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Research article

Sitting time in different contexts in Austrian adolescents and association with weight status

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Abstract: The detrimental effects of high amounts of sedentary time on various health outcomes have been well documented. Particularly among youth, there are many sedentary pursuits that compete with active leisure time choices, which contribute to a high prevalence of insufficiently active children and adolescents. Therefore, the present study examined the time spent in various sedentary behaviors and the association with body weight in Austrian adolescents. Sedentary time was assessed with the "Heidelberg Questionnaire to Record the Sitting Behavior of Children and Adolescents" for 1225 (49.8% male) middle- and high-school students between 11 and 17 years of age. Their body weights and heights were measured with participants wearing gym clothes. The weight categories were established based on body mass index (BMI) percentiles using the German reference system. The average daily sedentary time across the entire sample was 12.0 ± 1.6 h, and 45% of the sedentary behaviors during the entire week were attributed to schoolwork. Normal weight participants reported a lower amount of sitting time compared to their overweight and obese peers, where they spent more time with physical activity and sleeping. Specifically, a higher body weight was associated with more time spent with recreational sedentary behaviors, while differences across the weight categories were limited for work-related sitting. Given the detrimental health effects of high amounts of sedentary behaviors, additional efforts are needed to promote physical activity in adolescents, particularly for those with an excess body weight. As almost half of the sedentary behaviors were attributed to work, schools could be a particularly viable setting for interventions that target an active lifestyle.

Keywords: sedentary lifestyle; overweight; obesity; sitting time; physical activity; adolescents; school; health

1. Introduction

Physical activity or lack thereof plays an important role in the development of overweight and obesity, in addition to genetic predispositions, sociodemographic factors, and an energy-dense diet [1–4]. In epidemiological studies, obesity and being overweight are often associated with a lack of physical activity [5,6]. Accordingly, Blair [7] described physical inactivity as the main health problem of the 21st century. Sedentary behavior, which refers to activities with low energy expenditure (<1.5 metabolic equivalents (METs), whereby one MET approximately corresponds to the resting metabolic rate of the body when lying down [8]), and activities in a reclining position during waking hours [9]; however, this factor has been shown to be independently associated with various health outcomes [10,11].

The latest global estimates from the WHO impressively confirm the problem of excessive sedentary time and show that more than three quarters of young people spend most of their free time sitting [12]. For example, a recent study in Austrian children and adolescents showed that more than 70% of their waking hours was spent with seated behaviors [13]. The study further showed an increase in the sedentary time during the transition from childhood into adolescence. Moreover, research indicates that the sitting time is higher by about two hours per day in overweight and obese adults compared to people with normal body weights [14,15]. Given that sedentary behavior is an independent risk factor for all-cause mortality [16] and mental health issues [17], and the fact that an increase in a daily sitting time of 60 minutes has been associated with an 11% increase in the risk for cardiovascular disease, overweight and obese people are particularly affected [18–20].

Although some studies have shown a stagnating trend in the prevalence of overweight individuals at a high level in developed countries [21], there has been a continuous increase in overweight individuals and obesity across the globe in recent decades [22]. For example, the obesity rate among five to nineteen-year-old children and adolescents in Europe was around five times higher in 2016 than in 1975 [23]. In Austria, the number of overweight and obese children and adolescents is currently estimated at 25% to 30%, depending on the region [24]; in some European countries, the prevalence of obesity and being overweight in children and adolescents has even risen to over 40%, reaching alarming proportions [20]. Although some studies in older adults have shown that overweight and obese people spend more time sitting each day than people of normal weights [14,15,18,25,26], there is currently a lack of research that examines the association between sitting behaviors and weight status in adolescents. Given the increase in sedentary time during adolescence and the potential detrimental long-term health consequences of excess body weight at young ages [13,27], the aim of this study was to examine the amount of sedentary time in Austrian adolescents in different settings and to determine the association between their weight status and their daily sitting times. It was hypothesized that a higher body mass index (BMI) is associated with a higher amount of sitting.

