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RESEARCH ARTICLE

Adolescents' preference for later school start times

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Summary

As the chronotype delays progressively throughout puberty, early morning school start times (SSTs) contradict the sleep biology of adolescents. Various studies have demonstrated beneficial effects of later SSTs on sleep and health; however, adolescents' preferences for SSTs have to date never been investigated in detail. The present online survey study aimed to fill this gap and explored influencing factors. A total of 17 high schools in the Canton of Zurich, Switzerland, circulated the survey among their students. Participants were included if they reported their sex, age, and school (n = 5,308). Students indicated whether they preferred later SSTs. Additionally, five predictor blocks were assessed: sociodemographic, school-related, sleep, leisure-time, and health-related characteristics. We applied multivariate logistic regression models with fixed and random effects to predict the preference. The mean (SD) age of the students was 16.09 (1.76) years (65.1% female). The majority (63.2%) endorsed later SSTs with a preferred delay of 55 min (interquartile range 25–75 min). In the multilevel analysis (n = 2,627), sex, mother tongue, sleep characteristics, mobile device use at bedtime, caffeine consumption, and health-related quality of life were significant predictors for the preference. Hence, the majority of adolescents preferred later SSTs, and especially those with sleep or health-related problems. These characteristics have been consistently shown to improve after delaying SSTs. Thus, also from adolescents' view, later SSTs should be considered to improve the adolescents' health.

KEYWORDS
circadian rhythms, first morning lesson, high school, multilevel logistic regression analysis, online survey

1 | INTRODUCTION

Many adolescents suffer from chronic sleep deficits, which is especially concerning as sleep plays an important role throughout development (Gradisar et al., 2011; Owens et al., 2014; Volk & Huber, 2015). Indeed, the consequences of these sleep decrements are manifold, including increased daytime sleepiness, worse school performance, attentional and emotional regulation deficits, increased risk-taking behaviour (e.g. drug use), and mental and physical health complaints (Gibson et al., 2006; Millman, 2005; Owens et al., 2014).

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Whereas psychosocial influences, caffeine intake, and the use of digital devices are certainly among important contributors (Cain & Gradisar, 2010; Owens et al., 2014), a substantial body of evidence shows that the maturation of sleep regulation is one of the key factors (Carskadon, 2011; Crowley et al., 2007; Jenni & O'Connor, 2005). Circadian sleep phase preference delays progressively from childhood through adolescence (Carskadon et al., 1993; Randler et al., 2017; Roenneberg et al., 2004); correspondingly, adolescents tend to perform better in the afternoon than in the morning (Escribano & Díaz-Morales, 2014). Conversely, the build-up of sleep pressure (i.e. feeling tired), which enables an ideal time window for going to sleep and is therefore a key factor for a smooth transition into sleep, has been shown to be slower in adolescents than in younger children (Jenni et al., 2005).

Taken together, these biologically induced changes result in adolescents going to sleep later in the evening, but their sleep need does not show a corresponding decline (Carskadon, 2011; Crowley et al., 2007; Gradisar et al., 2011; Millman, 2005; Owens et al., 2014). At the same time, most schools start early in the morning, and thus, do not allow adolescents to sleep long enough to compensate for later bedtimes. Consequently, early school start times (SSTs) in the morning contradict the adolescents' sleep biology, and the majority do not obtain enough sleep on school days (Bowers & Moyer, 2017; Cain & Gradisar, 2010; Millman, 2005; Minges & Redeker, 2016; Owens et al., 2014; Wahlstrom & Owens, 2017). Likewise, numerous studies from all around the world have shown that adolescents at schools with later morning SSTs obtain more sleep, and the increased sleep duration is accompanied by improvements in daytime sleepiness, sleep difficulties, mental and physical health, school attendance/tardiness, and risk behaviour (Boergers et al., 2014; Bowers & Moyer, 2017; Minges & Redeker, 2016; Owens et al., 2014; Wahlstrom & Owens, 2017). Some studies have even shown better school performance for students at later-starting schools, but there is also conflicting evidence (Wahlstrom & Owens, 2017). From this perspective, delaying SST is a possible solution to counteract the common sleep deficit of adolescents. Needless to say, multiple other factors influence the preference for later SSTs. Opposing voices argue that school lessons would inevitably be extended towards the evening, which would conflict with extracurricular or leisure-time activities, consequently hampering the acceptance of later SSTs by adolescents (Kirby et al., 2011).

