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Weekday-to-weekend sleep duration patterns among young adults and outcomes related to health and academic performance

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Abstract

Background To examine whether weekday-to-weekend sleep duration (WWD) difference and specific WWD patterns are associated with mental and somatic health and academic performance in a student population.

Methods This study utilized cross-sectional data from the SHoT-2018 survey which includes responses from 50,054 full-time university/college students in Norway. Participants completed online questionnaires and reported sleep duration separately for weekdays and weekends. Medium sleep duration was defined as 7 to 9 h, short sleep duration as < 7 h and long sleep duration as > 9 h. Regression analyses were used to examine whether the degree and patterns of WWD was associated with health-related outcomes and academic performance.

Results The mean age of the sample was 23.2 years and comprised of 68.8% women. Most students (81.7%) slept longer on weekends compared to weekdays and 30.0% of the students reported a mean sleep duration shorter than 7 h. WWD difference was positively associated with higher odds of overweight/obesity, dissatisfaction with life, psychological distress, somatic burden and failed study exam. Concerning WWD patterns, the odds of students reporting unfavorably on the outcomes were particularly high for those who slept short on both weekdays and weekends, while those who slept short on weekdays seemed to benefit from sleeping longer ("catching up") on weekends.

Conclusions Overall, WWD was associated with adverse health outcomes for students. Short sleep duration both on weekday and weekend was associated with the most detrimental outcomes in terms of health and academic performance, while sleeping in on weekends may alleviate some of the detriments.

Keywords Weekday-to-weekend, Sleep duration, Students, Intra-individual variability, Sleep patterns

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Background

Sleep duration is strongly linked to daily function and health across all age groups (Gallicchio and Kalesan 2009; Silva et al. 2016; Matricciani et al. 2019). In young adults, the recommend sleep duration is 7 to 9 h per night (Hirshkowitz et al. 2015). However, a substantial proportion of young adults, including university and college students (hereinafter referred to as students), do not achieve this recommendation (Steptoe et al. 2006; Peltzer and Pengpid 2016; Sivertsen et al. 2019a, b). Both shorter and longer sleep duration are associated with higher risk of adverse health and well-being outcomes such as metabolic syndrome, mental disorders and even mortality (Cappuccio et al. 2010a, b; Åkerstedt et al. 2019; John et al. 2005; Itani et al. 2017). Previous studies in student populations have similarly shown that short and, to some degree, long sleep duration is associated with adverse health risk behavior, mental disorders, obesity and academic failure (Steptoe et al. 2006; Peltzer and Pengpid 2016; Vedaa et al. 2019; Sivertsen et al. 2021).

In addition to mean duration of sleep, there is increasing evidence that variability of sleep duration (e.g., day-to-day, weekday-to-weekend, between school term and school holidays) may be linked to a range of adverse health and impaired function outcomes (Bei et al. 2016). Individual variation or variability in sleep metrics is also referred to as intra-individual variability in sleep and may be influenced by a range of intrinsic and extrinsic factors (e.g., lifestyle, light exposure, genetics, environment, health disorders etc.) (Bei et al. 2016). Young adults have the highest degree of variability in their sleep duration among adults (Dillon et al. 2014). Students may be especially prone to variability in their sleep duration as many experience academic, social and economic demands which can influence their sleep priorities combined with less rigid curricular morning obligations compared to secondary school. Additionally, is well-established that adolescents and young adults typically demonstrate 'eveningness' (i.e., their chronotype preference is to be more active late in the day, to retire to bed later and to get up later) (Vitale et al. 2015; Enright and Refinetti 2017). This is partly due to the intrinsic circadian delay and slower build-up of homeostatic sleep drive associated with pubertal development that lasts into early adulthood (Randler et al. 2017).

The tendency to delay the circadian rhythm is usually influenced by daily entrainment of the sleep-wake rhythm of which light exposure is the most important zeitgeber (Münch et al. 2020). However, a mismatch can arise between the endogenous circadian rhythm of young adults and their environmental demands, something that may lead to short sleep duration on weeknights, often followed by compensatory sleep on weekends. In fact, such weekday-to-weekend sleep duration (WWD) difference, tend to peak during adolescence and early adulthood (Roenneberg et al. 2012) and has been shown to be highly prevalent among students, including in the sample used in the present study (Sivertsen et al. 2019a, b; Lund et al. 2010).

Beyond the prevalence of WWD difference, little is known about its associations to health and performance among students. Existing research tend to focus mainly on children, adolescents or adults in general, all of which are highly heterogeneous groups. For instance, employment status may affect WWD difference more than age in itself (e.g. young adults who enter the workforce may differ markedly from those who are students). A recent review of studies exploring associations of WWD differences among participants between the ages 6 and 24 years, underlines the wide range of health outcomes associated to WWD difference, including suicidality (Sun et al. 2019). Further, the review found a modest overall association between WWD difference and poor academic performance and depressive symptoms, as well as a higher risk of overweight/obesity and behavioral problems. An included study in this review, a large cross-sectional South Korean study among adolesecnts, even found that sleeping longer during weekends compared to weekdays was associated with suicidality. Only 2 of the 72 included studies in the review recruited students and investigated factors that correlated with WWD difference. One study found that larger WWD difference was correlated with poorer academic performance and more depressive symptoms, but not anxiety or body mass index (Wong et al. 2013). The other study, however, did not find a correlation between WWD and academic performance (Singleton and Wolfson 2009). A shared limitation with these 2 studies is that they have rather small samples (less than 1000 students included).

