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SPORT AND EXERCISE PSYCHOLOGY

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Sleep and lucid dreaming in adolescent athletes and non-athletes

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ABSTRACT

During lucid dreaming (LD), dreamers are aware of experiencing a dream and may consciously influence its content. This study used an online questionnaire to investigate the LD frequency and applications in 193 adolescent athletes and non-athletes (17.40 ± 2.09 years; 46% athletes, 54% controls). Given the critical role that sleep plays in adolescent health, development, and performance, associations of LD with various sleep parameters were also explored. LD is prominent in adolescents (67.4% experienced it at least once, 30.0% once a month or more, 12.9% at least once a week), but similar in terms of frequency and uses between athletes and non-athletes. A higher proportion of those who practiced sports/dance during LD reported improved waking self-efficacy (57.1%) over sport performance (42.9%). There was no indication that chronotype preference may influence LD nor that LD may be detrimental to adolescent sleep. Athletes and controls had similar sleep durations, daytime sleepiness, and sleep disturbances frequency, but athletes reported higher sleep quality. Despite, on average, meeting the minimum sleep recommendation guidelines for their age, a relatively large proportion of adolescents did not attain sufficient sleep, particularly on weeknights (47.4% 14–17 years; 20.0% 18–21 years), suggesting that restricted sleep remains prevalent in adolescent populations.

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Lucid dreaming; sleep; youth; youth athlete; performance; application

Main text introduction

During lucid dreaming (LD), dreamers are aware of experiencing a dream and may influence oneiric content (LaBerge, 1985). While research on LD has primarily centred on adult populations, its prevalence, uses, and implications for adolescents, particularly within the context of youth sports, remain largely unexplored. This study seeks to bridge this gap by investigating the LD behaviours and its associations with several sleep-related metrics including duration, quality, and daytime sleepiness in adolescent athletes and their aged-matched controls.

Approximately 55% of the general population experiences at least one lucid dream in their lifetime and 23% are frequent lucid dreamers (i.e., they lucid dream once a month or more) (Snyder & Gackenbach, 1988) (Saunders et al., 2016). Children and adolescents typically experience higher frequencies, suggesting a link between LD and brain maturational processes (Voss et al., 2012). Lucid dreams often originate spontaneously (Stumbrys et al., 2014) but can also be induced via induction methods (Tan & Fan, 2022). LD has clinical and practical applications, including nightmare treatment (Ouchene et al., 2023), alleviating insomnia (Ellis et al., 2021), creative problem-solving (Stumbrys & Daniels, 2010), and training motor skills (Bonamino et al., 2023a). Typically, lucid dreamers prioritise fun and pleasure during LD over more practical applications (Schädlich & Erlacher, 2012; Stumbrys & Erlacher, 2016). Similarly, a relatively small percentage of athletes use LD to practice sports skills (Daniel et al., 2022; Erlacher et al., 2012).

Concerns have emerged regarding the potential adverse effects of LD on sleep quality (Soffer-Dudek, 2020; Vallat & Ruby, 2019). Some LD induction techniques promote sleep interruption and fragmentation. In the Wake-up-Back-To-Bed (WBTB) method, for example, one wakes early in the morning and returns to sleep after a period of wakefulness (Tan & Fan, 2022). Sleep fragmentation can be detrimental to sleep architecture and sleep quality (Benkirane et al., 2022). Some evidence suggests a weak association between deliberate LD induction and poorer sleep quality (Aviram & Soffer-Dudek, 2018). Other studies show no link (Bazzari & Bazzari, 2022; Ribeiro et al., 2020; Stumbrys, 2023), particularly when controlling for nightmare frequency (Schadow et al., 2018). This suggests that the poorer sleep quality may be attributed to the nightmares commonly experienced by lucid dreamers (Stumbrys et al., 2014), rather than LD itself. Existing evidence, however, predominantly draws from adult samples, leaving this relationship less understood in adolescent populations. Since younger populations heavily rely on adequate sleep for their development, functioning, and well-being (Owens & Weiss, 2017), and given the higher LD frequencies in young people, understanding whether adolescents engaging in LD practices may be at risk of poor sleep is important.

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Maladaptive sleep behaviours, such as irregular sleep schedules and insufficient sleep, have been linked to various adverse outcomes, including increased daytime sleepiness, poorer psychological and physical health, higher injury risks, impaired recovery, and reduced cognitive, academic, and sport performance (Fox et al., 2020; Owens & Weiss, 2017). Adolescence is marked by natural shifts in sleep-regulating mechanisms, causing a greater physiological propensity towards later bedtimes and expression of evening-chronotype behaviours (Crowley et al., 2018). Chronotype reflects the intra-individual differences in one's preferred timing of sleep and activity (Montaruli et al., 2021) and may be linked to LD frequency. Morning-chronotypes peak in mental and physical performance in the early part of the day, evening-types in the latter (Montaruli et al., 2021). This characteristic may make morning-chronotypes more susceptible to LD, given that it frequently occurs towards the end of sleep episodes (LaBerge et al., 1986) and that it is characterised by increased activation of cortical areas associated with self-reflection and meta-cognition (Dresler et al., 2012). Further, morning-types exhibit higher dream recall (Schredl & Göritz, 2020), also positively correlated with LD frequency (Stumbrys, 2023). Conversely, evening chronotypes are more prone to snoozing alarms (Mattingly et al., 2022), a behaviour that has also been associated with LD frequency, potentially due to the resulting brief awakenings mimicking WBTB induction methods (Smith & Blagrove, 2015). Associations between LD and chronotype preference are, however, unexplored.

The shift in sleep timing that occurs in adolescents, driven by changes in sleep regulating mechanisms and social and environmental factors, becomes problematic when young people are required to meet strict early school times, meaning they may struggle to attain sufficient sleep. Student-athletes also face additional psychological and sporting pressures that may further disrupt their sleep-wake cycles (Fox et al., 2020; Van Rens et al., 2016). Compared to their non-athletic counterparts, young athletes are expected to excel both at school and in their sport, may experience pre-competition anxiety, and are often required to wake earlier or go to bed later to attend training sessions or competitions. These factors often come at the expense of adequate sleep duration and quality, resulting in poor sleep in both adolescents (Owens & Weiss, 2017) and young athletes (Fox et al., 2020).

Sleep loss has a direct impact on athletic performance and athlete's health and recovery. This includes delayed reaction times, impaired learning and memory consolidation, decision-making, and coordination, reduced time to exhaustion and time to task failure, increased perceived effort, fatigue, and pain scores, and overall decreased sport-specific and physical performance (Charest & Grandner, 2022; Coel et al., 2023; Walsh et al., 2021). Inadequate sleep negatively affects recovery processes, hindering cell growth and repair, hormone regulation, and immune functions, thereby increasing injury risks and prolonging recovery (Charest & Grandner, 2022; Coel et al., 2023). Psychologically, sleep loss can lead to mood disturbances, elevated stress levels (Charest & Grandner, 2022) and can contribute to overtraining (Patel et al., 2024) and burnout (Granz et al., 2019), all of which can further affect sport performance. Conversely, extended sleep can yield positive effects on sport performance including reaction time, sport-specific skill execution and physical performance (Cunha et al., 2023).