2. Materials and methods

The present study examined the amount of time spent in various sedentary behaviors and the association with the weight statuses of 11- to 17-year-old secondary school students. Using a list of all secondary schools (middle and high schools with students between grades 5 and 12) within the Federal State of Tyrol in western Austria, 10 schools were randomly selected for participation. Four schools declined to participate due to organizational reasons, which resulted in a possible sample size of more than 2000 students from the remaining six schools. The study was approved by the responsible school authority (Tyrolean Directorate of Education) and the Institutional Review Board of the University of Innsbruck (clearance certificate, 31/2022). Prior to data collection, the parents were informed about the study in writing and their written consent was obtained. Data collection occurred between March 2023 and April 2023, where students at the participating schools completed a questionnaire.

2.1. Assessment of daily sitting behavior

The time spent in various seated activities was assessed with the "Heidelberg Questionnaire to Record the Sitting Behavior of Children and Adolescents", which has been shown to provide valid estimates of sedentary behaviors in youths [28]. Specifically, the participants reported the amount of time (hours/day), rounded to the nearest 0.5 hours, for the following activities, separately for school-/weekdays and the weekend:

(1) Sleeping (time spent lying down);
(2) Eating (time spent sitting);
(3) Working while sitting at school;
(4) Working while sitting at home;
(5) Travelling time while sitting;
(6) Recreational screen use (e.g., games, computer, television, cinema);
(7) Other recreational sedentary behaviors (e.g., reading); and
(8) Physical activity.

As time spent in various behaviors were reported separately for weekdays (Monday to Friday) and weekend days (Saturday/Sunday), the average weekly values were calculated using the formula (hours weekday × 5 + hours weekend × 2)/7. In order to assure the accuracy of the data, the individual dimensions were first checked for plausibility. Questionnaires with logically incomprehensible outliers (e.g., total hours per day > or <24) were excluded from the analysis. Of the total of 1311 returned questionnaires, 1225 questionnaires were included in the analysis.

2.2. Assessment of weight status

The students' heights and weights were measured in light sportswear without shoes (barefoot) in the schools' gymnasium. The heights were measured with an accuracy of 0.1 cm using a mobile stadiometer (SECA® 213, Seca; Hamburg, Germany) and the body weights were measured with an accuracy of 0.1 kg using a calibrated body scale (SECA® 803, Seca; Hamburg, Germany). Based on these values, the students' BMIs (kg/m²) were calculated. Due to growth-related changes in the relationship of body weight and height, along with physiological alterations in body fatness, the BMI needs to be interpreted relative to the age and sex of the children and adolescents [29]. Therefore, the

BMI values were converted to BMI percentiles according to the German BMI reference system of Kromeyer-Hauschild et al. [30]. Based on this system, a BMI percentile between 10 and 90 was considered a normal weight. Students with values below the 3rd percentile were categorized as anorexic, and those between the 3rd and 10th percentile as underweight. If the BMI was between the 90th and 97th percentile, the students were categorized as being overweight, and participants with values above the 97th percentile were considered to be obese. For the analysis, the BMI values were categorized into 4 groups: underweight, normal weight, overweight, and obese, as no person was below the 3rd percentile and would have been classified as anorexic.

2.3. Data analysis

For the interval-scaled data, the means and standard deviations were calculated. Frequencies are presented for nominal and ordinal scaled data. As the sample included more than 1000 students, a parametric analysis was carried out to examine differences in the sitting times across the weight categories. In addition, differences in the sedentary behaviors between weekdays and the weekend were examined for the total sample and across the weight categories. Prior to the analyses, the distribution shapes were graphically checked for a bell-shaped progression and symmetry. Statistical processing and the analysis of the collected data was performed using the statistical program SPSS, version 29 (IBM Corporation, Armonk, NY), and the MedCal Statistical Software, version 22.021 (MedCalc Software Ltd, Ostend, Belgium). Statistical significance was set at $p < 0.05$ with a Bonferroni adjustment for multiple comparisons.