However, to the best of our knowledge, adolescents' preference for SSTs has to date never been investigated in detail. The aim of the present exploratory study was to fill this research gap, with a focus on factors associated with the preference. Sleep and health-related characteristics previously shown to be affected by SST were assessed. Additionally, we included sociodemographic, school-related, and leisure-time parameters, which might influence the preference for SSTs (e.g. actual SST, commute time to school, regular leisure-time activities such as sports). This in-depth analysis of adolescents' preference for later SSTs provides a better understanding of their perspective and needs.

2 | METHODS

2.1 | Participants

This cross-sectional online survey was approved by the local Ethical Review Board and conducted at the University Children's Hospital Zurich, Switzerland. The survey period spanned from May 2017 to July 2017 (i.e. during the school period). A total of 17 of the 20 public high schools in the canton of Zurich supported the study and agreed to circulate the survey among their 13,843 registered students. Overall, 6,252 students (45.2%) started the survey, but 899 (14.4%) did not answer any question. Furthermore, 45 students were excluded because they attended a non-public high school (n = 9) or data were missing regarding their sex, age, or school (n = 36). In total, 5,308 students were included (38% participation rate, ranging from 13% to 71% for the individual schools, probably related to the number of teachers who actually advertised the study).

2.2 | Procedure

The survey was created using LimeSurvey (www.limesurvey.org/de) in German. Participation was voluntary and anonymous. Students who answered the survey were offered participation in a voucher raffle (27 gift cards, total value CHF 2000 [Swiss francs]).

2.3 | Measures

The measures were selected based on the current literature and with an exploratory approach.

2.4 | Preference for later SSTs

The students were asked whether they would like the first morning lesson to start later (yes/no). Additionally, they indicated their preferred time for the first morning lesson, which was used to calculate the preferred shift from their actual SST. Also, they were asked about opportunities in their schedule to compensate for later SSTs (e.g. shorter breaks) and indicated their preferred option for recovering time (short morning break, short afternoon break, long morning break, long afternoon break, lunch break, free afternoons, "don't know", other).

2.5 | Potentially influencing characteristics were grouped in 5 blocks

2.5.1 | Sociodemographic characteristics

Sex, age, and mother tongue were assessed. Mother tongue was dichotomised in Swiss German versus non-Swiss German as an

indicator for different cultural environments, as sleep behaviour is also influenced by cultural norms (Jenni & O'Connor, 2005).

2.5.2 | School-related characteristics

The students were asked how long their school commute took and whether they used public (e.g. bus, train) or private transportation (e.g. bicycle, by foot). The beginning of the first morning lesson and the lunch break duration were taken from sample timetables provided by the schools. As the school day does not start on every day in the first morning lesson (but sometimes in the second or later), the students indicated their individual SST for each school day. Hence, the frequency of having school in the first morning lesson was defined (0–5 times a school week). Additionally, the following school-related variables were assessed:

- Number of optional lessons per week (i.e. voluntary lessons the students can choose to sign up for),
- Average learning time per day outside of regular school hours (e.g. homework),
- Current school stress on a 5-point Likert scale from "none/not present" to "very strong",
- And the average school grade in the last certificate using five categories according to the Swiss grading system from "insufficient grades" (Grades <4 of maximum 6) to "very good to excellent grades" (Grades >5.5 of maximum 6).

