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Original Article

Delayed sleep–wake phase disorder in young adults: prevalence and correlates from a national survey of Norwegian university students

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ABSTRACT

Background: Delayed sleep–wake phase disorder (DSWPD) during adolescence has been linked to impaired health and poor functioning. However there is a dearth of knowledge about DSWPD in young adulthood. We seek to contribute knowledge on the prevalence and correlates of DSWPD in this age group.

Methods: Data were drawn from a 2018 national survey of students in higher education in Norway (the SHoT-study). All 162,512 fulltime students in Norway were invited to participate and 50,054 students (69.1% women) aged 18–35 years were included (response rate = 30.8%). DSWPD was assessed by self-report, and was operationalized according to the criteria for DSWPD in the most recent edition of the International Classification of Sleep Disorders. Correlates of DSWPD were examined by validated self-report instruments covering a wide range of demographic and health domains.

Results: The overall prevalence of DSWPD was 3.3%, and significantly higher in male (4.7%) than female (2.7%) students. DSWPD was associated with being single, having financial difficulties, having divorced parents, being overweight/obese, and physical inactivity. Students with DSWPD had more sleep problems during weekdays, and higher levels of somatic and mental health problems. Students with DSWPD also had an elevated risk of self-harm-related thoughts and behaviors as well as suicidality.

Conclusion: DSWPD remains a significant problem among young adults, and the high symptom load across health domains indicates that suggests a need for existing evidence-based approaches to be scaled for college students who present with DSWPD.

1. Introduction

The well-known circadian delay occurring during puberty [1] is associated with considerable functional impairment. For some, the delay and its consequences for social and work obligations are at a level of severity that qualifies the individual for delayed sleep–wake phase disorder [2] (DSWPD). While DSWPD typically debuts during adolescence [3], very little is known about the developmental trajectory into early adulthood. One population-based study conducted in New Zealand reported that young adults aged 20–29 years had the highest rate of DSWPD across sleep and circadian diagnoses, which decreased with age [4].

There are also uncertainties related to possible gender differences in DSWPD. Some early clinical studies suggested a male preponderance [5], which was also the finding from a Swedish study of 1000 adolescents and young adults (16–26 years) [3]. In contrast, no gender differences were observed in the New Zealand epidemiological study [4]. To further complicate the matter, an epidemiological study of 10,000+ adolescents (16–19 years) from

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Norway reported a higher rate of DSWPD among female high school students compared to male students [6].

The etiology of DSWPD is multifactorial, with an inter-play between biological, psychological, and social factors contributing to the development and persistence of the disorder. Mental health problems often co-occur with DSWPD [6–8], with depressive symptoms being among the most common mental health comorbidities [3,9]. Further, childhood mental health problems have been found to be precursors to DSWPD in adolescence [10]. While some studies have linked DSWPD to several negative life style patterns, such as alcohol use and smoking [11], other studies have not found any difference in life style habits [12]. In terms of sociodemographic correlates, there are indications that low SES is associated with DSWPD in adolescence [3,4].

To date, the vast majority of studies on DSWPD have been conducted on adolescents. As such, we have limited knowledge regarding the prevalence of DSWPD in other age groups. In addition, we know little about the extent to which DSWPD is associated with other health problems, and negative life style patterns. Against this backdrop, the present study addressed four main questions using data from a large nationally representative sample of young people: (1) What is the prevalence of DSWPD in males and female college and university students? (2) Which sociodemographic factors are associated with DSWPD? (3) What characterizes sleep patterns of individuals with and without DSWPD? (4) To what extent is DSWPD in this age cohort associated with impaired somatic and mental health?

2. Methods

2.1. Procedure

The SHoT study (*Students' Health and Wellbeing Study*) is a large Norwegian survey of students in higher education, conducted by three large student welfare associations. Since 2010, three waves have been completed. This report is focused on the third wave, which was conducted in 2018. Detailed information of the SHoT study has been described in a previous publication [13], but in brief, data from *the SHoT2018* were collected from February to April, 2018, and included all fulltime Norwegian students aged 18–35, undertaking higher education. In all, 162,512 students received an invitation to participate, of whom 50,054 students completed the web-based questionnaires (response rate: 30.8%).

2.2. Ethics

The SHoT2018 study was approved by the Regional Committee for Medical and Health Research Ethics in Western Norway (no. 2017/1176). Informed consent was obtained electronically after the participants had received detailed information about the study.