3. Results

1225 students (610 male; 615 female) between 11 and 17 years of age were included in the analyses. While there was no sex difference in age, the male participants were significantly taller and heavier than female participants ($p < 0.01$). Additionally, the male participants displayed higher BMI percentiles than their female peers ($p < 0.01$) (Table 1).

Table 1. Anthropometric data of the study total population and separately for male and female participants. Values are mean with standard deviation.

	Total sample	Male participants	Female participants
Age (years)	13.3 ± 1.9	13.3 ± 1.9	13.3 ± 1.9
Height (cm)	161.4 ± 11.0	163.8 ± 12.3	158.9 ± 8.8
Weight (kg)	54.2 ± 13.8	56.6 ± 15.0	51.8 ± 12.1
BMI Percentile	60.8 +27.0	64.9 ± 26.1	56.6 ± 27.2

According to the Kromeyer-Hauschild classification [30], the majority of the participants (75.9%) were of a normal weight, while 3.7% were underweight, 14.3% were overweight, and 6.1% were obese. However, there was a significant difference in the prevalence of overweight individuals/obesity between the sexes ($p < 0.01$). While an average of 16.2% of the female students were classified as either overweight or obese across the entire study population, the prevalence of overweight individuals/obesity was 24.6% among male students.

3.1. Time spent in sedentary behaviors by weight status

The 3 major behavioral indices used (physical activity, sedentary behavior, and sleep) essentially showed a symmetrical bell-shaped distribution pattern. Across the entire sample, the average daily physical activity time was 3.4 ± 1.2 hours, the average daily sitting time was 11.9 ± 1.6 hours, and the average daily sleep time was 8.4 ± 1.0 hours. No significant sex differences were observed for the time spent in physical activity, sedentary behaviors, and sleep. The average daily sitting time was 12.0 ± 1.6 h for the female participants and 11.9 ± 1.6 h for the male participants; the average daily sleep time was 8.4 ± 1.0 h in both cases and the average daily physical activity time was 3.4 ± 1.2 h for the female participants and 3.5 ± 1.2 h for the male students.

Given the small number of underweight participants, along with the fact that the time spent in the 3 major activity indices did not significantly differ from the normal weight participants, the underweight participants were included in the normal weight category in the subsequent analyses. The normal weight participants significantly differed from the overweight and obese participants in all major activity indices ($p < 0.01$). Specifically, the average daily sitting time increased from 11.7 ± 1.4 h for the normal-weight participants to 12.5 ± 1.8 h for the overweight participants and 13.4 ± 1.9 h for the obese participants; the average daily sleep time decreased from 8.5 ± 0.9 h for the normal weight participants to 8.2 ± 1.0 h for the overweight participants and 8.0 ± 1.2 h for the obese participants. Moreover, the average daily physical activity time declined from 3.5 ± 1.2 h for the normal weight participants to 3.2 ± 1.4 h for the overweight participants and 2.5 ± 1.3 h for the obese participants (Figure 1). Accordingly, the amount of time spent sitting during waking hours increased from 76.8% for the normal weight participants to 79.7% for the overweight participants and 84.5% for the obese participants.