Whilst WWD difference on first account may appear detrimental, it may also constitute a natural feature of sleep (Dillon et al. 2014) and reflect a flexibility in sleep that might be favorable, or even necessary, in order to adapt to the demands of the environment. Extended weekend sleep, which entails longer sleep on weekends compared to weekdays has been associated with reduced obesity in children (Wing et al. 2009), and both lower risk of hypertension (Hwangbo et al. 2013) and mortality (Åkerstedt et al. 2019) in middle aged or older adults compared to short sleep throughout the week. To the best of our knowledge, no previous studies have examined whether extended weekend sleep compared to constant short sleep among students, in some respect might represent a protective behavior. In addition, no previous studies known to the authors have investigated the association between WWD patterns and health and performance in a large-scale population-based sample. Neither has there been any studies which explore the relation

between WWD patterns and somatic symptom burden or satisfaction with life among students. Given that WWD difference is prevalent among students and that research on WWD patterns and health is limited and opposing for this population, there is a need to further investigate this relationship.

The purpose of the present investigation was to gain a better understanding of WWD patterns in young adults. We aimed to examine whether WWD difference and specific WWD patterns were associated with mental and somatic health and academic performance in a large-scale population-based student sample.

Methods

Subjects and procedure

This study analyzed data from the Students' Health and Well-being Study (SHoT). This is a cross sectional national survey of students enrolled in higher education in Norway. The study was initiated by the three largest student welfare organizations in Norway and has been conducted every fourth year since 2010. Data presented in this study is from the SHoT2018 survey, conducted by the Norwegian Institute of Public Health, in which data was collected between February and April 2018. During these months, Norwegian students had curricular activities; however, the degree of mandatory participation varies significantly across different study programs. A full overview of the materials and methods of the SHoT2018 survey is published elsewhere (Sivertsen et al. 2019a, b). All full-time Norwegian students enrolled in higher education in Norway or abroad were invited electronically. Of the 162,512 eligible students to participate, 50,054 students completed the online questionnaire (30.8%).

Questionnaire

Demographic and lifestyle information

Data was collected regarding the participants age, sex, relationship status (`married/registered partner´, `cohabitant´, `romantic partner, but lives alone´, `single´), care for children (`yes´, `no´), financial difficulties ('never/seldom', 'sometimes', 'often'), average physical activity ('0 or <1 day', '3 days', '4 days'), work with income (`yes´, `no´), working night shifts (`yes´, `no´), study program (`one year´, `lower grade´, `higher grade´, `other´), chronotype preference (Morningness as 'Certainly morning type', Intermediate as 'More morning type than evening type' and 'More evening type than morning type', Eveningness as 'Certainly evening type') and use of alcohol by using the Alcohol Use Disorders Identification Test (AUDIT) (Saunders et al. 1993). Based on the AUDIT, the subgroup of `normal´ and `hazardous´ was made in accordance to the recommended cut-off by 8 points for hazardous alcohol use (Saunders et al. 1993). Reliability analyses of the AUDIT yielded a Cronbach's alpha of 0.76 in the current sample.

Sleep measure

Information about the participants sleep-wake cycle, sleep problems and chronotype preference were collected. The sleep questionnaire that was used is described in detail elsewhere (Sivertsen et al. 2019a, b). The students were asked about their usual bedtime (BT), rise time (RT), sleep onset latency (SOL) and wake after sleep onset (WASO) indicated by hours and minutes and data were reported separately for weekdays and weekends. Sleep duration was calculated as the time between BT and RT minus SOL and WASO. The weekly average sleep duration was calculated as (weekday sleep duration×5+weekend sleep duration×2)/7). For this study, missing values or reports of a sleep duration of less than 2 h or more than 16 h on weekend or weekday was excluded in accordance to other studies (Åkerstedt et al. 2019; Kripke et al. 2002). Sleep deficit was calculated by subtracting the reported sleep need from the reported sleep duration.

Psychological distress

The Hopkins Symptoms Checklist (HSCL-25) (Derogatis et al. 1974) was used to assess psychological distress. The HSCL-25 is a screening tool designed to detect symptoms of anxiety (10-item subscale) and depression (15-item subscale) during the past two weeks. One item about sleep (difficulties initiating and maintain sleep) was omitted from the composite score and replaced with the mean of the remaining items preventing overlapping outcomes to enable comparison with other studies (Vedaa et al. 2019). The total score sum of the items was divided by 25, giving an average score and dichotomized as no psychological distress (<2.0) versus psychological distress ($\geq$ 2.0) in alignment with previous reports from the SHoT studies (Knapstad et al. 2021). Reliability analyses of HSCL-25 yielded a Cronbach's alpha of 0.94.

Body mass index

Body mass index (BMI) was calculated as body weight in kilograms divided by the square of the height in meters and dichotomized as overweight/obesity ($\geq$25 kg/cm^2) or normal weight (<25 kg/cm^2) in accordance to the criteria of the World Health Organization.

Satisfaction with life

Satisfaction With Life Scale (SWLS) (Diener et al. 1985) is a 5-item scale that measures global cognitive judgements of life satisfaction. The total score ranges from five to 35, in which a higher score indicates higher quality of life. The score was dichotomized as 20 or greater (extremely satisfied/ satisfied/ slightly satisfied/neutral)

or below 20 (extremely dissatisfied/dissatisfied/slightly dissatisfied) (Pavot and Diener 2008). Reliability analyses in this study yielded a Cronbach's alpha of 0.89.