2.3. Instruments

2.3.1. Delayed sleep–wake phase disorder (DSWPD)

The following questions were used to assess DSWPD: "At what time do you usually go to bed", "How much time does it take before you fall asleep (hours and minutes)", "When do you usually get out of bed in the morning", "How many nights per week do you have difficulties falling asleep (0–7)", "How many nights per week do you have problems with nightly awakenings (0–7)", "How often do you oversleep ("never", "seldom", "sometimes", "mostly", "always")". The participants provided sleep data separately for weekdays and weekends. No information regarding the time-frame of these symptoms was available. To establish a proxy for assessing DSWPD (as close as possible given the available sleep items) in line with the third and current edition of the International Classification of Sleep Disorders (American Academy of Sleep Medicine, 2005), we employed the following 5 criteria, as specified in Johnson et al. [14]: 1) minimum 1-h shift in sleep-onset AND wake times from the weekdays to the weekend, 2) complaint of frequent ($\geq$3 days per week) difficulty falling asleep, 3) report of little or no ($\leq$1 day per week) difficulty maintaining sleep, and 4) frequent difficulty awakening (oversleep "sometimes" or more often), and 5) at least 7 h of sleep per night on the weekends. No information was available concerning the students' desired bed time or their inability to fall asleep at the desired time which, according to ICSD-3, would be required to fulfill the criteria for a clinical diagnosis of DSWPD. The operationalization used in the present study has previously been applied in studies of DSWPD in older adolescents [3,8,10].

2.3.2. Sociodemographic and lifestyle information

All participants indicated their sex and age, and participants were also asked about their relationship status. Financial difficulties were assessed by asking participants if they, during the last 12 months, had experienced difficulties affording costs of living (such as for food, transportation and accommodation; *never*, *rarely*, *sometimes*, *often*). Participants also indicated if they worked night shift work, and if they their parents were divorced. They were also asked if they were involved in the following organized volunteer student activities: Sports, cultural activities, student democracy, professional societies, or other interests/societies. Participants were categorized as an immigrant if either the student or one or both of his/her parents were born outside Norway. Body mass index was calculated based on self-reported body weight (kg) divided by squared height (m^2). The BMI was then split into 3 categories: normal/underweight (BMI $\leq$ 24.99), overweight (BMI 25.00–29.99) and obesity (BMI $\geq$ 30.00).

Physical activity was assessed using three sets of questions, which assessed the average number of times the participant exercised per week, as well as the average intensity and average hours each time [15]: 1) "*How frequently do you exercise?*" (Never, Less than once a week, Once a week, 2–3 times per week, Almost every day); 2) "*If you do such exercise as frequently as once or more times a week: How hard do you push yourself?*" (I take it easy without breaking into a sweat or losing my breath, I push myself so hard that I lose my breath and break into a sweat, I push myself to near-exhaustion); and 3) "*How long does each session last?*" (Less than 15 min, 15–29 min, 30 min to 1 h, More than 1 h". Based on international recommendations that adults should get at least 30 min of moderate to vigorous physical activity (MVPA) 5 days or more per week (=150 min per week) [16], we created a variable for which students answering both "Almost every day" on the frequency item, "I push myself so hard that I lose my breath and break into a sweat" on the intensity item, and "30 min or more" on the duration item, were categorized as meeting the recommendations of "MVPA: 150 min/week".

2.3.3. Other sleep variables

The participants' self-reported usual bedtime and rise time were indicated in hours and minutes, and data were reported separately for weekdays and weekends. Time in bed (TIB) was calculated as the difference between bedtime and rise time. Sleep onset latency (SOL) and wake after sleep onset (WASO) were also indicated separately for weekdays and weekends in hours and minutes. Sleep duration was defined as TIB minus SOL and WASO. Sleep efficiency was defined as the ratio of sleep duration to TIB, multiplied by 100 to yield a percentage.