Evidence on the prevalence and use of LD predominantly draws from adult samples, with limited attention given to younger populations. Further, a direct comparison of these traits between athletes and non-athletes remains unexplored. The crucial role sleep plays in adolescent health and performance also calls for a need to explore the potential effects of LD on the sleep of younger populations. This study used an online survey to examine these domains in a sample of adolescent athletes and non-athletes, and assessed chronotype preference as a potential influencing factor for LD.

Methods

Participants

The sample consisted of 193 adolescents aged 17.40 ± 2.09 years (range: 14–21 years) (45.6% male, 52.3% female, 2.1% other). Adolescents aged 14–21 years, without injury or illness that would prevent their day-to-day activities, training, or competing for longer than two weeks were included. Those with a history of sleep or psychiatric disorders, use of medications with sleep-related side effects, and with illicit drug use or other health concerns were excluded.

Participants were predominantly Australian (86.5%), with smaller proportions from other countries: UK (3.6%), New Zealand (3.1%), Singapore (2.1%), Netherlands (1%), China (0.5%), Egypt (0.5%), Hong Kong (0.5%), Japan (0.5%), and Papua Guinea (0.5%). The control group accounted for 54% of the sample (17.64 ± 2.12 years, range 14–21 years), and the athlete group for 46% (17.15 ± 2.04 years, range 14–21 years). Athletes participated in various individual and team sports, including athletics, Australian rules football, rock climbing, swimming, and volleyball. Dancers participated in several styles, including ballet, contemporary dance, and jazz. The athlete and control group did not differ with respect to age ($t(191) = 1.63$, $p = .11$) or gender ratio ($\chi 2 = .09$, $p = .76$) (gender "other" excluded due to low case count; <5).

Measures

Lucid dreaming behaviours

Participants estimated their dream recall frequency using a seven-point scale (0 = never, 1 = less than once a month, 2 = about once a month, 3 = twice or three times a month, 4 = about once a week, 5 = several times a week and 6 = almost every morning) (Schredl, 2004) and their nightmare and LD frequency using an eight-point scale (0 = never, 1 = less than once a year, 2 = about once a year, 3 = about two to four times a year, 4 = about once a month, 5 = about two to three times a month, 6 = about once a week, 7 = several times a week). Stumbrys et al., (2013) Class means were converted to obtain dream recall frequency in units of mornings per week (Schredl, 2004) and number of lucid dreams and nightmares per month. Stumbrys et al., (2013) Both scales are considered reliable measures for assessing individual differences in dream recall

(Schredl, 2004), and LD and nightmare frequency (Stumbrys et al., 2013). To ensure understanding, a definition of a lucid dream was also included (see Appendix).

Participants who had experienced at least one lucid dream were asked about the nature of their lucid dreams, i.e., whether they were spontaneous or deliberately induced. They also indicated whether they were aware of the practical potentials of LD, namely that LD can be used to rehearse skills or solve waking problems. Further, they reported what purposes they typically used LD for. Seven categories were provided, with one open-ended option to specify additional applications: (1) change a nightmare into a more pleasant dream (e.g., by confronting your attacker, transforming your attacker into a different dream character); (2) practice a particular dance or sport-related skill, movement, or strategy (e.g., dance movement, performance rehearsal, basketball free throw, offence or defence strategy); (3) practice other non-dance or non-sport related skills (e.g., musical instrument, presentation); (4) come up with new and creative ideas or insights (e.g., drawings, paintings, texts, musical pieces); (5) solve a particular problem (e.g., academic or work-related, conflict with others); (6) Have fun (e.g., fly, dance, play); (7) watch the dream passively (e.g., do nothing and simply observe the dream). Those who reported using LD to rehearse sports/dance also indicated whether they perceived improvements in waking sport performance and self-efficacy following LD practice.

Sleep parameters

Participants reported their habitual time in bed and time awake for every day of the week and indicated their average sleep latency (0 = 15 min or less; 1 = 16–30 min; 2 = 31–60 min; 3 = 60 min or longer) which was converted to minutes to sleep onset (0 = 7.5; 1 = 23; 3 = 45; 4 = 60). Total sleep time (TST) for every day of the week was estimated using time awake, time in bed from the previous night, and average sleep latency. Satisfaction with sleep quality (0 = very dissatisfied; 1 = somewhat satisfied; 3 = neither satisfied nor dissatisfied; 4 = somewhat satisfied; 5 = very satisfied) and weekly frequency of sleep disturbances (0 = never; 1 = less than once a week; 2 = once or twice a week; 3 = 3–4 times a week; 4 = 5–6 times a week, 5 = every night) were also assessed. Chronotype was measured using the reduced Horne and Östberg Morningness – Eveningness questionnaire (rMEQ) (Adan & Almirall, 1991), a 5-item questionnaire with satisfactory external validity in assessing chronotype preference in adolescent populations (Tonetti et al., 2024).

Daytime sleepiness was measured using the Cleveland Adolescent Sleepiness Questionnaire (CASQ) (Spilsbury et al., 2007), a 16-item Likert-type scale that assesses excessive daytime sleepiness in adolescents aged 11–17 years. Participants rated each item based on how they would typically feel during a usual week. CASQ total score (the higher the score the more excessive the daytime sleepiness) is measured as the sum of two elements: a degree of sleepiness (the higher the score, the higher the sleepiness) and a degree of alertness (the higher the score, the lower the alertness). Participants aged 14–17 years completed the original CASQ, and those aged 18 years or older used adapted versions (see Appendix). Cronbach's alpha for CASQ's degree of sleepiness was .84 and .88 for degree of alertness, suggesting acceptable internal consistency.

Procedures

Participants were primarily recruited through social media advertisements (from 11 to 25 November 2020) and a smaller proportion from national sporting organisations and Brisbane-based private schools with high-level sports programmes. They were assigned to the athlete group if they competed in their sport at a state level or higher or if they participated in dance for 20 or more hours per week. Otherwise, they were assigned to the control group.

Participants completed an online survey between August 2020 and October 2021. Before publishing the survey, the item's pool reading proficiency was estimated using the Flesch-Kincaid Grade Level readability test on Microsoft Office Word for Mac (Version 16.37). Results indicated suitability for children aged approximately 12 years, making the survey appropriate for the population studied (14–21 years old). To ensure understanding, six adolescents (five females, one male) aged 13–17 years read out loud each item and explained their understanding to the first author. Items were rephrased as necessary and the reading proficiency of the survey was re-assessed, remaining appropriate for 12-year-olds. Consent procedures included signed consent forms or affirming voluntary participation to partake in the study at the start of the survey (with parental/guardian consent also obtained if underage). The study was approved by the Human Ethics Committee of the affiliated university.