Somatic burden

Somatic burden was assessed by the Somatic Symptom Scale (SSS-8) (Gierk et al. 2014) which is an 8-item screening tool for detecting somatic symptoms during the last seven days. The SSS-8 is composed with a total score range of zero to 32, a higher score indicating a higher somatic symptom burden. The score was dichotomized as no/minimal/low/medium somatic symptom burden (<12) or high/very high somatic burden ($\geq$ 12, dichotomized to somatic burden). Reliability analysis yielded a Chronbach's alpha of 0.80.

Academic performance

Academic performance was assessed by the question: `Have you failed a study exam after you started studying at your college/university? ´ with the response options 'no' and 'yes'. Number of exams performed were not collected.

Statistical methods

All analyses were performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Normality of residuals were checked by visual inspection of histograms and Q-Q-plots. The association between the independent and dependent variables were presented as odds ratio (OR) in binary logistic regression analyses and beta-values (b) in linear regression analyses with 95% confidence intervals (CI).

Medium sleep duration was defined as sleeping 7 to 9 h (Hirshkowitz et al. 2015), short sleep duration was defined as <7 h and long sleep duration>9 h. In order to investigate associations between WWD patterns and physical and mental health, we created six different WWD pattern groups: (Gallicchio and Kalesan 2009) Those who report short sleep duration on weekdays and on weekends (Short-Short), (Silva et al. 2016) those who report short sleep duration on weekdays, but medium or long on weekends (Short-Medium/Long), (Matricciani et al. 2019) those who report medium sleep duration both on weekdays and on weekends (Medium-Medium), (Hirshkowitz et al. 2015) those who report long or medium sleep duration on weekdays, and short on weekends (Long-Short), (Steptoe et al. 2006) those who report medium sleep duration on weekdays and long sleep duration on weekends (Medium-Long), and finally (Peltzer and Pengpid 2016) those who report long sleep duration both on weekdays and weekends (Long-Long). Certain groups like Long-Medium had few participants and were included in combined groups like Long-Short as illustrated in Table (further details provided in Supplementary Figure S1).

When exploring the overall association to WWD difference, this was calculated as the absolute difference in number of hours slept on weekdays compared to weekend. Linear regression models were then conducted with WWD difference as an independent variable and BMI, psychological distress, satisfaction with life, and somatic symptom burden as dependent continuous variables. Academic performance was only available as a dichotomous variable, and logistic regression was therefore used for this association.

Binary logistic regressions were employed to examine the association between WWD patterns as independent variables and the dichotomized variables BMI, psychological distress, satisfaction with life, somatic symptom burden, and academic performance as dependent variables. Analyses were conducted separately for each dependent variable and with the Medium-Medium sleepers as the reference category. In order to compare the Short-Short sleepers with the Short-Medium/Long sleepers, additional analyses were run with Short-Short sleepers set as the reference group. For each of the dependent variables, three models were examined with adjustment of different covariates: (Gallicchio and Kalesan 2009) Model 1: unadjusted, (Silva et al. 2016) Model 2: adjusting for background variables including sex, age, relationship status, care for children, financial difficulties, use of alcohol, physical activity, work with income, and study program, (Matricciani et al. 2019) Model 3: Model 2+additional adjustment for chronotype preference and working night shifts.

Results

Sample characteristics

In total, 45,951 of the 50,054 participating students gave information about their sleep duration and were included in the current study. Table 1 present students background characteristics stratified by WWD patterns. The mean age of the sample was 23.2 years (Standard Deviations (SD) 3.3 years). Approximately two thirds of the sample were women (68.6%) and the mean sleep duration throughout the week was 7 44 min (SD 1 h 11 min), while 30.0% of the students reported a mean sleep duration less than 7 h. Around two thirds of the students who slept less than 7 h had a longer sleep duration on the weekend compared to on weekdays. The largest WWD pattern subgroup was the Medium-Medium sleepers (38.4%) (Table 2) and 8% of the total student sample had a short sleep duration (less than 7 h) throughout the week. The Short-Short sleepers reported a sleep need of 7 h 37 min (SD 1 h 28 min) and had a sleep deficit of 2 h 12 min (SD 1 h 51 min) on weekdays. Additionally,

Table 1 Demographic variables Demographical characteristics and lifestyle variables among students in the SHoT-2018 study stratified by weekday-to-weekend sleep duration group