2.5.3 | Sleep characteristics

Sleep–wake patterns were assessed separately for scheduled (SC; e.g. school days) and free days (FR; e.g. weekend days) according to the Munich Chronotype Questionnaire (MCTQ; Roenneberg et al., 2003). The students indicated the respective clock times (e.g. bedtime) on a ruler (1-min steps). The sleep period was calculated afterwards as the time between bedtime and wake-up time. The sleep phase preference, or chronotype (MSFsc), was determined by the mid-sleep point (hr:min), which is highly correlated with other circadian markers (Simpkin et al., 2014). Many adolescents sleep less on SC days and partly compensate this sleep deficit by sleeping longer on FR days (Crowley et al., 2007; Gradisar et al., 2011; Owens et al., 2014). Consequently, the mid-sleep point needs to be corrected for the confounding sleep deficit accumulated during SC days based on the weekly sleep duration (Roenneberg et al., 2003).

The average sleep period was calculated by averaging the weighted sleep periods for SC and FR days ([5 × sleep period SC + 2 × sleep period FR]/7). The sleep deficit was determined as the difference between sleep period on SC and FR days (FR–SC days). The higher the positive difference, the greater the sleep deficit.

To assess sleep difficulties, six questions of the School Sleep Habits Survey were used (SSHS; Carskadon et al., 1991; Table 1). Daytime sleepiness was assessed with a shortened and slightly adapted version of the Epworth Sleepiness Scale (ESS; Johns, 1991). Students had to rate their sleepiness on a 4-point Likert scale in the following situations: while watching television, movies, and videos, as a passenger in a car during a 1-hr drive without a break, and as a listener in a lecture at school. Answers were summed to a total score (range 0–9, one missing value allowed).

2.5.4 | Leisure-time activities

Students were asked about the amount of screen time per day (in hours, e.g. smartphone, tablet, iPad, computer) and about the frequency with which they used a mobile device (their cellphone or a tablet) specifically at bedtime per week (from never [0] to every day [5]). Additionally, they indicated whether they had regular leisure-time activities (yes/no, e.g. sports, music), and students aged >16 years were asked whether they had a regular paid job (yes/no).

2.5.5 | Health-related characteristics

The students were asked whether they were affected by a chronic physical or mental disease (yes/no). Furthermore, their average caffeine consumption per week was assessed (food and beverages containing caffeine; total score ranging from 0 to 20). Students aged >16 years were asked whether they smoked and how much alcohol they consumed per week (total score ranging from 0 to 15). Health-related quality of life (HRQoL) was assessed with the KIDSCREEN-10 validated questionnaire (Ravens-Sieberer et al.,

TABLE 1 Frequency (%) of sleep problems within the last 2 weeks before the assessment (n = 5,308)

	Sleep problems, *n* (%)				
Frequency of sleep problems	**Arriving too late at school due to oversleeping**	**Falling asleep at school lesson**	**Going to bed very early in the evening**	**Difficulties falling asleep in the evening**	**Problems sleeping through the night**
Never	3,869 (72.9)	3,580 (67.4)	1,893 (35.7)	1,308 (24.6)	2,916 (54.9)
Once or twice	964 (15.2)	1,067 (20.1)	1,465 (27.6)	1,244 (23.4)	1,299 (24.5)
3–4 times	227 (4.3)	305 (5.7)	968 (18.2)	950 (17.9)	490 (9.2)
>4 times	88 (1.6)	196 (3.7)	820 (15.5)	1645 (30.9)	439 (8.3)
Missing	160 (3.0)	160 (3.0)	162 (3.1)	161 (3.0)	164 (3.1)

2010). Total scores were transformed into T-values (higher values indicate better HRQoL).

2.6 | Statistical analyses

The data was analysed using SPSS, version 24 (IBM Corp., Armonk, NY) and RStudio 1.0.153. Two-tailed tests were used for all analyses, and $p < .05$ was considered significant. Variables with non-normal distributions (Kolmogorov–Smirnov test) are presented with median and interquartile range (IQR), others with mean and standard deviation (*SD*). Wilcoxon signed-rank tests were performed to compare sleep–wake patterns.