Data analysis

Data analysis was conducted on IBM SPSS (Version 28). Group differences were examined via independent sample t-tests for continuous variables (age, TST, CASQ scores), Mann-Whitney U tests for ordinal variables (LD frequency), and chi-square for categorical variables (LD applications, perceived sleep quality, sleep disturbances frequency). Cohen's d and Cramer's V are also reported. The gender "other" was excluded from all gender analyses due to low case count (<5). Kendall's tau was used to assess correlations in non-parametric variables (e.g., LD frequency). Due to the restricted sample size, it was not possible to explore correlations between LD frequency and chronotype preference nor to evaluate differences in LD applications across the entire LD frequency range. Differences in chronotype and LD applications were examined between frequent (LD frequency of once per month or more) and infrequent lucid dreamers (less than once a month) with chi-square. LD frequency correlations and chronotype analyses were conducted within the LD sub-sample only (i.e., consisting of participants who experienced at least one lucid dream).

Sleep health was compared between frequent, infrequent, and non-lucid dreamers using one-way ANOVA in continuous variables, and chi-square in categorical variables. Paired sample t-tests were used for week and weekend TST comparisons, and one-sample t-tests to compare participants' TST with the minimal sleep recommendations guidelines (8 h for 14–17 years, 7

Table 1. Relative lucid dreaming frequency.

Category	Relative frequency (%) Whole Sample (N = 193)	Athletes (n = 88)	Controls (n = 105)	14-17 years (n = 99)	18-21 years (n = 94)
Never	32.6	36.4	29.5	38.4	26.6
Less than once a year	16.1	15.9	16.2	12.1	20.2
About once a year	5.2	5.7	4.8	9.1	1.1
About two to four times a year	16.1	18.2	14.3	18.2	13.8
About once a month	9.3	8	10.5	10.1	8.5
About two or three times a month	7.8	6.8	8.6	4	11.7
About once a week	6.2	4.5	7.6	4	8.5
Several times a week	6.7	4.5	8.6	4	9.6

h for 18–25 years). Hirshkowitz et al., (2015) Significance was set to $p < .05$.

Results

Lucid dreaming frequency

Table 1 shows the relative LD frequency for the whole sample, for the athlete and control group, and the younger (14–17 years) and older (18–21 years) subsample. Overall, out of 193 participants, 67.4% experienced a lucid dream at least once in their lifetime, 30.0% were frequent lucid dreamers and 12.9% lucid dreamed once a week or more. On average, participants experienced 1.56 ± 3.25 nightmares per month (median: 0.25; IQR: 2.42) and 1.80 ± 4.5 lucid dreams per month (median: 0.08; IQR: 1.00), whereas dream recall was 2.16 ± 2.04 mornings per week (median: 1.00; IQR: 2.88).

The non-LD subsample (i.e., participants who have never experienced LD) consisted of 63 adolescents (49.2% athletes, 50.8% controls) aged 17.03 ± 2.01 years (range 14–21 years) (49.2% male, 49.2% female, 1.6% other). The LD subsample consisted of 130 adolescents (43.1% athletes, 57.0% controls) aged 17.60 ± 2.02 years (range 14–21 years) (43.8% male, 53.8% female, 2.3% other). On average, they experienced 1.81 ± 3.56 nightmares (median: 0.25; IQR: 2.42) and 2.67 ± 5.28 lucid dreams (median: 0.25; IQR: 2.42) per month and recalled dreams 2.48 ± 2.12 mornings per week (median: 1.00; IQR: 2.88). Overall, participants generally experienced spontaneous lucid dreams (36.2% only spontaneous; 25.4% mostly spontaneous; 17.7% about the same; 14.6% mostly intentional; 3.1% only intentional) and were mostly unaware of the potentials of LD (55.4% vs 44.5%).

LD frequency did not differ between athletes and controls ($U = 1823.00$, $Z = 1.19$, $p = .23$, $r = .10$), and male and female lucid dreamers ($U = 1874.50$, $Z = .60$, $p = .55$, $r = .13$). It correlated positively with age ($\tau = .15$, $p = .03$), dream recall ($\tau = .32$, $p < .001$) and nightmare frequency ($\tau = .18$, $p = .08$). The correlation coefficient between LD frequency and dream recall lowered, but remained significant when controlling for nightmare frequency ($\tau = .30$, $p < .001$). There were no chronotype differences between frequent and infrequent lucid dreamers (χ^2 (2) = .21, $p = .90$, Cramer V = .04).

Lucid dreaming applications

Table 2 shows the frequency of LD applications, separately for athletes and controls, and for the younger and older subsample. Overall, the most frequent application was passive watching (67.5%), followed by having fun (43.1%), nightmare treatment (42.3%), problem-solving (26.0%), creativity (20.3%), practising sport/dance skills (17.1%) and practising non-sport /non-dance skills (5.7%). The open-ended option retrieved no additional uses of LD, as participants' responses already fell within the pre-defined categories and were thus assigned accordingly. For instance, "Inserting myself into stories, particularly fantasy" and "Having sexual interactions" were assigned to having fun.

Table 3 shows the group, gender, age, and LD frequency differences per LD application type. No differences were found between the athlete and control group nor were there any age or gender differences. When comparing athletes and controls, the category "Practising sport/dance skills" was excluded from the analysis due to a technical issue with the survey that caused the category being displayed to only approximately one-third of the control sample. Compared to infrequent lucid dreamers, frequent lucid dreamers were more likely to use LD to solve waking problems. No other differences were observed for the remaining applications.

Table 2. Frequency of lucid dreaming applications.

Category	Relative frequency (%) LD subsample (n = 123)	Athletes (n = 53)	Controls (n = 70)	14-17 years (n = 59)	18-21 years (n = 64)
Passive watching	67.5	69.8	65.7	67.8	67.2
Having fun	43.1	34.0	50.0	37.3	48.4
Nightmare	42.3	41.5	42.9	42.4	42.2
Problem solving	26.0	28.3	24.3	28.8	23.4
Creativity	20.3	22.6	18.6	22.0	18.8
[a]Practising sport/dance skills	17.1	28.3	8.6	22.0	12.5
Practising non-sport/non-dance skills	5.7	7.5	4.3	5.1	6.3

LD subsample = Lucid dreaming subsample.
[a]Due a technical issue, this application category was only displayed to approximately 1/3[rd] of the control sample.

Table 3. Group, gender, age and lucid dreaming frequency differences per lucid dreaming application type.