	Short-Short		Short-Medium/Long		Medium-Medium		Long-Short		Medium-Long		Long-Long		Total	
	n = 3723	SD/(%)	*n* = 10,115	SD/(%)	*n* = 17,656	SD/(%)	*n* = 2827	SD/(%)	*n* = 9098	SD/(%)	*n* = 2532	SD/(%)	*N* = 45,951	SD/(%)
Sex, female	2549	(68.5)	7012	(69.3)	11,595	(65.7)	1914	(67.7)	6589	(72.4)	1874	(74.0)	31,533	(68.6)
Age groups														
18–20 years	522	(14.0)	1887	(18.7)	2767	(15.9)	506	(17.9)	1784	(19.8)	578	(23.2)	8044	(17.5)
21–22 years	931	(25.0)	3054	(30.2)	5355	(30.7)	921	(32.6)	3103	(34.5)	842	(33.7)	14,206	(30.9)
23–25 years	1121	(30.1)	3038	(30.0)	6025	(34.6)	883	(31.2)	2932	(32.6)	760	(30.4)	14,759	(32.1)
26–28 years	552	(14.8)	1221	(12.1)	2155	(12.4)	312	(11.0)	787	(8.8)	223	(8.9)	5250	(11.4)
29–35 years	537	(14.4)	781	(7.7)	1125	(6.5)	170	(6.0)	388	(4.3)	93	(3.7)	3094	(6.7)
Relationship status														
Single	2101	(56.4)	5221	(51.6)	8766	(49.7)	1610	(57.0)	3929	(43.3)	1107	(43.8)	22,734	(49.5)
Has children	557	(15.5)	480	(4.7)	825	(4.7)	172	(6.1)	158	(1.7)	43	(1.7)	2235	(4.9)
AUDIT														
Normal	1623	(43.6)	4117	(40.7)	7845	(44.4)	925	(32.7)	4272	(47.0)	1194	(47.2)	19,976	(43.5)
Hazardous	2100	(56.4)	5998	(59.3)	9811	(55.6)	1902	(67.3)	4826	(53.0)	1338	(52.8)	25,975	(56.5)
Chronotype preference														
Morningness	436	(11.7)	608	(6.0)	2060	(11.7)	268	(0.9.5)	593	(6.5)	131	(5.2)	4096	(8.9)
Intermediate	2062	(55.4)	5722	(56.6)	11,577	(65.7)	1743	(61.7)	5926	(65.3)	1510	(59.9)	28,540	(62.1)
Eveningness	1204	(32.3)	3761	(37.2)	3974	(22.6)	805	(28.5)	2557	(28.2)	881	(34.9)	13,182	(28.7)
Delayed Sleep Phase Syndrome	0	(0.0)	137	(1.4)	70	(0.4)	8	(0.3)	40	(0.4)	7	(0.3)	262	(0.6)
Insomnia complaints	2043	(54.9)	4635	(45.8)	4109	(23.3)	773	(27.3)	2029	(22.3)	475	(18.8)	14,064	(30.6)
Overweight/Obese	1391	(39.1)	3561	(36.7)	5098	(29.9)	942	(34.6)	2666	(30.5)	759	(31.2)	14,417	(32.6)
Somatic burden	1836	(52.7)	3997	(42.0)	4013	(24.2)	808	(31.0)	2188	(25.5)	637	(26.7)	13,479	(31.2)
Dissatisfied with life	1866	(50.1)	4088	(40.4)	4996	(28.3)	972	(34.4)	2505	(27.5)	767	(30.3)	15,194	(33.1)
Failed study exam	1511	(40.6)	3745	(37.0)	5481	(31.0)	1045	(37.0)	2666	(29.3)	886	(35.0)	15,334	(33.4)
Sleep duration mean	5:30	0:59	6:44	0:40	7:58	0:27	8:13	1:04	8:32	0:27	9:51	0:34	7:44	1:11
Sleep duration weekdays	5:26	1:08	6:03	0:49	7:52	0:33	8:36	1:06	8:02	0:35	9:46	0:38	7:27	1:20
Sleep duration weekend	5:44	1:04	8:28	1.00	8:15	0:33	6:16	1:12	9:48	0:36	10:03	0:45	8:26	1:21
Sleep duration need	7:37	1:28	7:54	1:17	7:56	0:58	8:04	1:13	8:17	1:05	8:42	1:16	8:01	1:10
Sleep deficit weekday	-2:12	1:51	-1:51	1:34	-0:05	1:04	0:32	1:25	-0:15	1:13	1:04	1:17	-0:35	1:38
Sleep deficit weekend	-1:53	1:49	0:34	1:28	0:18	1:05	-0:47	1:33	1:31	1:10	1:20	1:21	0:25	1:35

Table 2 Subgroups in combined weekday-to-weekend sleep duration groups

Combined group name	*n*	Subgroups included	*n*	Definition
Short-Short	3723	Short-Short	3723	Weekday TST < 7 h and weekend TST < 7 h
Short-Long	10,115	Short-Medium	7670	Weekday TST < 7 h and weekend TST 7–9 h
		Short-Long	2445	Weekday TST < 7 h and weekend TST > 9 h
Medium-Medium REF	17,656	Medium-Medium	17,656	Weekday TST 7–9 h and weekend TST 7–9 h
Long-Short	2827	Medium-Short	1460	Weekday TST 7–9 h and weekend TST < 7 h
		Long-Short	84	Weekday TST > 9 h and weekend TST < 7 h
		Long-Medium	1283	Weekday TST > 9 h and weekend TST 7–9 h
Medium-Long	9098	Medium-Long	9098	Weekday TST 7–9 h and weekend TST > 9 h
Long-Long	2532	Long-Long	2532	Weekday TST > 9 h and weekend TST > 9 h