To investigate how the preference for later SSTs is influenced, multivariate logistic regression models with mixed effects were calculated using the *glmer* function in RStudio (lme4 package; Bates et al., 2015). As the students attended different schools, the data structure is hierarchical and thus requires a multilevel model with fixed and random effects (Hox, 2010). As a first exploratory step, we investigated whether the predictor blocks had a significant influence on the preference for later SSTs. For this purpose, we calculated a separate model for each predictor block:

- Model 1: Preference~Sociodemographic characteristics
- Model 2: Preference~School-related characteristics
- Model 3: Preference~Sleep characteristics
- Model 4: Preference~Leisure-time activities
- Model 5: Preference~Health-related characteristics

Then, we tested these models against the null model consisting only of the intercept using likelihood ratio tests. If the test was significant, the characteristics contained in this model (i.e. the predictor block) were included in the final analysis. Thus, the final model presented in this article contains all predictor blocks, which improved the prediction of the preference for later SSTs.

The conditional coefficient of determination (R^2) to estimate the explained variance in generalised mixed models is reported (theoretical method, MuMIn package Barton, 2020; Nakagawa et al., 2017).

3 | RESULTS

3.1 | Sociodemographic and school-related characteristics

The adolescents (65.1% females) attended 17 schools with similar SSTs (mean [range] 07:45 [07:30–08:05] hours; Table 2). The majority of students (54.1%) reported starting school three to four times per week in the first morning lesson. Most schools' lunch break lasted ~1 hr (mean [*SD*] 1.02 [0.12] hr). The commute to school took a

TABLE 2 Samples' characteristics (n = 5,308)

Characteristic	Value
Female sex, *n* (%)	3,454 (65.1)
Age, years, mean (*SD*; range)	16.09 (1.76; 10–23)
≥16 years, *n* (%)	3,433 (64.7)
Mother tongue, *n* (%)	
Swiss German	3,593 (67.7)
Other	1,681 (31.7)
Missing	34 (0.6)
Frequency of having school in the first morning lesson per weak, *n* (%) students	
Never	173 (3.3)
Once or twice	1,182 (22.3)
3–4 times	2,726 (51.4)
5 times	1,201 (22.6)
Missing	26 (0.4)
Duration of school lunch break (min), *n* (%) students	
45	345 (6.5)
55–65	4,067 (76.6)
70–75	896 (16.9)
Optional lessons per week, *n* (%)	
None	2,830 (53.3)
One	1,596 (30.1)
More than one	862 (16.2)
Missing	20 (0.4)
Duration of commute to school, min, mean (*SD*; range)	31.69 (16.11; 1–150)
Means of transport, *n* (%) students	
Public	4,078 (76.8)
Private	1,209 (22.8)
Missing	21 (0.4)
Homework/learning time per day, hr, mean (*SD*; range)	1.67 (1.10; 0–8.00)
Current school stress, *n* (%) students	
None	304 (5.7)
Small	1,727 (32.5)
Rather strong	1,694 (31.9)
Strong	1,094 (19.8)
Very strong	516 (9.7)
Missing	18 (0.3)
Last average school grades (Swiss grading system), *n* (%) students	
Insufficient (<4)	177 (3.3)
Sufficient to good (4–4.5)	1,992 (37.5)
Good (4.6–5)	2,170 (40.9)
Good to very good (5.1–5.5)	853 (16.1)
Very good to excellent (5.6–6)	98 (1.8)
Missing	18 (0.3)

Abbreviations: *SD*, standard deviation.

mean (*SD*) of 31.69 (16.11) min, with the majority of students (76.8%) using public transport. In addition to regular school, the students learned for a mean (*SD*) of 1.67 (1.10) hr/day. School stress was rated as "rather strong" or higher by 61.4%. Almost all students (96.3%) reported sufficient grades in the last certificate.