	Group		Gender		Age		LDF[b]	
Category	χ^2	Cramer V	χ^2	Cramer V	t	Cohen d	χ^2	Cramer V
Passive watching	0.23	.043	0.32	.05	0.88	.17	0.22	.04
Having fun	3.16	−.16	3.17	−.16	−1.30	.23	1.1	.01
Nightmare	0.02	−.01	0.43	−.06	−0.31	−.06	0.73	.08
Problem solving	0.25	.05	0.59	−.07	−0.18	−.04	5.02*	.20*
Creativity	0.31	.05	0.39	−.06	1.02	.23	0.03	−.02
Practising sport/dance skills	-	-	0.001	−.003	1.54	.37	1.52	−.11
Practising non-sport/non-dance skills	0.60	.07	0.65	−.07	−0.003	−.001	0.4	.06

LD subsample = Lucid dreaming subsample; LDF = Lucid dreaming frequency.
[a]Due to low case count, differences in application types were assessed between frequent and infrequent lucid dreamers (i.e., once a month or more and less than once a month, respectively).
**p*<.05.

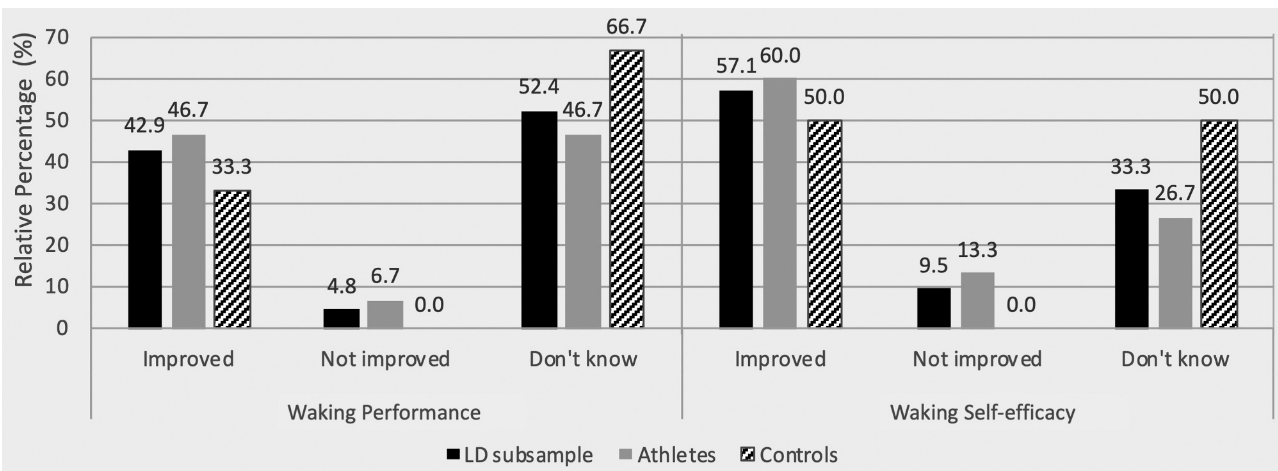

Figure 1. Perceived waking sport/dance performance and self-efficacy following lucid dreaming practice of sports/dance skills. Noted to the right of each bar is the percentage of participants not attaining the minimum sleep recommendation guidelines for their age (8 h for 14-17 years of age, and 7 h for 18-21 years of age) (Hirshkowitz et al., 2015).

Figure 1 depicts participants' reports of waking performance and self-efficacy, in executing sport/dance skills after rehearsing them in a lucid dream, separately for athletes and controls.

Lucid dreaming and sleep parameters

Frequent, infrequent, and non-lucid dreamers did not differ in TST ($F(2, 176) = 0.76$, $p = .47$, $\eta^2 = .01$), CASQ total scores ($F(2, 155) = 2.12$, $p = .12$, $\eta^2 = .03$), CASQ degree of sleepiness ($F(2,155) = 2.63$, $p = .08$, $\eta^2 = .03$), and CASQ degree of alertness ($F(2, 155) = 1.37$, $p = .26$, $\eta^2 = .02$).

Female lucid dreamers had higher CASQ total scores, higher CASQ degree of alertness, and poorer perceived sleep quality than males, but similar TST, CASQ degree of sleepiness, and frequency of sleep disturbances, while age was positively correlated with perceived sleep quality (Table 4). LD frequency was not correlated with any sleep health parameters, namely TST ($\tau = .04$, $p = .54$), CASQ scores ($\tau = .11$, $p = .29$) (when controlling for gender), CASQ degree of sleepiness ($\tau = .01$, $p = .19$), CASQ degree of alertness ($\tau = .13$, $p = .20$) (when controlling for gender), perceived sleep quality ($\tau = .10$, $p = .30$) (when controlling for gender and age), and sleep disturbances frequency ($\tau = .03$, $p = .75$) (when controlling for age).

Adolescent sleep

TST was longer on weeknights compared to weekends, both for athletes (+43.96 min, $t(83) = 5.75$, $p < .001$; Cohen $d = .63$) and controls (+41.68 min, $t(94) = 5.26$, $p < .001$; Cohen $d = .54$). Athletes and non-athletes did not differ in weeknight TST, weekend TST, CASQ scores, and sleep disturbances frequency, but athletes had higher sleep quality (Table 5).

One-sample t-tests indicated that participants exceeded the minimum sleep recommendation guidelines for their age on weekend nights, but not on weeknights. The younger sample (14–17 years) exceeded the 8-h guidelines (Hirshkowitz et al., 2015) on weekend nights (athletes: +58.56 min, $t(51) = 6.43$, $p < .001$, Cohen $d = 0.89$; controls: +51.98 min, $t(42) = 4.11$, $p < .001$, Cohen $d = 0.63$) but just met them on weeknights (athletes: +1.50 min, $t(51) = 0.19$, $p = .43$, Cohen $d = 0.03$; controls: −12.91 min, $t(42) = -1.14$, $p = .26$, Cohen $d = -0.17$). The older sample (18–21 years) exceeded the 7-h guidelines (Hirshkowitz et al., 2015) on weekend nights (athletes: +85.31 min, $t(31) = 5.94$, $p < .001$, Cohen $d = 1.05$; controls: +80.77 min, $t(51) = 7.40$, $p < .001$, Cohen $d = 1.03$) and weeknights (athletes: +62.63 min, $t(31) = 5.85$, $p < .001$, Cohen $d = 1.04$; controls: +58.27 min, $t(51) = 7.40$, $p < .001$, Cohen $d = 0.89$). Nearly half of the younger sample (47.4%) failed to attain the guidelines for their age on weeknights (48.1% athletes, 46.5% controls) and

Table 4. Gender, age, and group differences in sleep health.