REF; Reference group, TST; sleep duration (total sleep time), h; hours

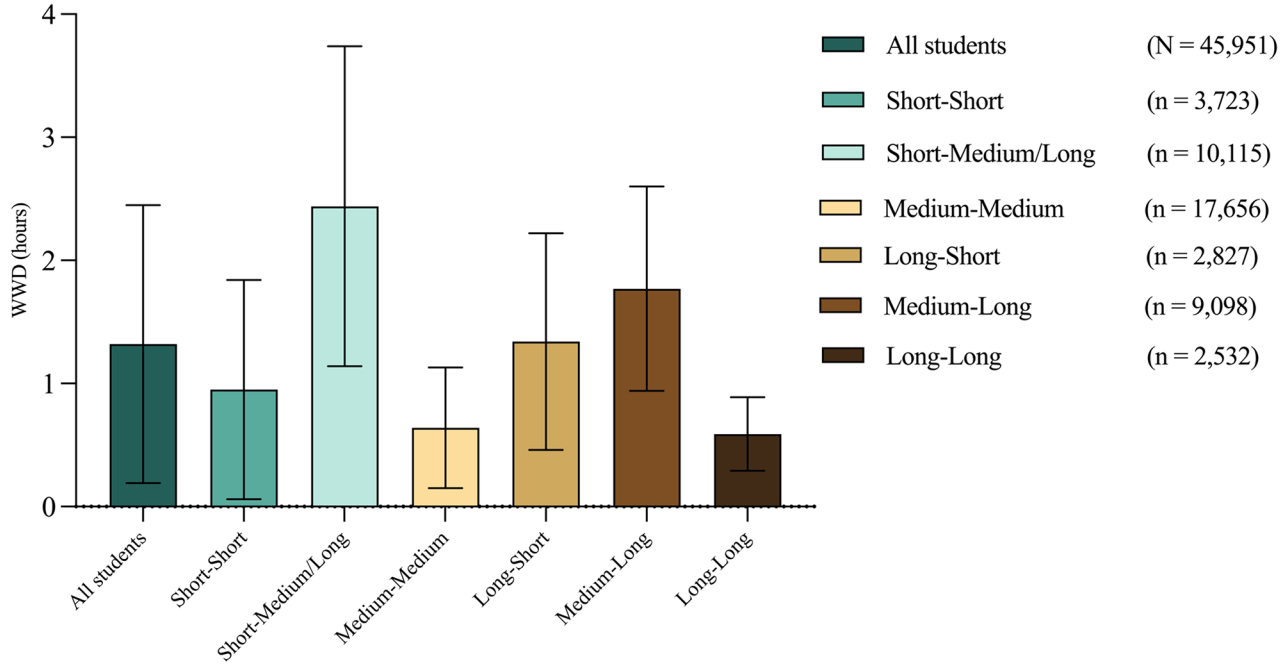

Fig. 1 Weekday-to-weekend sleep duration difference Mean weekday-to-weekend sleep duration difference (WWD) reported in hours in the different groups of weekday-to-weekend sleep duration patterns. Error bars indicate standard deviations

they were comparatively older, more frequently reported being married, having children and having insomnia complaints (54.9%).

Weekday-to-weekend sleep duration difference

There was a moderate correlation between weekday and weekend sleep duration (Pearson r=0.463, p=<0.001) in which 37,550 (81.7%) of the students had a longer sleep duration on weekends relative to weekdays. Among all responders, the mean WWD difference was 1 h 19 min (SD 1 h 6 min) equaling 1.3 h (Figs. 1) and 9,427 (20.5%) of the students had a WWD>2 h (not presented in figure). Short/Medium-Long sleepers had the highest WWD (2 h 26 min, SD 1 h 18 min) whereas the Long-Long sleepers had the lowest difference (35 min, SD 35 min) (Fig. 1). When using WWD difference as a continuous variable, the regression analyses demonstrated that greater WWD difference was associated with slightly higher BMI (b=0.10, 95% CI: 0.07 to 0.14, p=<0.001), marginally higher psychological distress score (b=0.04, 95% CI: 0.03 to 0.04, p=<0.001) and higher somatic symptom burden score (b=0.50, 95% CI: 0.45 to 0.54, p=<0.001), lower satisfaction with life score (b = -0.32, 95% CI -0.38 to -0.27, p<0.001) and higher odds of failed study exam (OR=1.03, 95% CI 1.00 to 1.04, p=0.050) (not presented in table).

Weekday-to-weekend sleep duration patterns

In logistic regression analyses, we found that, compared to Medium-Medium sleepers, being a Short-Short, Short-Medium/Long or Long-Short sleeper was associated with higher odds of overweight/obesity, above threshold for psychological distress, dissatisfaction with life, somatic burden, and failed study exam in both unadjusted and

adjusted regression models (Fig. 2, Supplementary Table S1). In the fully adjusted models, the OR (aOR) was particularly high for Short-Short sleepers: psychological distress (aOR=3.04; 95% CI: 2.80 to 3.30), somatic symptom burden (aOR=3.17; 95% CI: 2.92 to 3.46) and dissatisfaction with life (aOR=2.11; 95% CI: 1.95 to 2.28). In contrast, the Medium-Long and Long-Long sleep duration patterns were associated with a slightly lower odds of having a somatic burden or psychological distress compared to Medium-Medium sleepers, although they had a somewhat higher odds of overweight/obesity (Fig. 2). There was no clear association between WWD patterns and dissatisfaction with life. Medium-Long sleepers had a slightly lower odds of reporting failed study exam (OR=0.93, 95% CI 0.88 to 0.99), whereas Long-Long pattern was associated with higher odds of reporting failed study exam, compared to Medium-Medium sleepers (OR=1.20; 95% CI 1.09 to 1.31).