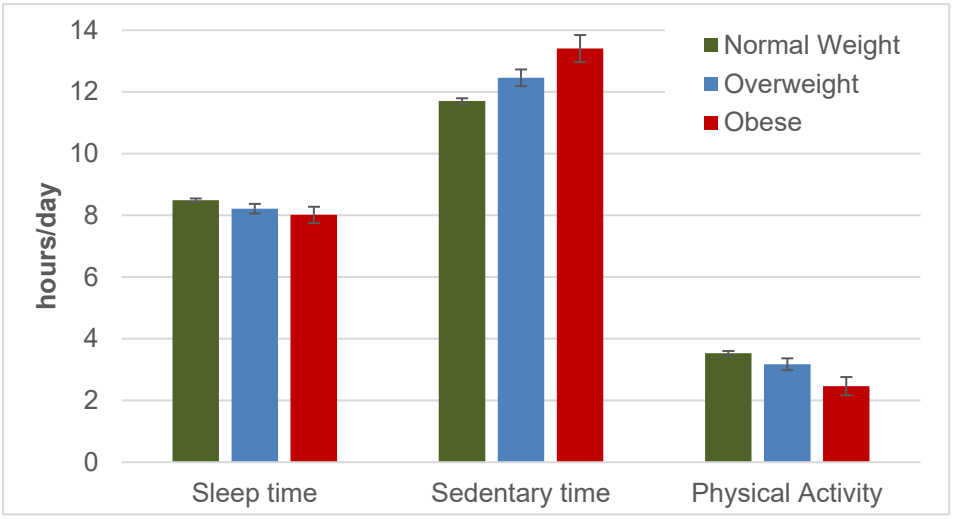

Figure 1. Mean daily sleep time, sitting time and time spent in physical activity in normal weight (including underweight), overweight and obese participants. Values are means with 95% CI.

Considering specific seated behaviors separately, 44.5% of the sitting times were attributed to work, while 25.5% and 18.4% were attributed to the recreational use of electronic media and other

recreational pursuits, respectively. Additionally, the spent in specific sedentary behaviors significantly differed across the weight categories (Table 2). The sitting times increased across the weight categories in all categories (p for trend <0.01), except for the sitting times while eating, where no difference was observed. These results remained essentially unchanged after adjusting for age.

Table 2. Daily sedentary time by weight category. Values are mean ± standard deviation.

	Normalweight	Overweight	Obese
Sitting while eating (hours/day)	1.4 ± 0.5	1.3 ± 0.5	1.3 ± 0.5
Sitting for work (hours/day)*,[2]	5.2 ± 0.7	5.4 ± 0.8	5.5 ± 1.0
Sitting while using electronic media (hours/day)[2,3]	3.0 ± 1.1	3.2 ± 1.0	3.6 ± 1.4
Sitting for other recreational pursuits (hours/day)[1,2]	2.1 ± 1.0	2.4 ± 1.0	2.7 ± 1.3

Note: * includes sitting time in school on weekdays;
[1] sig. difference between normal weight and overweight ($p < 0.05$, after Bonferroni adjustment);
[2] sig. difference between normal weight and obese ($p < 0.05$, after Bonferroni adjustment);
[3] sig. difference between overweight and obese ($p < 0.05$, after Bonferroni adjustment).

Sex specific analyses revealed no differences across the weight categories for sitting for work in the female participants. However, the normal weight girls spent significantly less time sitting while using electronic media compared to obese girls ($p < 0.01$), and less time sitting for other recreational pursuits compared to overweight girls ($p = 0.01$). Among the boys, a normal weight was associated with a lower sitting time for work and recreation (media use and other recreational pursuits) compared to obese boys ($p < 0.02$), while there were no significant differences between normal weight and overweight participants (Figure 2).