	Gender			Age		Group		
Sleep Health Measures	N	*t*	Cohen's d	N	Pearson's r	N	*t*	Cohen's d
TST	117	0.19	.36	120	−.06	120	0.86	.16
CASQ total	105	[a]2.14*	.42*	107	−.09	107	−.64	.12
CASQ sleepiness	105	1.62	.32	107	−1.3	107	−.47	.09
CASQ alertness	105	[a]2.06*	.40*	107	−.01	107	−.64	.12
			Cramer's V		Kendall's τ			Cramer's V
PSQ	120		.30*	123	.17*	123		.20
FSD	119		.14	122	−.19**	122		.17

TST = total sleep time averaged across 7 nights; CASQ = Cleveland Adolescent Sleepiness Questionnaire; CASQ total = CASQ total score; CASQ alertness = CASQ degree of alertness; CASQ sleepiness = CASQ degree of sleepiness score; SDF = sleep disturbances frequency.
Statistics used: independent samples t-tests for gender and group differences in TST, CASQ total, CASQ alert, and CASQ sleepiness; Chai-square with Fisher's exact test for gender and group differences in PSQ and SDF; Pearson's *r* for correlations between age, TST, CASQ total, CASQ sleepiness, and CASQ alertness; Kendall's τ for correlations between age, PSQ, and FSD. Gender "other" excluded from gender analysis due to low case count.
[a]Females had a higher CASQ total score (+4.40), a higher CASQ degree of alertness score (+2.06) and poorer perceived sleep quality than males.
*$p < .05$.**$p < .01$.

Table 5. Sleep health differences between athletes and controls.

		Athletes		Controls				
	N	Mean	SD	Mean	SD	*t*	*p*	Cohen d
TST	179	494.48	52.52	485.17	64.41	1.04	.30	0.16
TST week	179	481.93	58.34	473.21	69.60	0.90	.37	0.14
TST weekend	179	525.89	73.39	514.89	81.70	0.94	.35	0.14
CASQ Total	158	35.94	9.46	38.22	10.76	−1.42	.08	0.23
CASQ alert	158	14.54	5.10	15.81	5.30	−1.54	.13	0.25
CASQ sleepiness	158	21.40	6.71	22.41	7.08	−0.92	.38	0.15
		n	%	n	%		*p*	Cramer V
Sleep quality							0.04	.23
Very dissatisfied		4	4.7	6	6.2			
Somewhat dissatisfied		12	14.1	27	27.8			
Neither		11	12.9	18	18.6			
Somewhat satisfied		42	49.4	38	39.2			
Very satisfied		16	18.8	8	8.2			
SDF							0.07	.24
Never		9	10.7	6	6.2			
Less than once a week		35	41.7	29	29.9			
1-2 times a week		24	28.6	24	24.7			
3-4 times a week		9	10.7	20	20.6			
5-6 times a week		4	4.8	6	6.2			
Every night		3	3.6	12	12.4			

TST = total sleep time averaged across 7 nights; TST week: nightly total sleep time on weeknights; TST weekend: nightly total sleep time on weekends; CASQ = Cleveland Adolescent Sleepiness Questionnaire; CASQ total = CASQ total score; CASQ alertness = CASQ degree of alertness; CASQ sleepiness = CASQ degree of sleepiness score; SDF = sleep disturbances frequency.
Differences in TST, TST week, TST weekend, CASQ total, CASQ alert, and CASQ sleepiness assessed with independent samples t-tests. Differences in sleep quality and SDF assessed with Chai-square with Fisher's exact test.

one-fifth (20.0%) on weekend nights (19.2% athletes, 20.8% controls) (Figure 2A). Approximately one-fifth of the older sample (21.4%) did not meet the guidelines on weeknights (21.9% athletes, 21.2% controls), and about one-sixth (15.5%) on weekend nights (21.9% athletes, 11.5% controls) (Figure 2B).

Discussion

The present study explored the LD and sleeping behaviours in adolescent athletes and their non-athlete counterparts. Approximately 67% of the cohort reported having experienced at least one lucid dream in their lifetime, 30% were frequent lucid dreamers, and 13% lucid dreamed once a week or more. Further, LD frequencies in adolescent athletes were comparable to those of non-athletes, consistent with findings in older cohorts (Erlacher et al., 2012; Schredl & Erlacher, 2011). A study on 214 Swiss students aged 17.2 ± 1.2 years (range: 14–21 years) showed a lower prevalence (51%) but a comparable proportion of frequent lucid dreamers (29%) (Fingerlin, 2013). Overall, findings are in line with current evidence, also reporting higher LD frequencies in younger age groups compared to adults (see Saunders et al. (2016) for a meta-analysis). For instance, out of 1807 adults aged 47.75 ± 14.41 years (range: 18–97 years), 62.5% experienced at least one lucid dream and 24.1% were frequent lucid dreamers (Schredl et al., 2022). Similarly, in another sample aged 47.75 ± 14.41 years (*N* = 2492, range: 16–93 years), these proportions amounted to 58.8% and 24.7% (Hess et al., 2017). Additionally, adult samples tend to show a significant decline in LD frequency with age (Hess et al., 2017; Schredl & Göritz, 2015), further highlighting that while a significant number of adults experience LD, the frequency is generally higher among younger cohorts.