3.2 | Sleep characteristics

Sleep–wake patterns were significantly later on FR days than on SC days (Table 3). The median (IQR) sleep period was 8.29 (7.68–8.81) hr. However, the adolescents had a median (IQR) sleep deficit of 1.75 (0.75–2.67) hr on SC days. The MSFsc was on average at 03:52 hours (03:10–04:41 hours). Within the last 2 weeks before the assessment, ~30% of the students arrived at school late at least once due to oversleeping and/or fell asleep during a school lesson (Table 1). Furthermore, ~60% reported going to bed very early at least once in this time period. The most frequently indicated insomnia problem was difficulty falling asleep (30.9% more than four times in the last two weeks). The mean (*SD*) daytime sleepiness score was 4.05 (2.26).

3.3 | Leisure-time activities

Regular leisure-time activities were reported by 65.7%. Screen time amounted to a daily mean (*SD*) of 2.61 (2.08) hr. Approximately 70% of the adolescents indicated that they had used a mobile device at bedtime.

3.4 | Health-related characteristics

Nearly three-quarters reported no physical (72.6%) or mental illness (74.9%). Most students (75%) regularly consumed caffeine. Among students aged >16 years, 16.1% reported that they had a regular paid job alongside school. Of the students aged >16 years, 60.0% reported regularly consuming alcohol and 6.7% reported smoking (19.2% missing). The mean (*SD*) HRQoL score was 43.49 (8.65). Of the 10 items, being full of energy (31.1%), having enough time for themselves (26.9%), and being able to do things they wanted in their free time (25.9%) were rated the least frequently (never/seldom).

3.5 | Preference for later SSTs in the morning

Later SSTs were endorsed by 63.2% of the students (24.7% indicated no, 12.1% missing). The mean (*SD*) preferred SST was at 08:38 (00:37) hours, which corresponds to a preferred delay of 55 min (IQR 25–75 min). Only 3.0% indicated a preference for an earlier SST. To compensate for the later SST, 26.1% selected shortening the lunch break and 20% shortening the long morning or afternoon break. In contrast, shortening the smaller breaks (13.1%) or cancelling a free afternoon (5.7%) were less frequently selected (23.7% missing; 11.5% reported that they did not know how to compensate).

3.6 | Multilevel analysis for the preference for later SSTs

As a first step, we investigated which predictor blocks significantly improved the prediction of the preference for later SSTs. Each logistic regression model containing one of the predictor blocks (i.e. the characteristics belonging to it) was significantly better than the null model. Therefore, all predictor blocks were included in the final analysis.

In total, 2,627 students were then included in the multivariate logistic regression analysis with fixed and random effects (50.5% were excluded because of partially incomplete data). Excluded adolescents reported similar preferences for later SSTs as the included ones (χ^2 = .47, p = .50), but they differed in regard to sex (χ^2 = 20.73, p < .001) and age (Z = −45.11, p < .001), as more boys than girls and more younger adolescents than older ones were excluded (Table 4).

The model accounted for 30% of the total variance (R^2 = 0.30). Among sociodemographic characteristics, male sex and non-Swiss-German mother tongue were significantly associated with the preference for later SSTs. School-related characteristics were not significant predictors. Except for three variables (falling asleep at school, waking up too early, difficulties sleeping through the night), all sleep-related characteristics significantly predicted the preference for later SSTs. Longer average sleep period, later chronotype (MSFsc), greater sleep deficits, and higher daytime sleepiness increased the probability of preferring later SSTs by between 1.17 and 1.46. Furthermore, the frequency of arriving late at school and going to bed very early, and difficulty falling asleep were all significantly associated with the preference. Mobile device use at bedtime was the only significant predictor of the leisure-time activities. Among health-related characteristics, greater weekly caffeine consumption and lower HRQoL increased the probability of preferring later SSTs.