To investigate whether sleeping longer on the weekend had a compensatory effect, we compared the Short-Medium/Long sleepers with the Short-Short sleeping pattern as the reference group. In the fully adjusted logistic regression analysis, this comparison showed that those who had a medium or long sleep duration on weekends (Short-Medium/Long sleepers) had lower odds for psychological distress (OR 0.58, 95% CI: 0.53 to 0.63), dissatisfaction with life (OR=0.66, 95% CI: 0.63 to 0.74), somatic burden (OR=0.62, 95% CI: 0.57 to 0.67) and failed study exam (OR=0.77, 95% CI: 0.71 to 0.83) (Supplementary Table S2). However, there were no significant difference in terms of overweight/obesity between the two groups (OR=1.01, 95% CI: 0.93 to 1.10).

Discussion

This study examines whether WWD difference and WWD patterns among students are associated with outcomes related to health and academic performance. Overall, most students slept longer on weekends compared to weekdays, and having a higher WWD difference was associated with higher odds of overweight/obesity, psychological distress, somatic symptom burden, lower satisfaction with life and failed study exam. Further, after adjusting for multiple covariates including employment status and chronotype preference, the results suggest that a short sleeping duration on weekdays and/or weekends was associated with higher odds of experiencing adverse outcomes. However, students who slept short in weekdays and medium or long on weekends, had a lower

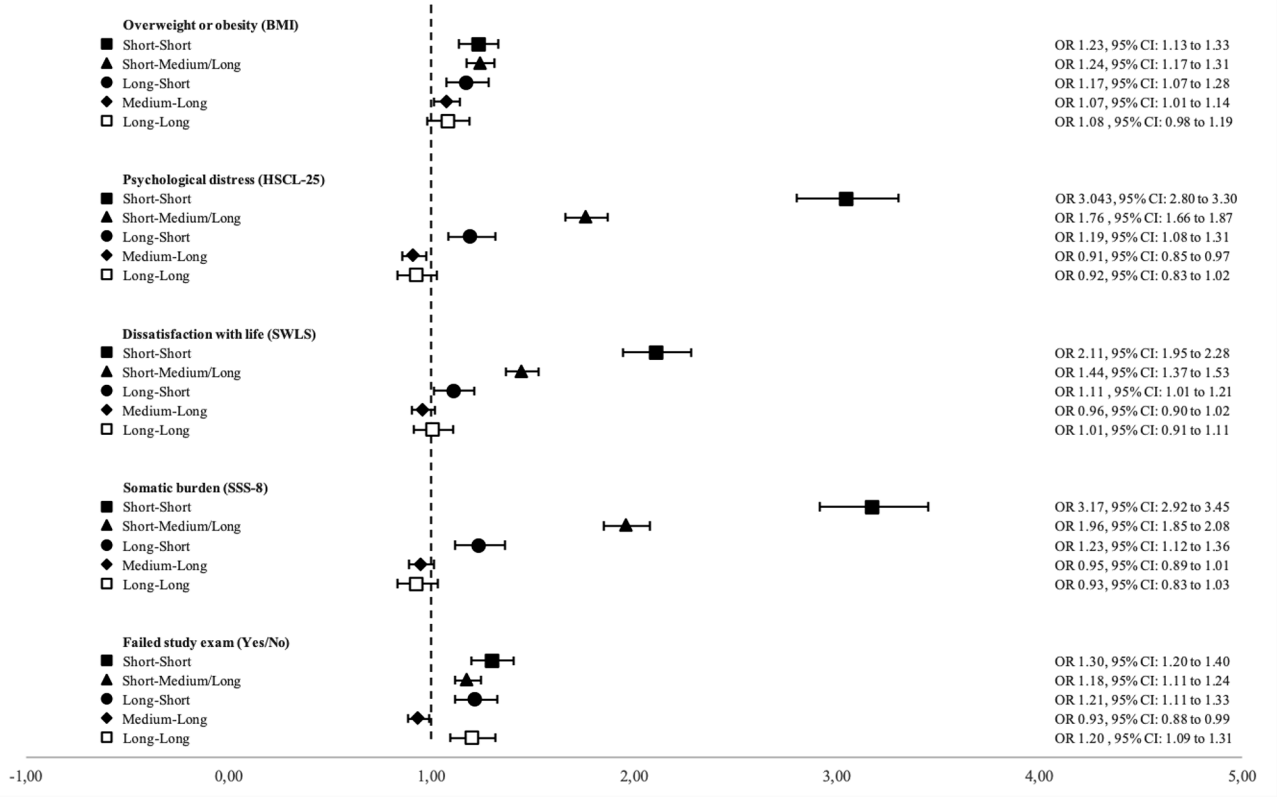

Fig. 2 Weekday-to-weekend sleep duration patterns and odds ratios for adverse outcomes Binary logistic regression analysis with values representing odds ratio (OR). Medium-Medium sleepers (OR = 1) is the reference category in all analyses. This figure presents model 3 in Supplementary Table S1 which adjusts for sex, age, relationship status, care for children, financial difficulties, use of alcohol (AUDIT), physical activity, work with income, study program, chronotype preference and working night shifts

odds of reporting psychological distress, somatic burden, failed study exam and dissatisfaction with life compared to students who had a short sleep duration throughout the week. Sleeping longer than 9 h both on weekdays and on weekends was associated with higher odds of failed study exam compared to sleeping between 7 and 9 h throughout the week.