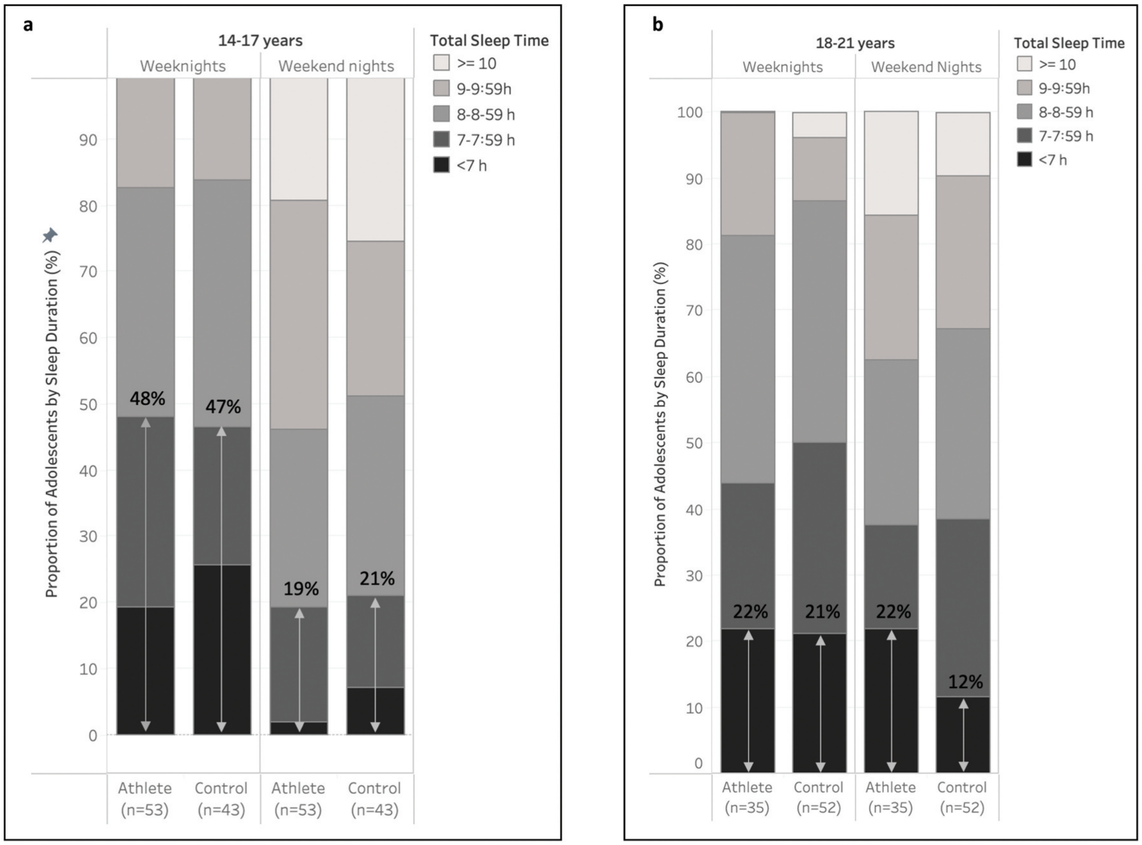

Figure 2. Relative weeknight and weekend total sleep time per age category and group. Panel A shows the proportion of adolescent athletes and non-athletes aged 14–17 years by weeknight and weekend sleep duration, whilst panel B, the proportion of those aged 18—–21 years. Noted on each bar is the percentage of participants not attaining the minimum sleep recommendation guidelines for their age (8 hours for 14–17 years of age, and 7 h for 18–21 years of age) (Hirshkowitz et al., 2015).

It is worth noting that while this study did not specifically measure LD frequency on weekdays versus weekends, this aspect opens avenues for several considerations. Weekends, characterised by a potentially greater opportunity for sleep with fewer distractions due to the absence of work, school, or other obligations, could offer a more favourable environment for experiencing LD. Longer sleep durations can lead to more Rapid Eye Movement (REM) sleep cycles, during which LD is more likely to occur (LaBerge et al., 1981, 1986). Further, individuals practicing LD induction techniques may find weekends more convenient due to having more time and a more relaxed state of mind. For example, results from Schredl et al. (2020) suggest that participants, to avoid compromising their overall sleep duration, selected nights where they could sleep in to practice WBTB induction method (which involves interrupting sleep, before returning to sleep following a period of wakefulness).

The lucid dreamers in this study predominantly experienced naturally occurring lucid dreams (62% only or mostly spontaneous), with only a small proportion either only, or mostly, intentionally inducing them (18%). The most popular LD application was passive watching (67.5%). This is the first time that passive watching as an LD application is being explored. It is unclear whether this large proportion is due to a lack of dream manipulation skills (which may prevent participants from actively engaging with their dreams and thus using LD for other purposes) or whether passive watching during LD is a personal choice. Passive watching may also be a particular way of having fun in a lucid dream. In this case, it may explain why, compared to previous evidence (Schädlich & Erlacher, 2012; Stumbrys & Erlacher, 2016), having fun (43.1%) was not the most popular application. Findings from an interview study, for instance, indicate that sometimes adolescent lucid dreamers choose to take a passive stance to see where the dream takes them, or to enjoy their dreams as they are (e.g., like watching a movie) (Bonamino et al., 2023b).

About two-fifths (43.1%) of the lucid dreamers used LD to change nightmares into more pleasant dreams. This relatively high proportion is expected as LD often originates from nightmares (Stumbrys et al., 2014). Children and adolescents, for instance, have reported that their first LD experiences commenced in dream situations of need, e.g., when needing to escape nightmares (Voss et al., 2012). Further, the effectiveness of LD for treating nightmares is supported by several clinical interventions (Ouchene et al., 2023).

Approximately one-quarter of the lucid dreamers reported using LD to solve a particular problem (26.0%), and one-fifth for creativity purposes (20.3%. Practicing sport/dance (17.1%) and non-sport/dance skills (5.4%) were the least popular applications. Due to a technical issue, only one-third of the controls were displayed the sport/dance skill application. The estimate provided is thus not representative of an adolescent LD population and should be interpreted with caution. Findings are nonetheless consistent with previous evidence, highlighting the "unpopularity" of practical applications among lucid dreamers (Schädlich & Erlacher, 2012; Stumbrys & Erlacher, 2016). Despite preliminary research supporting the effectiveness of LD for creative problem-solving (Stumbrys & Daniels, 2010) and practising skills (Bonamino et al., 2023a), it may be that lucid dreamers are not aware of these opportunities. A substantial proportion of adolescent lucid dreamers in this study (55.4%) reported not being aware of the practical potentials of LD. It may also be that participants lacked sufficient dream manipulation to influence their dreams and create appropriate dream settings, thus restricting the activities they could engage in when LD (Bonamino et al., 2023b). Stumbrys and Erlacher (Stumbrys & Erlacher, 2017) reported that lucid dreamers are mostly able to control their dream body, whereas influencing one's surroundings and maintaining dream lucidity are less common.

LD can be considered a form of mental practice, an effective and well-established technique, involving cognitive rehearsal of movements without overt physical movement (Simonsmeier et al., 2021). Like mental practice, performing movements during LD activates the corresponding cortical networks and elicits similar autonomic responses as when those movements are executed physically during wakefulness (Dresler et al., 2011; Erlacher & Schredl, 2008). Experiments have shown waking performance improvements in coin-tossing (Erlacher & Schredl, 2010), sequential finger-tapping (Stumbrys et al., 2016), and dart-throwing (Schadlich et al., 2017) after LD motor practice, suggesting LD's potential for motor training. Further, accounts from lucid dreamers indicate that LD motor practice can also promote self-confidence and self-efficacy (Bonamino et al., 2023b; Schädlich & Erlacher, 2018). Participants in this study who rehearsed sport/dance during LD also reported enhanced self-efficacy and motor performance. However, a greater proportion reported an improved self-efficacy (57.1%) compared to performance (42.9%). This is the first time that self-efficacy and motor performance following LD motor practice are directly compared, and it may indicate that practicing motor skills during LD may sometimes be more beneficial to self-efficacy beliefs than motor performance, aligning with findings from a recent interview study (Bonamino et al., 2023b). The proportions reported in this study, however, did not consider the non-athletes who may have still used LD to rehearse sport/dance, but to whom the question was not displayed due to the technical issue. Among the 15 athletes practicing sports/dance skills in their lucid dreams, 46.7% perceived waking performance improvement. This estimate was lower than in previous studies (77% (Erlacher et al., 2012); 60% (Daniel et al., 2022)), potentially due to different response options used where athletes were restricted to a yes-or-no option, whilst in this study they were also provided with the neutral option ("I don't know").

