-sectional data, it suggests that the timing of sleep changes over the course of emerging adulthood.

A small number of studies have examined sleep/wake patterns over the transition from high school to college. In a brief report, Carskadon and Davis surveyed close to 1000 undergraduate students in the spring before entering college, and again during the first fall semester [19]. These preliminary findings showed a significant pattern of sleeping less and delaying nighttime sleep by about 2 hours across the tran-

sition to college. Pilcher *et al* documented that sleep habits are one of the first daily habits to change for first-year college students, and other studies found that college students, in general, exhibit irregular sleep-wake cycles with bedtime delays on weekends and short sleep durations on weekdays [20–23]. Moreover, college students today are getting less sleep than students in the past, and a high proportion of students suffer from a number of sleep problems. National surveys of undergraduates, for example, have shown a steady decline in median hours of sleep reported: from 7.75 in 1969 to 6.65 in 2001, with first and second year students reporting less time in bed because of earlier wake times and more erratic sleep-wake schedules [24–26]. In addition, in recent surveys nearly 75% of college students reported occasional sleep problems such as difficulty falling asleep, sleep disturbances, delayed sleep phase syndrome, and excessive daytime sleepiness [27–29].

Just over a decade ago, the National Institutes of Health recognized adolescents and emerging adults (ages: 12–25 years) as a population at high risk for problem sleepiness based on “evidence that the prevalence of problem sleepiness is high and increasing with particularly serious consequences” [30]. However, relatively little systematic sleep research has focused on this critical developmental time-emerging adulthood.

A well-designed study of over 1000 undergraduates' sleep-wake patterns and emotional well being by Lund *et al* helps fill in some of the gaps in our knowledge, regarding emerging adults' sleep and daytime functioning [16]. First, their results demonstrate that the serious problem of insufficient and erratic sleep in middle and high school age adolescents does not come to an end with graduation, but continues into the college or emerging young adult years [16]. Second, in comparing their first-year college students to the high school students surveyed in the 2006 National Sleep Foundation Sleep in America Poll or other previous studies of high school age adolescents, weeknight bedtimes and rise times appeared to be 1 hour 15 minutes later [16,31,32]. Yet, first year students had significantly later bed and rise times than older third and fourth-year college students [16]. This is a striking finding as it is in keeping with Roenneberg's

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work described earlier. After age 20, Roenneberg *et al* found that mid-point times became increasingly earlier again; in other words, sleep schedules seem to become increasingly more delayed over the course of adolescence, yet this pattern seems to change by the third or fourth year of college—which generally corresponds to about ages 20–22 [18]. These striking cross-sectional findings suggest a developmental change; however, they clearly need to be examined further, using a longitudinal study design and more objective measures such as polysomnography, actigraphy, salivary melatonin. Third, Lund *et al* evaluated the factors that might predict sleep quality in this sample of college students, using measures of mood, perceived distress, and substance use [16]. As the authors discuss themselves, college students overwhelmingly reported that academic and emotional stress were significantly associated with poor sleep quality. Perceived stress accounted for significantly more of an impact on sleep than caffeine and alcohol use, exercise frequency, or computer/television use. Other studies have found that insufficient sleep and poor sleep quality are associated with stress, negative mood, and difficulties with stress management [32–35]. The transition to college may be particularly stressful for emerging adults, and developing sleep patterns may be one of the first daily habits to change for many first-year college students [26,36]. As Lund *et al* point out in the discussion of their findings, the stressors of the college years, particularly early on, may serve as “predisposing, precipitating, and perpetuating factors” for sleep problems at a time when stable, less delayed sleep-wake schedules are still emerging [16].

The other study published in the current issue of this Journal examines a countermeasure to stress for adolescents—exercise [17]. As the authors note, exercise and/or sports participation are often positively connected to psychosocial well being and stress reduction in adults, as well as adolescents [37–39]. Likewise, in Driver and Taylor’s review, they argue that although only moderate effect sizes have been noted, meta-analyses demonstrate that exercise increases total sleep time, delays rapid eye movement onset, increases slow-wave sleep, and reduces rapid eye movement sleep [40]. The sleep-promoting efficacy of exercise in adults or adolescents, however, has yet to be established. Brand *et al* compared 258 high school-age, Olympic-quality athletes, with 176 controls on their sleep patterns, exercise, and psychological well being, using prospective logs and self-report questionnaires [17]. The adolescent athletes reported healthier sleep quality, shorter sleep latencies, fewer nighttime awakenings, less daytime sleepiness, and better concentration in comparison to the controls. In addition, the athlete group experienced less anxiety and depressed mood [17].

In keeping with Lund *et al*, Brand *et al* findings indicate that being an athlete who exercises regularly and, as a result, reports lower levels of anxiety and stress, seems to predict higher quality sleep-wake patterns and less daytime sleepiness [16,17]. Both of these timely studies highlight the important stress-coping-sleep relationship for high-school

and college-age adolescents. As these two research groups suggest, however, it is still unclear as to how stress is related to sleep and why significant exercise might be beneficial to an adolescent’s sleep. For example, in the case of stress, sleep restriction and poor sleep quality appear to be associated with increased cortisol levels [41,42]. In particular, the over-activation of the hypothalamic-pituitary-adrenal axis may represent a negative means of coping with stress, which may explain sleep disruptions and irregular sleep patterns, perhaps because allostatic load may prevent adaptive sleep regulation [34,42]. Adolescents with increased sleep disruptions, shorter sleep duration, later bedtimes, and poorer sleep quality have higher levels of afternoon cortisol and exaggerated cortisol responses to acute lab stressors compared to those with better sleep patterns [34,43]. Few studies have examined the relationship between actigraphically estimated sleep patterns and cortisol in college students, a particularly stressful developmental period where sleep requirements are often not met. In fact, in recent pilot data from our laboratory, we found that inadequate actigraphically estimated sleep, delayed schedules, and weekly irregularity were connected to higher salivary cortisol levels [44]. Less desirable health behaviors, such as insufficient sleep, may alter emerging adults’ stress response, or lead to increased cortisol output, which may be associated with sleep-wake dysregulation.

Coming from different angles, both of these studies point out that the relationship between stress, coping strategies, and sleep remains unclear and may be crucial to understanding how older adolescents successfully regulate their sleep/wake patterns over the emerging adulthood transition. On the one hand, stress may alter sleep, yet sleep may represent an attempt to counteract the negative effect of stress [45]. Furthermore, health-coping strategies, such as exercise, may mediate the stress-sleep relationship. Finally, researchers, educators, and health care providers need to better understand the developmental trajectory of sleep and circadian timing over the late adolescence-emerging adulthood years.

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