4 | DISCUSSION

The present exploratory study is the first to investigate in detail adolescents' preference for later SSTs. For this purpose, we analysed the survey responses of 5,308 students from public high schools in the Canton of Zurich in Switzerland. The results provide further evidence for insufficient sleep amongst adolescents, and the majority (63.2%) indicated a preference for later SSTs. The average preferred SST was at 08:38 hours, which corresponds to a delay of almost 1 hr from the actual SSTs between 07:30 and 08:05 hours. Notably, only 3% reported preferring earlier SSTs. To compensate for later SSTs, many students selected shortening the lunch break or the longer breaks in the morning or afternoon. Sociodemographic, school-related, sleep,

TABLE 3 Descriptive statistics for self-reported sleep–wake patterns on scheduled and free days and for all days combined

	Scheduled days			Free days					
Variable	***n***	**Median (IQR)**	**Mean (*SD*)**	***n***	**Median (IQR)**	**Mean (*SD*)**	***n***	***p*[a]**	**Effect size *d*[b]**
Bedtime, hours	4,993	22:30 (22:00–23:00)	22:35 (00:56)	4,811	24:00 (23:00–01.00)	23:53 (01:26)	4,811	<.001	−1.07
Lights-off time, hours	4,170	23:00 (22:15–23:30)	22:55 (00:54)	4,186	24:00 (23:10–01:00)	24:13 (01:23)	3,849	<.001	−1.11
Wake-up time, hours	4,932	06:15 (06:00–06:30)	06:18 (00:29)	4,782	09:15 (08:30–10:00)	09:23 (01:25)	4,740	<.001	−2.93
Get-up time, hours	4,909	06:30 (06:10–6:45)	06:29 (00:31)	4,757	09:50 (09:00–10:45)	09:53 (1:29)	4,701	<.001	−3.06
Sleep period, hr	4,932	7.75 (7.08–8.33)	7.71 (1.02)	4,782	9.50 (8.50–10.50)	9.29 (1.26)	4,740	<.001	−1.43
Mid-sleep point time, hours	4,932	02:45 (02:02–02:45)	02:26 (00:33)	4,782	04:30 (03:45–05:25)	04:38 (01:14)	4,740	<.001	−2.31

	All days combined		
	n	**Median (IQR)**	**Mean (*SD*)**
Average sleep period[c], hr	4,740	8.29 (7.68–8.81)	8.22 (0.92)
Sleep deficit duration, hr	4,740	1.75 (0.75–2.67)	1.79 (1.54)
MSFsc, hours	4,740	03:52 (03:10–04:41)	04:00 (01:13)

IQR, interquartile range; MSFsc, mid-sleep point corrected for sleep deficit accumulated during scheduled days; *SD*, standard deviation.

[a]Wilcoxon test was performed.

[b]Effect size according to Cohen's *d* was calculated (0.20, small effect; 0.50, medium effect; >0.80, large effect) (Cohen, 1962).

[c]Average sleep period defined by weighted sleep period for scheduled and free days = (5 × sleep period on SC + 2 × sleep period on FR)/7.

TABLE 4 Summary of multilevel logistic regression analysis with preference for later school start times in the morning as dependent variable (n = 2,627)