Adolescent athletes and non-athletes used LD for similar purposes. However, due to the technical issue, it remains unclear how sport/dance practice during LD may differ between the two populations. Contrary to previous studies (Schädlich & Erlacher, 2012; Stumbrys & Erlacher, 2016), no gender or age differences in LD applications were observed. Compared to infrequent lucid dreamers, frequent lucid dreamers were more likely to use LD to solve waking problems, but no other differences were found. This aligns partly with previous evidence where individuals with higher LD frequencies were more likely to use LD for problem-solving but less likely for nightmare treatment (Stumbrys & Erlacher, 2016). Age group differences between this and previous research (Schädlich & Erlacher, 2012; Stumbrys & Erlacher, 2016) may explain the discrepancy in findings.

Consistent with the literature (Stumbrys, 2023), LD frequency positively correlated with dream recall and nightmare frequency. A weak, positive correlation was also observed for age, implying that older adolescents might experience higher LD frequencies. This finding contrasts with the usual trend of LD frequency decreasing with age (Saunders et al., 2016). The relatively young and narrow age range and standard deviation of participants in this study, compared to previous evidence, will have made an age effect less likely to emerge. That LD frequency positively correlates with age in adolescents also suggests that declines in LD frequency might not occur until later in life. This aligns with neurophysiological evidence indicating continued structural and functional brain growth into the twenties (Guyer et al., 2023), supporting the proposed link between LD and brain maturation processes (Voss et al., 2012).

This study is the first to assess chronotype in an LD population. Due to the restricted sample size, associations between LD frequency and chronotype were not explored. Instead, chronotype differences between frequent, infrequent and non-lucid dreamers were examined, but none were observed. Considering that LD often occurs towards the end of sleep episodes (LaBerge et al., 1986), higher morning alertness traits, typical in morning types (Montaruli et al., 2021), may enhance the likelihood of LD. This contradicts the notion that LD is more frequent in adolescents, as they typically favour evening chronotypes (Karan et al., 2021). However, evening chronotypes are more prone to snoozing alarms (Mattingly et al., 2022), a behaviour common also in lucid dreamers (Smith & Blagrove, 2015). Snoozing alarms can cause sleep interruptions and potentially induce sleep-onset Rapid Eye Movements (REM) periods (Takeuchi et al., 2001) increasing the likelihood of LD. More research is encouraged to further investigate chronotype preference as a potential influencing factor for LD.

Recently, concerns have been raised about the potential adverse effects of LD on sleep quality (Soffer-Dudek, 2020; Vallat & Ruby, 2019). Findings from this study do not support these concerns. No differences in TST, perceived sleep quality and sleep disturbances frequency were observed between frequent, infrequent, and non-lucid dreamers. LD frequency was also not associated with any of the sleep parameters measured. Findings are consistent with the current literature, showing no associations between LD and sleep duration (Bazzari & Bazzari, 2022) or sleep quality (Bazzari & Bazzari, 2022; Ribeiro et al., 2020; Stumbrys, 2023). Rather, LD may promote the feeling of being refreshed in the morning (Schredl et al., 2020), higher subjective sleep quality (Stumbrys, 2023) and diminished daytime dysfunction (Stumbrys, 2023).

Whilst some evidence suggests a correlation between higher LD frequencies and self-reported night awakenings (Bazzari & Bazzari, 2022), this study found none. This may be attributed to variations in sleep disturbances measure. Instead of focusing solely on night awakenings (Bazzari & Bazzari, 2022), this study considered difficulties in initiating as well as maintaining sleep. Sleep disturbances in lucid dreamers may stem from LD induction. Interrupted sleep can facilitate LD by acting as WBTB methods where one interrupts their sleep and then returns to sleep following a period of wakefulness (Stumbrys et al., 2012). Although one study found a link between poor sleep quality and deliberate LD induction attempts (Aviram & Soffer-Dudek, 2018), another found no associations between sleep quality and deliberately induced versus spontaneous lucid dreamers (Stumbrys, 2023). Further, Schredl et al. (2020) observed that participants applying the WBTB method experienced longer sleep durations than those without, suggesting that they specifically selected nights where they could perform WBTB without comprising their overall sleep duration. Nonetheless, poor sleep and reduced sleep quality remain a self-reported negative effect of LD (though these are often attributed to LD induction) (Mallett et al., 2022; Stumbrys, 2023). These may have implications on cognitive functioning, motor performance, and overall health and well-being (Owens & Weiss, 2017), and highlight the need for alternative induction methods that do not compromise sleep health.

Athletes exhibited similar TST, daytime sleepiness levels, and frequency of sleep disturbances, but higher sleep quality than non-athletes. Evidence regarding sleep in adolescent athletes and non-athletes is inconsistent. While some studies have shown maladaptive sleep in athletes (Fox et al., 2020) other have observed improved sleep compared to non-athletes (von Rosen et al., 2019). Other evidence reports similar sleep between the two populations on weekdays, but worse in athletes on weekends (Saidi et al., 2023). Discrepancies in results may be due various factors including demographic and cultural differences (Gariepy et al., 2020), school start times (Gariepy et al., 2020), training schedules (Steenekamp et al., 2021) and methodological disparities (Lucas-Thompson et al., 2021).

Consistent with the literature (Fox et al., 2020; Owens & Weiss, 2017), both athletes and non-athletes slept longer on weekends compared to weeknights. On weekends, adolescents have a greater opportunity for sleep as they are generally not required to wake early to attend school, work, or sporting commitments (or at least often not as early as during weekdays). This shift in sleep-wake cycles likely originates from a need to restore sleep debt, which accumulates from shorter weeknight sleep durations (Gradisar et al., 2011). Overall, participants met the sleep recommendation guidelines for their age, particularly on weekends. However, a significant portion experienced insufficient sleep on weeknights, with 47.4% of the younger sample and 21.4% of the older one sleeping less than the recommended 8 h. Among the older cohort, athletes (21.9%) were nearly twice as likely as non-athletes (11.5%) to sleep less than 7 h, possibly due early wake times for training or competitions. These findings indicate that restricted sleep remains common in younger populations. Adolescents experience a biological shift in sleep regulating mechanisms, causing a natural tendency towards delayed bedtimes and evening-chronotypes behaviours (Crowley et al., 2018). Couple with strict early school times and early morning training times, these biological factors contribute to inadequate sleep durations. This mismatch between biological sleep needs and external schedules highlights the challenges adolescents face in obtaining sufficient restorative sleep, which is critical to their cognitive functioning, athletic performance, recovery, and health and well-being (Fox et al., 2020; Owens & Weiss, 2017).