2.4. Correlates of DSWPD

2.4.1. Mental disorders

Self-reported mental disorders were assessed by a pre-defined list adapted to fit this age-cohort. The list was based on a similar operationalization used in previous large population-based studies (the HUNT study [17]) and included several subcategories for most conditions/disorders (not listed here). For mental disorders, the list comprised the following specific disorders/group of disorders: ADHD, anxiety disorder, autism/Asperger, bipolar disorder, depression, PTSD (posttraumatic stress disorder), schizophrenia, personality disorder, eating disorder, Tourette's syndrome, obsessive-compulsive disorder (OCD), and other. The list did not contain definitions of the included disorders/conditions. In the current study, only ADHD, anxiety, and depressive disorder were included (due to low n among the other disorders/lack of statistical power).

2.4.2. Suicidal ideation, suicidal behavior and self-harm

History of suicidal ideation, suicide attempts and self-harm were assessed with three items drawn from the Adult Psychiatric Morbidity Survey (APMS) [18]; "*Have you ever seriously thought of taking your life, but not actually attempted to do so?*", "*Have you ever made an attempt to take your life, by taking an overdose of tablets or in some other way?*", and "*Have you ever deliberately harmed yourself in any way but not with the intention of killing yourself? (ie, self-harm)*", respectively. The questions about thoughts of self-harm were adapted from the Child and Adolescent Self-harm in Europe study (CASE) [19]. "*Have you ever seriously thought about trying to deliberately harm yourself but not with the intention of killing yourself but not actually done so?*" (yes/no).

2.4.3. Mental health symptoms

Mental health symptoms were assessed using The Hopkins Symptoms Checklist (HSCL-25) [20], derived from the 90-item Symptom Checklist (SCL-90), which is a screening tool designed to detect symptoms of anxiety and depression. It is composed of a 10-item subscale for anxiety and a 15-item subscale for depression, with each item scored on a Likert scale from 1 ("*not at all*") to 4 ("*extremely*"). The period of reference is the past two weeks. An investigation of the factor structure based on the SHoT2014 dataset showed that a uni-dimensional model had the best psychometric properties in the student population in contrast to the original subscales of anxiety and depression [21]. We followed scoring based on the SHoT2014 in the present study.

2.4.4. Somatic symptoms

Somatic health was assessed by the Somatic Symptom Scale-8 (SSS-8): an 8-item reliable and valid self-report measure of somatic symptom burden, originally derived from the well-validated PHQ-15 [22].

2.4.5. Loneliness

Loneliness was assessed using an abbreviated version of the widely used UCLA Loneliness Scale, "The Three-Item Loneliness Scale (T-ILS)" [23]. The T-ILS items were each rated along a 5-point Likert scale ("never", "seldom", "sometimes", "often", and "very often"). The instructions and items were: *For each question below, please indicate how often you have felt that way during the last year: 1) How often do you feel that you lack companionship? 2) How often do you feel left out, and 3) How often do you feel isolated from others?* The T-ILS has displayed satisfactory reliability and both concurrent and discriminant validity [23].

2.4.6. Quality of life

Quality of life was assessed by the Satisfaction With Life Scale (SWLS) [24]. The SWLS is a 5-item scale designed to measure global cognitive judgments of one's life satisfaction (not a measure of either positive or negative affect). Participants indicate how much they agree or disagree with each of the 5 items using a 7-point scale that ranges from 7 (strongly agree) to 1 (strongly disagree). The higher the score on the SWLS, the better quality of life.

2.4.7. Positive affect

The Positive and Negative Affect Schedule (PANAS) [20] is a 20-item questionnaire which is comprised of two subscales, one that measures positive affect (PA) and the other which measures negative affect (NA). The positive affect scale of interest here includes the terms interested, alert, enthusiastic, excited, proud, inspired, strong, active, and attentive. Participants are instructed to rate to what extent they experience each emotion at the present time, rated on a 5-point scale from "very slightly or not at all" (coded as 1) to "extremely" (coded as 5). A composite score is calculated with higher scores representing greater positive affect. The NA subscale was not included in the SHoT study.

2.4.8. Alcohol-related problems

Potential alcohol-related problems were measured by the Alcohol Use Disorders Identification Test (AUDIT), which is a widely used instrument developed by the World Health Organization for identifying risky or harmful alcohol use [25,26]. The 10-item AUDIT included items measuring the frequency, typical amount and episodic heavy drinking frequency (items 1–3), alcohol dependence (items 4–6) and problems related to alcohol consumption (items 7–10) [27]. The AUDIT scores range from 0 to 40 where higher scores reflect more serious problems.