There have been few previous investigations of WWD difference and WWD patterns among students. The mean WWD difference in the present sample was 1.3 h and is comparable to similar studies which have reported a WWD differences from 0.5 to 2.3 h (Wong et al. 2013; Tsai and Li 2004). Our findings support the notion that WWD difference is associated with unfavorable outcomes (Bei et al. 2016). To our knowledge, this is the first study on students that demonstrate a statistically significant positive association between WWD difference and the outcomes somatic symptom burden and dissatisfaction with life. The positive association between WWD difference and psychological distress and failed study exam supports similar findings in one previous study (Wong et al. 2013). This specific study was conducted in China (i.e. a different culture than that of the present sample), and although many of the results are overlapping, they did not find an association between WWD difference and BMI. The present study demonstrates a small positive association between WWD difference and BMI; it is possible to speculate whether this could be because of the larger sample size and akin ease to detect small associations.

Current research exploring the mechanisms between WWD difference and outcomes of health and function remain scarce, but there are some findings of interest. Large WWD differences can diminish the reward-related brain function (Hasler et al. 2012), which in turn possibly could explain why WWD difference is associated with psychological distress and lower satisfaction with life. In another study, sleeping-in late on weekends appears to have a subsequent cost with so-called 'Monday morning blues' (also called 'social jet lag'); a delay of the circadian rhythm and increased daytime sleepiness and fatigue the following weekdays (Taylor et al. 2008). Although we can only speculate, this may be one underlying mechanism accounting for the association with somatic burden – the outcome that in our findings was most strongly associated to WWD patterns in the present study.

Students who had a shorter duration of sleep throughout the week had notably higher odds than the other WWD patterns in terms of reporting dissatisfaction with life, psychological distress, somatic burden and academic failure. Our findings therefore support previous studies showing a wide range of negative health associations of overall short sleep for young adults (Vedaa et al. 2019; Sivertsen et al. 2021) and demonstrate that this is also the case when comparing short sleep throughout the week to other WWD patterns. Although the present study was based on cross-sectional data, other studies have used longitudinal designs and demonstrated a similar association between short sleep and adverse health and performance outcomes (Kalak et al. 2014; Xie et al. 2021). It is nevertheless a need for further studies experimental study designs that can make casual conclusions. Further, studies should also investigate possible reasons of why a majority of students vary their sleep duration throughout the week and sleep less than they are recommended to do. More than 50% of students in the present study who reported short sleep throughout the week, also had insomnia complaints. Insomnia disorder may be an involuntary reason of sleeping short throughout the week as short sleep duration is considered to be a phenotype of insomnia disorder (Vgontzas et al. 2013; Bathgate et al. 2017). Making efficacious insomnia treatments (Riemann et al. 2023) more accessible to students may have potential for improving the experience of their sleep duration in this group, although many studies indicate that the overall sleep duration (measured by day-to-day recordings) is not increased by such interventions (Vedaa et al. 2020; Rochefort et al. 2019).

One reason for having WWD difference for students may be a misalignment between their circadian rhythms and curricular obligations. Thus, one may suggest that chronotherapeutic educational interventions could help to advance the circadian rhythms. However, educational school-based interventions to increase sleep length have so far shown to have minimal effect on students' sleep, with some exceptions in individual studies (Kaar et al. 2021). Structural measures have so far shown to have a better effect on the sleep of young people. One study have shown that if the start times of school/lectures is delayed by 25–60 min in the morning, the sleep duration for young people increases correspondingly on weekdays (Minges and Redeker 2016). Later start times in the morning has also been associated with reduced daytime sleepiness among students, fewer depressive symptoms, better attendance, alertness and grades, and the incidence of traffic accidents among young people may decrease (Minges and Redeker 2016; Wheaton et al. 2016; Vedaa et al. 2012).

The students sleeping short on weekdays and longer on weekends, had highest degree of WWD difference and reported to be most sleep deprived on weekdays. Our findings show that that this group, relative to those sleeping overall short, had lower odds for reporting psychological distress and somatic symptom burden, as well as lower odds of reporting being dissatisfied with their life or having failed a study exam. Students who reported medium or long sleep duration on weekdays and longer weekend sleep duration, also had a tendency of less

psychological distress and failed study exam, relative to those who slept medium throughout the week, but the ORs were not consistently statistically significant for all tested outcomes and the effect sizes were small. Thus, our results could imply that short sleep is detrimental, but could be less of a risk factor if combined with sleeping medium or long on weekends. Overall, this might indicate that the ability and possibility to sleep somewhat longer on weekends is better than not doing so as it could be a protective factor although this compensation may not be sufficient to achieve health values comparable to the student's sleeping medium throughout the week.