For adolescent athletes and non-athletes alike, these insights highlight the critical need for tailored interventions to improve sleep hygiene and schedule management. Health care providers and coaches working with adolescent athletes should consider integrating strategies that account for their unique sleep challenges, such as adjusting training schedules to allow for adequate recovery and prioritising sleep education to optimise performance and overall well-being. Several studies have shown that adolescent athletes obtaining less than 8 h of sleep per night are more likely to sustain an injury (Mason et al., 2023). Insufficient sleep can have broad repercussions on multiple facets critical for athletic performance, aspects, including motor execution, reaction times, coordination, decision-making, fatigue, increased perceived effort, mental well-being and recovery (Charest & Grandner, 2022; Coel et al., 2023; Walsh et al., 2021). Conversely, interventions aimed at improving sleep, particularly through increasing nightly sleep durations or through napping, can be effective in enhancing both cognitive and physical performance (Cunha et al., 2023). For instance, a 5–7-week sleep extension intervention in collegiate basketball players resulted in improved sport performance (faster sprint times, greater shooting accuracy) and PVT scores, enahnced subjective practice and game ratings performance, lower daytime sleepiness levels and improved moods (Mah et al., 2011). Non-athletes could benefit from similar approaches, ensuring that academic demands and extracurricular activities are balanced with adequate sleep opportunities. For example, interventions aimed at delaying school times have consistently been shown to promote longer sleep durations on school-nights, likely due to later wake times later, lower reliance on weekend catch-up sleep, and improved regularity in sleep patterns (Mousavi & Troxel, 2023).

The present study has several limitations. All measures were self-reported, meaning it was not possible to empirically verify participants' LD experiences and to accurately assess sleep duration and quality. Research has demonstrated discrepancies between self-reported and objectively measured sleep, specifically with adolescents overestimating sleep durations (Lucas-Thompson et al., 2021), suggesting that participants' TST may be less than reported. Further, sleep onset of "60 minutes or more" was converted onto "60 minutes", suggesting that some participants may have experienced longer sleep latencies. Sleep quality was also assessed using a simple Likert-type scale. While this approach provides an indication of subjective sleep quality, it does not offer the comprehensive assessment provided by more established tools such as Pittsburgh Sleep Quality Index (Buysse et al., 1989). Longitudinal studies using objective sleep measures, such as wrist actigraphy combined with dream journals or LD questionnaires, would provide more accurate insights into the impact of LD on sleep. Additionally, no dream reports were collected. These would have been valuable for exploring individual experiences associated with different LD applications. The technical issues with the questionnaire also likely led to a non-representative estimate for using LD for practicing sport/dance skills (and its impact on waking performance and self-efficacy) in the control group. Differences in the use of this application between athletes and non-athletes thus remain unclear.

Also of note is the impact of the COVID-19 pandemic, which caused significant difficulties in recruiting participants and subsequently extended the data collection period of this study to 14 months. This extended period likely included both school terms and vacations, as well as competitions and off-seasons for the athletes; however, these measures were not captured. Given participants' diverse geographical location (both inter-state within Australia and various countries worldwide) it was not feasible to account for the varying school terms, school start times, and sporting seasons, which can impact adolescent sleep (Bei et al., 2014; Gariepy et al., 2020; Vlahoyiannis et al., 2021). This may have introduced confounding factors affecting participants' sleep and lucid dreaming survey responses. Future research should consider more consistent timeframes and collect specific location data to minimise these potential confounders. Lastly, this study used a contemporary definition of adolescence (10–24 years) guided by Sawyer et al. (2018), rather than the traditional range of 10–19 years (World Health Organization, 2011), thus making comparisons with studies using more traditional definitions potentially problematic. To avoid spurious results from dichotomisation (Royston et al., 2006), age was also treated as a continuous variable. Categorising individuals into age groups using arbitrary cut-off scores can be problematic as differentiating individuals close in age (e.g., 17 years and 51 weeks versus 18 years and one week) becomes challenging. Future studies should consider incorporating measures of cognitive or biological maturity (e.g., pubertal status) when exploring individual differences in younger populations.

Overall, findings indicate that LD is prevalent among younger populations and is similar in frequency and uses between athletes and non-athletes. Passive watching was the most popular application, possibly indicating limited dream manipulation abilities that hinder exploration of other LD uses. Practicing sports skills during LD may boost waking self-efficacy more frequently than sport performance. It is advisable that future studies incorporate measures of self-efficacy to further explore how self-efficacy and motor performance are affected by LD. This study showed no indication that chronotype preference may influence LD occurrence, nor that LD is detrimental to sleep health in adolescents. However, further research using objective measures would provide valuable insights into the role of LD, particularly LD induction methods, on sleep health. Athletes and non-athletes also exhibit similar sleeping behaviours and, despite on average meeting the sleep recommendation guidelines for their age, they still express a sleep need, as indicated by longer weekend TSTs. Lastly, a significant proportion of adolescents do not regularly obtain sufficient sleep, indicating that persistent challenges with sleep duration remain prevalent in younger populations, posing risks to their cognitive functioning, athletic performance, recovery, and general health and well-being.

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Ethics approval

This study has been approved by the Human Ethics Committee of the (first author's) affiliated university – approval number: 2000000005

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APPENDICES

Lucid dreaming definition provided to participants.

In a lucid dream, one becomes aware of the fact that he or she is dreaming. The awareness can last for a brief moment or for a longer period. Sometimes, after having become lucid, the dreamer can influence the content of their dreams and voluntarily alter the dream events. During a lucid dream, for example, a dreamer can start flying, summon dream characters, create objects, and even change a nightmare into a positive dream. A dreamer can also do nothing and simply observe the dream course passively. Some dreamers can also wake themselves up from a lucid dream.

Amended Cleveland Adolescence Sleepiness Questionnaire items for participants aged 18 years or over

CASQ Item N°	Participants attending university	Participants attending work
1	I fall asleep during my morning lectures.	I fall asleep during my morning shifts at work.
2	I go through the whole day at university without feeling tired.	I go through the whole day at work without feeling tired.
3	I fall asleep during the last lecture of the day.	I fall asleep during the last hour of my shift at work.
6	I fall asleep at university in my afternoon lectures.	I fall asleep at work in my afternoon shift.
7	I feel alert during my lectures.	I feel alert during my shifts at work.
8	I feel sleepy in the evening after university.	I feel sleepy in the evening after work.
9	I feel sleepy when I ride in a bus to an event.	I feel sleepy when I ride in a bus to an event.
10	In the morning when I am at university, I fall asleep.	In the morning when I am at work, I fall asleep.
11	When I am in class I feel wide-awake.	When I am at work I feel wide-awake.
12	I feel sleepy when I study in the evening after university.	I feel sleepy when I do house-work or any other work in the evening after work.
13	I feel wide-awake in the last lecture of the day.	I feel wide-awake in the last hour of my shift at work.
15	During the day at university, there are times when I realise that I have just fallen asleep.	During the day at work, there are times when I realise that I have just fallen asleep.
16	I fall asleep when I study at home in the evening.	I fall asleep when I work at home in the evening.

CASQ = Cleveland Adolescence Sleepiness Questionnaire. Items 5 and 14 (not shown here) were delivered as per the original CASQ items (Spilsbury et al., 2007). At the start of the survey, participants reported their main occupation (student at school; student at university; full-, part-, or casual worker), used to direct them to the appropriate CASQ version.