	Prediction of the preference for later school start		
Fixed effects	***B***	***SE B***	**OR (95% CI)**
Intercept	1.69	3.76	
Sociodemographic characteristics			
Age, years	0.00	0.05	1.00 (0.91–1.11)
Male sex	0.40***	0.12	1.49 (1.18–1.89)
Non-Swiss German mother tongue	0.37**	0.11	1.45 (1.16–1.81)
School-related characteristics			
School start time, hr:min	−0.66	0.44	0.52 (0.22–1.23)
School first lesson, frequency/week	0.02	0.04	1.02 (0.94–1.11)
Lunch time duration, min	0.33	0.53	1.39 (0.49–3.92)
Commute to school duration, min	−0.18	0.22	0.83 (0.54–1.28)
Private transport	−0.23	0.14	0.79 (0.60–1.04)
Learning time duration, hr	−0.01	0.05	0.99 (0.90–1.08)
Number of optional lessons/week	0.03	0.05	1.03 (0.93–1.14)
School stress, scale 1–5	0.04	0.06	1.04 (0.93–1.17)
Last average school grade, scale 1–5	0.04	0.06	1.05 (0.92–1.18)
Sleep characteristics			
Average sleep period, hr	0.18***	0.06	1.20 (1.06–1.35)
Sleep deficit, hr	0.15***	0.04	1.17 (1.09–1.25)
MSFsc, hr:min	0.38***	0.05	1.46 (1.32–1.62)
Arriving late at school, frequency	0.29***	0.07	1.34 (1.17–1.52)
Falling asleep at school, frequency	0.06	0.04	1.06 (0.98–1.15)
Going to bed very early, frequency	0.09***	0.02	1.10 (1.05–1.14)
Waking up too early, frequency	−0.02	0.02	0.98 (0.94–1.03)
Difficulties falling asleep, frequency	0.03*	0.01	1.03 (1.00–1.06)
Difficulties sleeping through the night, frequency	0.03	0.02	1.03 (0.98–1.08)
Daytime sleepiness score, range 0–9	0.13***	0.03	1.13 (1.08–1.19)
Leisure-time activities			
Regular leisure activities, yes/no	−0.11	0.12	0.90 (0.70–1.14)
Job, yes/no	0.19	0.12	1.21 (0.95–1.53)
Screen time/ day, hr	0.04	0.03	1.04 (0.99–1.09)
Mobile device use at bedtime, frequency	0.09**	0.03	1.10 (1.02–1.17)
Health-related characteristics			
Physical illness, yes/no	−0.26	0.16	0.77 (0.56–1.06)
Mental illness, yes/no	−0.17	0.20	0.84 (0.57–1.26)
Smoking, yes/no	−0.22	0.22	0.81 (0.52–1.25)
Number of caffeinated drinks/week	0.04*	0.02	1.04 (1.01–1.07)
Number of alcoholic drinks/week	0.01	0.03	1.01 (0.95–1.07)
HRQoL	−0.03***	0.01	0.97 (0.95–0.98)
Random effects	**Variance**	**SD**	
School	0.01	0.11	

B, regression coefficients; CI, confidence interval; HRQoL, health-related quality of life; OR, odds ratio; *SE B*, standard error of regression coefficients.

*p < .05, **p < .01, ***p < .001.

leisure-time, and health-related characteristics were all shown to be important predictors. In the final analysis including all predictors, sex, mother tongue, sleep characteristics, mobile device use at bedtime, caffeine consumption, and HRQoL were significantly associated with the preference for later SSTs.

In our present sample, 65% were female, which can at least partially be explained by the higher percentage of females attending high school in Switzerland (SKBF, 2018). The observed sleep period and the rather late chronotype are in the expected range (Gradisar et al., 2011; Roenneberg et al., 2004). As has been reported frequently (Crowley et al., 2007; Gradisar et al., 2011; Roenneberg et al., 2004), the students slept less on school days (7.75 hr) than on free days (9.5 hr), leading to a sleep deficit of 1.75 hr. The frequency of sleep-related problems was comparable with previous reports (Gibson et al., 2006; Gradisar et al., 2011).

In the multilevel analysis, sex had the highest odds ratio (OR): males were 1.49 (95% confidence interval [CI] 1.18–1.89) times likelier to prefer later SSTs than females, presumably linked to differential changes in sleep regulation over the course of development (Roenneberg et al., 2004). In addition, having a foreign mother tongue increased the probability of a preference. Cultural differences in social conventions and dining times might account for this (Jenni & O'Connor, 2005). In contrast, age was not a significant predictor.

None of the school-related characteristics significantly predicted the preference. We caution against the interpretation that these characteristics are not important contributors, as some of the associations might be incorporated within relations with other characteristics included in the analysis. For example, we assumed that longer commutes to school would increase the preference for later SSTs because those adolescents need to rise even earlier. Similarly, longer learning times, lower grades, more school stress, and a greater number of free subjects might result in later bedtimes and/or less sleep. Because sleep-related characteristics were controlled for in the model, the effects might have been mitigated.