2.5. Statistics

IBM SPSS Statistics 26 for Windows (SPSS Inc., Chicago, Ill) was used for all analyses. Independent sample t-tests and χ^2-tests were used to examine differences in sociodemographic, lifestyle and sleep variables in students with and without DSWPD. Sum scores on the mental and somatic health scales were converted to standardized *t*-scores (mean = 50 and 1 SD = 10) to ease comparisons across instruments, and between-group effect sizes (pooled SD) were calculated using the Cohen *d* formula. These effect sizes are usually interpreted according to Cohen's guidelines (Cohen, 1988), with *d*s about 0.20, 0.50, and 0.80 representing small, moderate and large effect sizes, respectively. Logistic regression analyses were used to assess the association between DSWPD and the dichotomous variables (mental disorders and suicidality), adjusting for sex and age. Multiple testing corrections (Benjamini–Hochberg) were applied to the results of statistical tests where appropriate.

3. Results

3.1. Prevalence of DSWPD

The overall prevalence of DSWPD was 3.3% (95% CI: 3.1–3.5), and was significantly higher in male (4.7% [95% CI: 4.4–5.0]) than female (2.7% [95% CI: 2.5–2.8]; $p < 0.001$) students. As detailed in Table 1, DSWPD was inversely associated with age – the highest DSWPD prevalence was observed among students aged 18–20 years (3.6%), compared to 2.0% of students aged 29–35 years. Also, DSWPD was significantly associated with being single, having financial difficulties, having divorced parents, and working night shift. Ethnicity was, however, not significantly associated with DSWPD.

Table 1
Prevalence of delayed sleep–wake phase disorder (DSWPD) by sociodemographic and lifestyle characteristics.

		Prevalence of DSWPD		
		n	%	(95% CI)
Sex*	Female	914	2.7%	(2.5–2.8)
	Male	719	4.7%	(4.4–5.0)
Age group*	18–20 years	313	3.6%	(3.2–4.0)
	21–22 years	523	3.4%	(3.1–3.7)
	23–25 years	546	3.4%	(3.2–3.7)
	26–28 years	173	3.0%	(2.6–3.5)
	29–35 years	70	2.0%	(1.6–2.6)
Relationship status*	Not single	645	2.6%	(2.4–2.8)
	Single	1003	4.0%	(3.8–4.3)
Financial difficulties*	Never	557	2.3%	(2.2–2.5)
	Rarely	412	3.6%	(3.3–4.0)
	Sometimes	456	4.2%	(3.8–4.6)
	Often	223	5.7%	(5.0–6.5)
Night/shift work*	Yes	372	3.7%	(3.3–4.0)
	No	986	3.0%	(2.8–3.2)
Immigrants status	Ethnic Norwegian	1524	3.3%	(3.2–3.5)
	Immigrant	124	3.1%	(2.6–3.7)
Divorced parents*	Yes	616	3.7%	(3.4–4.0)
	No	1027	3.1%	(2.9–3.3)
BMI category*	Normal/underweight	1039	3.2%	(3.0–3.4)
	Overweight	393	3.5%	(3.1–3.8)
	Obesity	172	4.0%	(3.5–4.7)
Exercise frequency*	Never	140	6.4%	(5.4–7.5)
	Less than once a week	315	5.1%	(4.6–5.7)
	Once a week	331	4.2%	(3.8–4.7)
	2–3 times per week	638	2.9%	(2.7–3.2)
	Almost every day	219	1.9%	(1.6–2.1)
MVPA: 150 min/week*	Below recommended level	1529	3.5%	(3.3–3.6)
	Above recommended level	119	2.1%	(1.7–2.5)

*$p < 0.001$, based on overall Chi-squared test. BMI = body mass index, MVPA = moderate to vigorous physical activity.

In terms of lifestyle factors, DSWPD was more prevalent among overweight (3.5%) and obese (4.0%) students, as well as among students who exercised little, for which a dose-response association was observed: the less frequent the exercise, the higher the prevalence of DSWPD. Similarly, the prevalence was significantly higher among those not meeting the recommended criteria for MVPA (3.5% vs. 2.1%; see Table 1 for details).

Table 2
Sleep characteristics in students with and without delayed sleep–wake phase disorder (DSWPD).