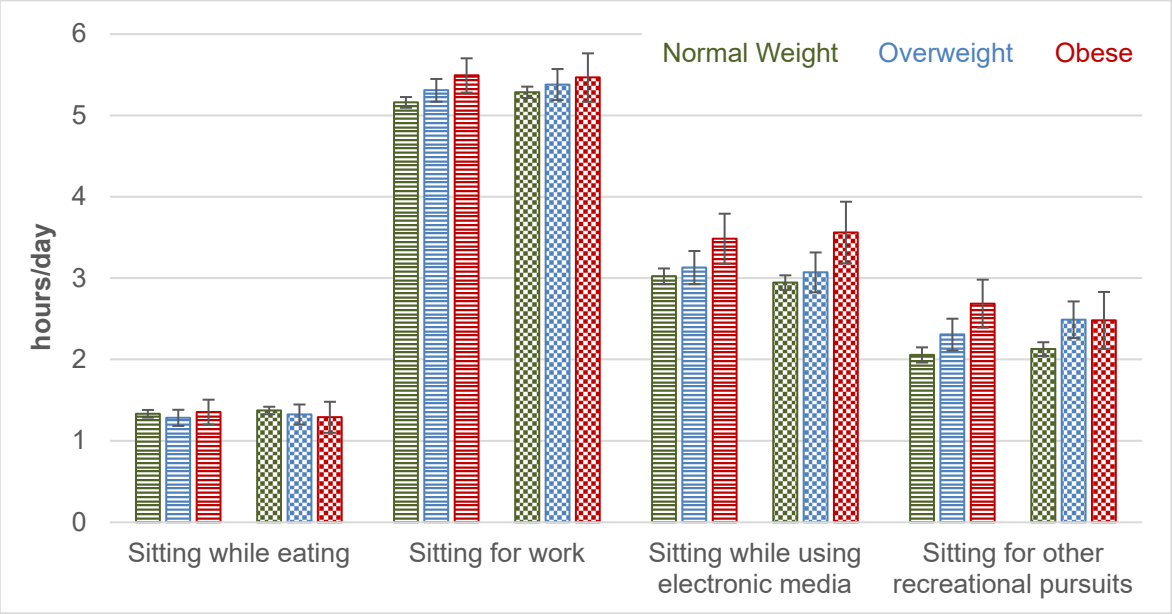

Figure 2. Daily sitting time in different behaviors separately for male and female participants. Values are means adjusted for age and 95% CI.

3.2. Comparison weekday/weekend day

Across the entire study population, the time spent in various pursuits significantly differed between weekday and the weekend ($p < 0.01$). The sleep time, the time spent sitting while eating, and the sitting time for recreational pursuits (media and other) were longer on the weekends, while the time spent sitting for work at home was longer on the weekdays. These results were similar across different weight groups, which resulted in significantly higher sitting times in the recreational pursuits of overweight and obese participants on both the weekdays and the weekend, while the time spent sitting for work at home and for meals did not differ across the weight categories (Table 3).

Table 3. Sedentary pursuits on weekdays and the weekend across weight categories. Values are mean ± standard deviation.

	Normal weight		Overweight		Obese	
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
Sleep (hours/day)	7.9 ± 1.1	9.9 ± 1.3	7.6 ± 1.3	9.7 ± 1.3	7.3 ± 1.3	9.8 ± 1.9
Sitting while eating (hours/day)	1.2 ± 0.6	1.7 ± 0.6	1.2 ± 0.5	1.7 ± 0.6	1.2 ± 0.6	1.6 ± 0.7
Sitting work at home (hours/day)[2]	1.5 ± 0.8	1.1 ± 0.8	1.7 ± 0.6	1.2 ± 0.8	1.8 ± 1.1	1.4 ± 1.1
Sitting using electronic media (hours/day)[1,2,a,b]	2.6 ± 1.2	3.9 ± 1.5	2.8 ± 0.9	4.1 ± 1.6	3.1 ± 1.4	4.8 ± 2.0
Sitting other recreational pursuits (hours/day)[1,2,a]	1.7 ± 1.1	3.0 ± 1.3	2.0 ± 1.1	3.4 ± 1.4	2.4 ± 1.4	3.4 ± 1.6

Note: [1] sig. difference between normal weight and overweight participants on weekdays ($p < 0.05$);
[2] sig. difference between normal weight and obese participants on weekdays ($p < 0.05$);
[a] sig. difference between normal weight and obese participants during weekend ($p < 0.05$);
[b] sig, difference between overweight and obese participants during weekend ($p < 0.05$).