The general advice for maintaining healthy sleep and circadian rhythm typically means that you keep sleep duration stable throughout the week. However, our findings are in line with some other studies that suggest benefits of sleeping longer on weekends. For instance, one cohort study found lower mortality in adults who slept short on weekdays and longer in weekends compared to those sleeping short throughout the week (Åkerstedt et al. 2019). Although we cannot be sure if the longer sleep duration on weekends was in fact compensatory or merely extended sleep in our study, the self-reported data of sleep deficit in our study strengthens an assumption that the longer weekend sleep could be compensatory. For instance, the group who slept short on weekdays and longer on weekends reported weekday sleep deficit and sufficient weekend sleep. Although the ability to "catch up" on sleep on weekends may be advantageous, there is likely an upper limit with individual differences on how much one can prolong sleep on weekends before the beneficial aspects are outweigh by possible problems (e.g., due to a substantially delay in circadian rhythms). The degree of beneficial and unbeneficial WWD difference is little investigated. Another unexplored aspect of WWD difference is that the same degree of WWD difference could be experienced very differently and have dissimilar consequences for an individual based for instance on their chronotype preference, personality, mental or somatic health.

Students who slept more than the recommended 9 h on both weekdays and weekends had higher odds for reporting failed study exam, compared to students sleeping medium (7 to 9 h). However, sleeping more than 9 h was not associated with being overweight/obesity, dissatisfied with life, having somatic burden nor having psychological distress. These findings are somewhat contrary to other studies in the general adult population which long sleep has been associated with negative health outcomes and mortality (Cappuccio et al. 2010a, b), but support previous findings that long sleep duration is less of a concern than short sleep duration among young adults (Steptoe et al. 2006). For young adults, the biological need for sleep may be somewhat higher than that of older age groups. It is also the case that the adverse health outcomes associated with long sleep in previous studies to some extent may be an expression of underlying disease (especially for older adults) whereas this might be less prevalent in student populations.

Limitations and strengths

The findings of this study should be considered in light of several limitations. Foremost, the cross-sectional design of the study precludes causal inferences based on our findings. Additionally, the response rate of 31% imply that we must exercise caution when generalizing the findings to the entire student population. Another limitation pertains to the fact the data are self-reported which in itself could result in inaccuracies (Tsuchiyama et al. 2003). However, the phenomena dissatisfaction with life, somatic symptom burden and psychological distress are by nature subjective, making self-report possibly the best method of measuring. Academic performance was somewhat narrowly assessed through only one question pertaining exam failure. The sleep data in this study are participants' single estimation of mean weekday and weekend sleep duration, with obvious limitations in terms of precision. Further, we have examined sleep duration without considering the possible impact of the timing of their sleep. It is conceivable that the relationship between WWD difference and the outcome variables investigated in this study is also affected by when the individuals sleep in relation to their circadian rhythm. Although these are aspects not considered in this study, we have adjusted for the participants' chronotype preference, which to some extent represents people's timing of their sleep. Another possible limitation is that the assessment of sleep in this study does not consider whether the participants take naps. We know from previous studies that young adults can often use naps to compensate for insufficient night time sleep, and that this can significantly affect function during the day, but also contribute in creating and maintain sleep problems. The major strength of the present study is the large sample size which gives us sufficient statistical power to conduct subgroup analyses. The detailed sleep measures used in this epidemiological study is also a strength. Additionally, the analyses are adjusting for important background factors like employment status and chronotype preference which might otherwise have impacted the results.

Conclusions

Our study indicates, that students having a stable sleep duration of minimum 7 hours throughout the week, have less risk for adverse outcomes of health and academic performance. Sleeping overall short was associated with higher odds for negative health and academic failure, whereas sleeping 7 to 9 hours on weekdays and

9 hours or more on weekends was associated with lower odds of these outcomes. Students who attained more than 9 hours sleep throughout the week did not have higher odds of negative health outcomes compared to those who slept 7 to 9 hours, but a slightly higher odds of failed study exam which may implicate that having an upper sleep recommendation for young adults is of less relevance compared to short sleep. Our findings show that, compared to sleeping short throughout the week, it may be a health and academic advantage to sleep longer on weekends. In other words, when short sleep is the only alternative on weekdays, perhaps students should be advised to 'catch-up sleep' during weekends, at least up to a certain point. This could reflect a positive effect of compensatory sleep. Since our study precludes inferences about directionality, it remains to assess this in controlled studies which can determine causality.

Abbreviations

aOR	Odds Ratio in adjusted models
AUDIT	Alcohol Use Disorders Identification Test
b	Beta-values
BMI	Body Mass Index
BT	Bed Time
CI	Confidence Intervals
HSCL-25	The Hopkins Symptoms Checklist
OR	Odds Ratio
RT	Rise Time
SD	Standard Deviation
SHoT	Students' Health and Well-being Study
SOL	Sleep Onset Latency
SSS-8	Somatic Symptom Scale
SWLS	Satisfaction With Life Scale
WASO	Wake After Sleep Onset
WWD	Weekday-to-Weekend Sleep Duration

Supplementary Information

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Supplementary Material 1

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Author contributions

The concept was drafted by CLV and ØV. HK and BS assisted in the paper conceptualization CLV, ØV and MRS contributed to the analysis design. CLV did the formal analysis and investigation. CLV did the original draft preparation. MRS, HK, ØV, BS, KS, JS reviewed and modified the original manuscript. All authors read and approved final manuscript.

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Data availability

The data that support the findings of this study is in the SHoT2018 which is administrated by the National Institute of Public Health. Approval from a Norwegian regional committee for medical and health research ethics [https://helseforskning.etikkom.no] is a pre-requirement for the availability of these data.

Declarations

Ethics approval and consent to participate

The SHoT2018 study was approved by the Regional Committee for Medical and Health Research Ethics in Western Norway (no.2017/1176). All participants gave informed consent electronically.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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