	No DSWPD		DSWPD		
	Mean hrs:min	SD hrs:min	Mean hrs:min	SD hrs:min	*p*-value
Weekdays					
Bedtime	23:14	1:01	23:40	1:03	<0.001
Risetime	7:42	1:17	8:23	1:19	<0.001
Time in bed	8:28	1:07	8:42	1:13	<0.001
Sleep onset latency	0:46	0:42	1:27	0:44	<0.001
Wake after sleep onset	0:15	0:32	0:09	0:22	<0.001
Sleep duration	7:26	1:23	7:05	1:22	<0.001
Sleep efficiency, %	87.8	12.0	81.1	10.2	<0.001
Weekends					
Bedtime	00:38	1:18	01:33	1:13	<0.001
Risetime	9:49	1:23	11:09	1:10	<0.001
Time in bed	9:11	1:11	9:36	1:03	<0.001
Sleep onset latency	0:34	0:37	0:48	0:40	<0.001
Wake after sleep onset	0:12	0:31	0:06	0:16	<0.001
Sleep duration	8:24	1:24	8:41	1:00	<0.001
Sleep efficiency, %	91.54	10.14	90.75	7.11	<0.001

Tests are adjusted for all pairwise comparisons using the Benjamini–Hochberg correction.

In terms of participation in voluntary activities, a different pattern emerged: Students with DSWPD were significantly more involved in both cultural activities, student democracy, professional societies, and other interests/societies. There were no differences between those with and without DSWPD in terms of participation in sport activities (see Fig. 1 for details).

3.2. DSWPD and other sleep characteristics

Detailed sleep characteristics among students with and without DSWPD are outlined in Table 2. Compared to students without DSWPD, students with DSWPD had significantly later weekday bedtime (23:14 vs. 23:40) and risetime (7:42 h vs. 8:23 h), longer SOL (46 min vs. 87 mins), as well as shorter WASO (15 min vs. 9 mins). The average weekday sleep duration in the DSWPD group was 7:05 h, compared to 7:26 h in the no-DSWPD group (all *ps* < 0.001).

Similar findings were observed for weekend sleep parameters, with some exceptions: The DSWPD group had significantly *longer* sleep duration (8:41 h) compared to the no-DSWPD group (8:24 h).

3.3. DSWPD and mental and somatic symptoms

As displayed in Fig. 2, students with DSWPD had significantly higher levels of mental health problems (HSCL-25) and somatic symptoms (SSS-8). DSWPD students also reported more loneliness (T-ILS), poorer quality of life (SWLS), as well as lower positive affect (PANAS). In terms of alcohol problems, students with DSWPD also scored significantly higher on the AUDIT. Cohen's *d* effect-sizes were in the small-to-moderate range (0.26–0.48).

3.4. DSWPD and mental disorders and suicidality

The prevalence of ADHD, anxiety and depression were all significantly higher in the DSWPD group compared to the no-DSWPD group. Adjusting for sex and age, the odds of having a mental disorder in the DSWPD group ranged from OR = 1.8 to 2.1 (see Table 3 for details) compared to not having DSWPD. As detailed in Table 3, students with DSWPD also had increased odds of reporting both lifetime suicidal thoughts and behaviors and NSSH thoughts and behaviors (all ORs around 1.5; $p < 0.001$).

4. Discussion

The estimated prevalence of DSWPD in the present population-based study was 3.3%, and significantly higher in male (4.7%) than female (2.7%) students. DSWPD was positively associated with being single, having financial difficulties, having divorced parents, being overweight/obese, and with physical inactivity. Young adults with DSWPD also reported more sleep problems during weekdays, higher levels of somatic and mental health problems, and they also had elevated risk of self-harm and suicidality.

The observed overall prevalence rate in the current study is nearly identical to a recent study of older adolescents (aged 16–19 years), which used the same operationalization of DSWPD [3,8,10,28]. However, the current study found the opposite gender pattern as the prior study: While more females than males fulfilled the criteria for DSWPD in late adolescence [3], the current study shows that males are more likely to develop DSWPD when they reach young adulthood. Few other population-based studies of older adolescents have examined gender differences in DSWPD, most likely due to the low overall prevalence rates and the need for very large samples to detect statistically significant gender