Sleep characteristics, except for three variables (falling asleep at school, waking up too early, difficulties sleeping through the night), were all significant predictors for the preference. As expected, chronotype was the most important one (OR 1.46, 95% CI 1.32–1.62): the later an adolescent's sleep phase, the likelier a preference for later SSTs was indicated. Additionally, students with a longer sleep period (as an indicator of greater sleep need), higher sleep deficit, more frequent sleep problems, and increased daytime sleepiness were more likely to prefer later SSTs. Among leisure-time activities, mobile device use at bedtime, which can cause hyperarousal and interfere with falling asleep (Owens et al., 2014), increased the probability of a preference. Recently, Kater and Schlarb (2020) proposed that not the duration of mobile device use, but rather the motive to do so explains the sleep-disruptive effect (i.e. problem-avoidance). In sum, the more problematic the adolescent's sleep behaviour, the likelier was a preference for later SSTs.

While neither a physical or mental illness nor smoking affected the preference, caffeine consumption showed a significant association. Among health-related characteristics, HRQoL was the most predictive: adolescents with lower HRQoL were more likely to prefer later SSTs than those with higher values.

Taken together, although adolescents generally endorsed later SSTs, those with poor sleep, higher caffeine consumption, or lower HRQoL were especially likely to prefer later SSTs. Crucially, these characteristics have been shown most consistently to improve after delaying SST (Boergers et al., 2014; Bowers & Moyer, 2017; Minges & Redeker, 2016; Owens et al., 2014; Wahlstrom & Owens, 2017). Thus, it is likely that the adolescents assessed in the present study would benefit from later SSTs. Alternatively, or concomitantly, cognitive–behavioural strategies and parental involvement may help to reduce the chronic sleep deprivation of adolescents (Blake et al., 2017; Short et al., 2011).

The strengths of the present study include its exploratory approach, the large number of students who responded within a short period of time, and the diversity of characteristics examined. However, some limitations should be mentioned. First, the cross-sectional design only allows associations to be established. Second, the study was based on self-reports, which are prone to biases such as social desirability. Additionally, estimating sleep period using retrospectively reported bedtimes and wake-up times might be imprecise. Future studies should include more objective data. Third, more boys than girls and more younger adolescents than older ones were excluded from the multilevel analysis, and HRQoL was lower than normative values. However, comparable data of high school students in Switzerland are currently not available and further studies are required to replicate and explain this unexpected finding. Also, the generalisability might be limited as all adolescents went to school in Switzerland. Fourth, the validity of the shortened version of the ESS remains to be investigated. Fifth, other variables not considered in the present study (e.g. parental characteristics) might also affect the preference for later SSTs. Lastly, other important stakeholder's views on SST, such as teachers and parents, and cultural differences should also be incorporated. Additionally, in the present study, the preference for later SSTs was assessed dichotomously (yes versus no). Including more detailed answer alternatives, e.g. "Yes, as long as school won't end later in the afternoon", would provide more specific insights.

In conclusion, while controlling for sociodemographic and school-related characteristics as well as leisure-time activities, we found that sleep and health-related characteristics (caffeine consumption and HRQoL) have a major influence on adolescents' preference for later SSTs. Due to the biologically determined delay in sleep phase during puberty, early SSTs contradict the sleep biology of adolescents (Bowers & Moyer, 2017; Carskadon et al., 1993; Escribano & Díaz-Morales, 2014; Jenni et al., 2005; Minges & Redeker, 2016; Owens et al., 2014; Roenneberg et al., 2004; Wahlstrom & Owens, 2017). Thus, a delay of SST, as preferred by the majority of adolescents, may be considered as a way of improving the health of adolescents.

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CONFLICT OF INTERESTS

All authors declare no conflict of interest.

AUTHOR CONTRIBUTION

HW designed the study, coordinated and supervised data acquisition and analysis, and drafted the initial manuscript. JNA continued the analyses, drafted the manuscript, and critically reviewed and revised the manuscript. NW and DJ acquired the data, carried out the initial analyses and reviewed the manuscript. As principal co-investigators RH and OGJ conceptualised the study, supervised the study team, and critically reviewed the manuscript for important intellectual content. All authors had full access to all the data, approved the final manuscript as submitted, and agree to be accountable for all aspects of the work.

DATA AVAILABILITY STATEMENT

The data underlying this article may be shared on request to the corresponding author.

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