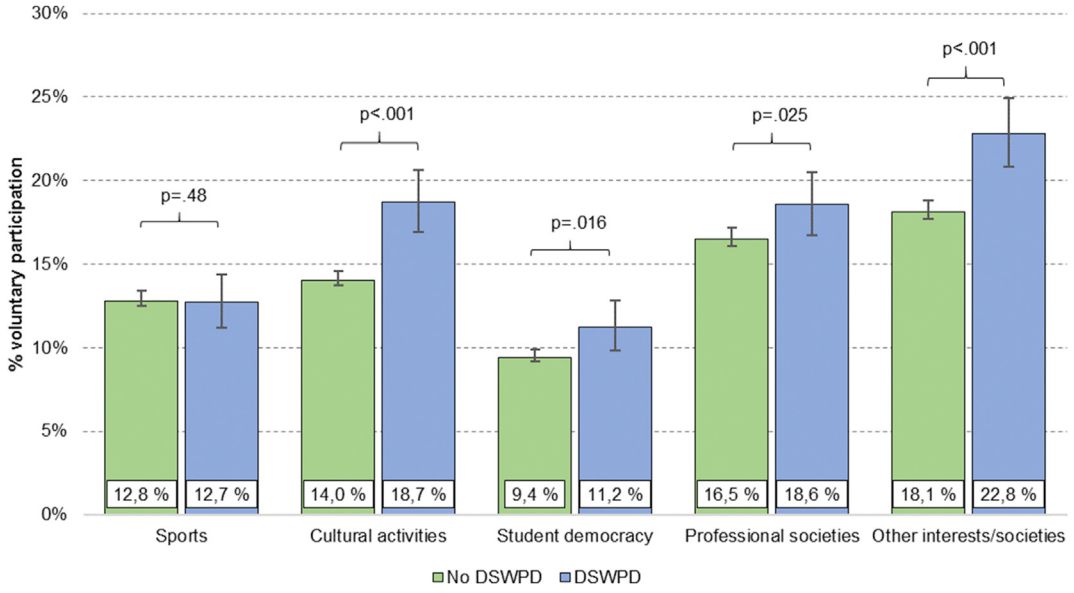

Fig. 1. Participation in organized volunteer student activities in students with and without delayed sleep–wake phase disorder (DSWPD). Error bars represent 95% confidence intervals.

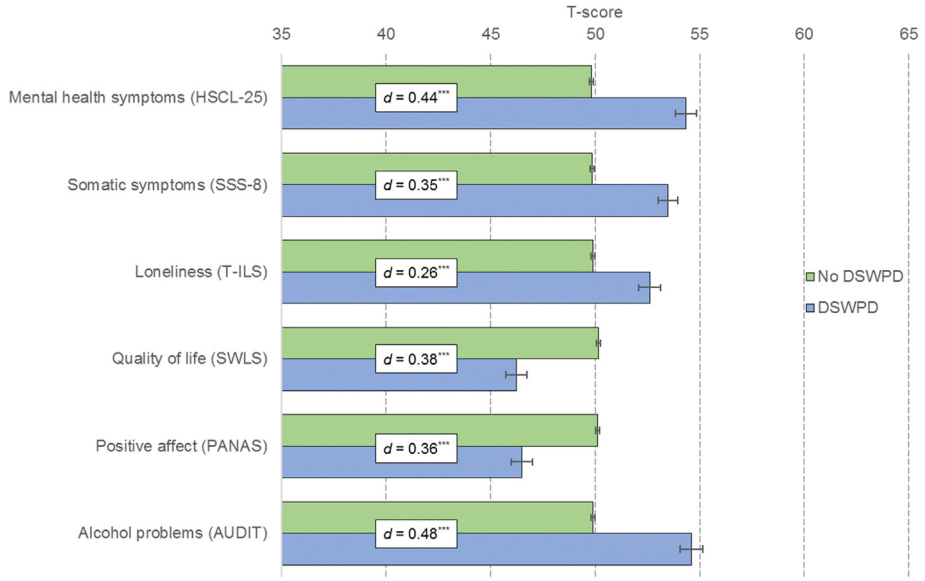

Fig. 2. Differences between students with and without delayed sleep–wake phase disorder (DSWPD) on somatic and mental health variables, represented in T-scores (in bars) and Cohen's d effect size (in white text box). Error bars represent 95% confidence intervals.

Table 3
Mental disorders and suicidality in students with and without delayed sleep–wake phase disorder (DSWPD).

	No DSWPD		DSWPD			Adjusted model[a]			
	%	(n)	%	(n)	Chi-square value	OR	95% CI	*p*-value	Nagelkerke R-square
ADHD	0.9%	(424)	1.6%	(27)	10.30	2.05	1.37–3.06	<0.001	0.014
Anxiety disorder	9.9%	(4775)	15.0%	(247)	45.84	1.79	1.55–2.07	<0.001	0.023
Depressive disorder	10.8%	(5212)	18.7%	(308)	101.10	2.07	1.81–2.36	<0.001	0.020
NSSH	19.5%	(9378)	24.1%	(397)	21.60	1.48	1.31–1.67	<0.001	0.042
NSSH thoughts	22.5%	(10,786)	28.4%	(468)	32.43	1.53	1.37–1.71	<0.001	0.043
Suicide attempt	4.1%	(1994)	5.6%	(92)	8.34	1.51	1.22–1.88	<0.001	0.013
Suicide thought	20.8%	(9983)	27.9%	(458)	48.31	1.53	1.37–1.71	<0.001	0.008

[a] Adjusted for sex and age; NSSH = non-suicidal self-harm.

differences. The male preponderance in the present study was, however, in line with a study by Thorpy et al. [5], while in a previous epidemiological study by Johnson et al. [14], no gender specific rates were reported. Still, the findings are in line with a large epidemiological study showing that females are more morning-oriented than males until the age of 30 [29]. Methodological differences may account for some of the differences across studies. It is also interesting that the higher prevalence rate of DSWPD among males in the current study is in sharp contrast to the prevalence of insomnia, which – using the same dataset as the current one [30] – has been found to be significantly higher among females.

In terms of age differences, it is noteworthy that the natural course of DSWPD follows the peak of the age curve outlined by Roenneberg et al. [31] where a peak occurs around 20–21 years. However, the current study shows that 2% of those in their late 20s/early 30s still qualify for a DSWPD diagnosis, suggesting that DSPWD is not merely a disorder for the individuals under 25 years of age.

Consistent with prior research among older adolescents [3], the sleep pattern of college and university students with DSWPD exhibited the expected sleep characteristics, with substantially less sleep due to a later bedtime and early awakening during the weekdays, as well as recovery sleep during the weekends, while their WASO was actually *shorter* than that of their peers. As such, the present study confirms that the sleep pattern of young adults with DSWPD is located at an extreme end of a continuum of normal sleep. What perhaps differentiates normal sleep patterns from a diagnostic level of DSWPD may therefore only partly be the sleep characteristics; more important are perhaps the associations with adverse health outcomes.

The current study found DSWPD to be associated with poorer health across a range of domains. While very few studies have examined health outcomes of DSWPD, there are a few notable exceptions. In the youth@hordaland study from 2012, older adolescents with DSWPD reported higher symptom load across several mental health measures, including symptoms of depression, anxiety, hyperactivity and inattention [8]. Another study based on the same dataset found a strong overlap between DSWPD and symptoms of insomnia, including both nocturnal symptoms and other measures of reduced daytime functioning [3]. Similarly, Saxvig et al. [11] found that adolescents with DSWPD also had higher prevalence of both case-level anxiety and depression. The current study corroborates these findings by showing that DSWPD is associated with worse somatic and mental health, more loneliness and poorer quality of life in general, as assessed by increased symptom load scores on self-report instruments. In addition, the current study shows that college students with DSWPD also have increased risk of several self-report mental disorders on a diagnostic level, including ADHD, anxiety disorder, and depressive disorder. Moreover, to the best of our knowledge, this study is the first to provide evidence of a significant association between DSWPD and self-destructive behaviors, including self-harm and suicidality. Recent studies have pointed to worryingly high prevalence rates of self-harm and suicide thoughts/attempts among college students [32], and the current study shows that students with disturbed sleep patterns is a particularly vulnerable group the one should pay attention to.

The current study has some noteworthy findings regarding how some lifestyle habits were associated with DSWPD. First, as also reported in previous studies [3], we found that students with DSWPD in general had increased risk of being overweight and obese, being physically inactive, as well as drinking too much alcohol. In contrast, in terms of participation in voluntary activities, students with DSWPD were in fact *more* involved in both cultural activities, student democracy, professional societies and other interests/societies. As such, the current study depicts a more nuanced picture of students with DSWPD: despite reporting more loneliness and physical inactivity, as well as more health problems in general, they appear to be as active or even more active in extracurricular activities compared to the general student population. While one may only speculate about the reasons behind these contrasting findings, some of these activities are perhaps quite time consuming, or take place late in the evening, forcing the students to postpone their sleep schedule.

4.1. Clinical implications

The current study suggests that DSWPD does not fade away when adolescents transition into young adulthood. With a prevalence of 3.3%, this equates to thousands of young adults who are experiencing the ill effects of DSWPD. As such, interventions targeting college and university students qualifying for DSWPD are called for. Single chronotherapy components (eg, bright light therapy) have shown promise in alleviating sleeplessness, cognitive performance deficits and even insomnia symptoms in clinical trials for DSWPD [33], yet need to be scaled to service the broader young adult population. Treatment of DSWPD typically comprises gradually advancing bright light exposure in the patients' biological morning. Avoidance/reduction of light in the evening/night seems to facilitate treatment response [34]. Bright light treatment is often combined with administration of exogenous fast release melatonin 12 h before bright light therapy [35]. Cognitive therapy focusing on sleep education, sleep hygiene, behavioral advancement of sleep timing, relaxation, cognitive restructuring and stimulus control may be beneficial as adjunct treatment [36,37]. Given the high prevalence and the negative impact of DSWPD more easily available treatments, like internet based therapy for this disorder, should be developed. Also worth considering are the promise of transdiagnostic treatments for the broader spectrum of "night-owl" youth, encompassing DSWPD as well those below the diagnostic threshold but who are still at risk [38].

4.2. Methodological considerations

Strengths of the current study include the large and heterogeneous sample, the use of well-validated instruments, and controlling for several potential confounders. The most important limitation is the cross-sectional design as this limits our ability to study the directionality between DSWPD and the studied correlates. For example, poor mental health may be both a risk factor of DSWPD [10], as well as a consequences or co-morbid condition existing alongside DSWPD.[8]Another important limitation is the modest response rate (31%), with little information about the characteristics of non-participants beyond age and gender distribution. Selective participation could bias the prevalence observed to the extent that the selection was correlated with DSWPD. On the one hand, non-participants of health surveys in general have poorer health than participants [39]. The current results may, therefore, represent an underestimation of the true prevalence of DSWPD in the target population. On the other hand, people are in general more prone to participate in a survey if the topic is relevant to them personally [40]. As the information material of the SHoT2018-study focused on "how the students *really* are and feel", one may speculate that this might lead to a higher participation rate of individuals who felt that the topic was of particular relevance to them. Since response rates are particularly important in prevalence studies, care should be taken when generalizing the current findings to the whole student population. Rather, it may be more appropriate to emphasize the associations, as these estimates are less prone to selection bias [41]. Using a web-based survey

approach may have contributed to the modest response rate, as electronic platforms have been shown to yield somewhat lower participation rates compared to traditional approaches [42,43]. However, there are also reports showing similar response rates between online and paper questionnaires [44]. Furthermore, the definition DSWPD was based on self-report, and consequently lacks clinical evaluation and measurement by sleep diary. Importantly, we had no information regarding the desired bedtime or adolescents' inability to fall asleep at the desired time which, according to the ICSD-3, is required in order to meet the criteria for a clinical diagnosis of DSWPD. Although self-reported sleep parameters, including SOL and WASO, typically differ from those obtained from objective assessments [45], recent studies have shown that such self-reported sleep assessments can be recommended for the characterization of sleep parameters in both clinical and population-based research [46]. Also, the accuracy of self-reported SOL and WASO are generally better in young adults compared to older individuals [47].

Finally, the data was collected from February to April in a geographical region with large differences in hours of daylight across the year, which may have had an effect on sleep and its timing. Studies from very high latitudes do indeed show some delay in sleep phase, with a slight increase in insomnia problems and fatigue during the winter as compared to the summer season [48–51]. DSWPD has also been linked to higher risk of seasonal affective disorder (SAD) [52]. However, findings from a large population-based study in Norway which collected data over a period of 2 years, found no evidence of monthly variations neither in insomnia rate nor time in bed [53], even though the amount of daylight varied from 4 to 21 h across the year. And with DSWPD being strongly linked to anomalies of the intrinsic circadian system, we do not consider variations in daylight hours to be a central issue in the current study.

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Conflict of interest

None declared.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2020.09.028.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2020.09.028.

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