In addition, it could be shown that differences between the weekdays and the weekend were more pronounced in the obese participants for the sleep time and sitting while eating compared to those with normal body weights ($p < 0.05$). Moreover, the obese participants displayed a higher difference in sitting using electronic media between the weekdays and the weekend compared to the overweight and normal weight participants ($p < 0.05$) (Figure 3). There were no differences in the increase in sedentary pursuits from the weekdays to the weekend between the normal weight and overweight participants.

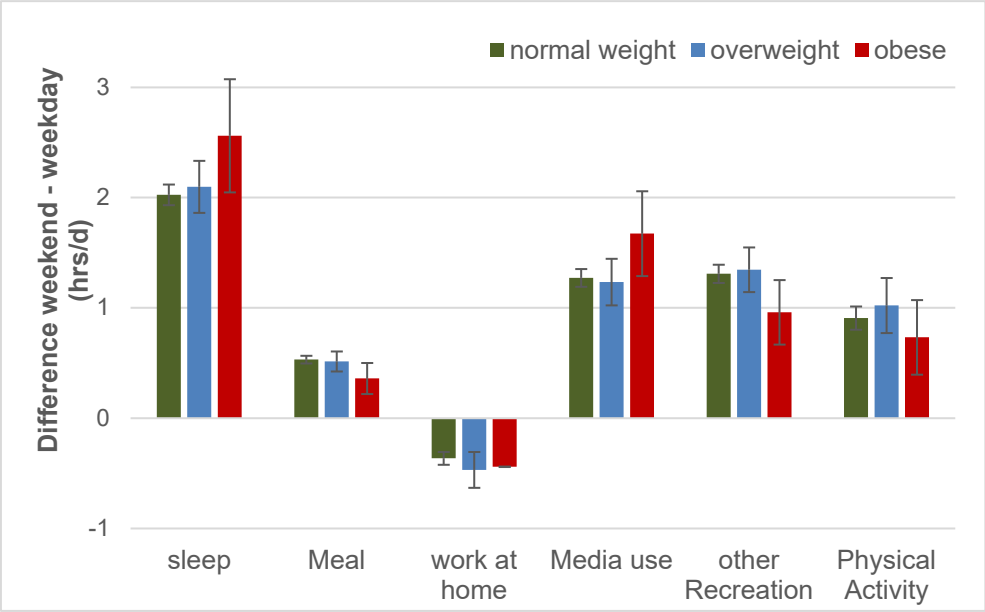

Figure 3. Differences in time spent in sedentary pursuits and physical activity between weekdays and weekends across weight categories. Values are mean differences with 95% CI.

4. Discussion

The aim of the present cross-sectional study was to determine the daily sitting times in Tyrolean adolescents and examine the association with body weight. The results showed that the adolescents spent more than ¾ of their time awake with seated activities. Furthermore, the sitting time increased with increased body weights, which resulted in almost a 1 h/day higher sitting time for the obese participants compared to their normal weight peers. Even though almost half of the time spent sitting was attributed to work, differences in the sitting times across the weight categories were primarily attributed to higher sitting times during leisure time in overweight and obese participants, which also significantly increased during the weekend compared to the weekdays.

This positive association between sitting times and increased body weights has also been observed in other studies. For example, Rosenberg et al. [14] and Scheers et al. [15] demonstrated that overweight and obese adults spend an average of two hours/day more with seated behaviors than those of normal weights. Given the negative health effects of sedentary time on the cardiovascular system, it is considered an independent risk factor for all-cause mortality [18]; therefore, this adds to an increased risk of non-communicable diseases in overweight and obese individuals [18,20,31]. As a high body weight in adolescence lays the foundation for obesity and associated non-communicable diseases (NCDs) in adulthood, this pattern affects their health and well-being throughout the course of their life [32–34].

On the other hand, physical activity and sleep time were higher for the normal weight participants compared to overweight and obese participants. In fact, the time spent in physical activity was almost cut in half for the obese participants compared to their peers. Similar results have been shown in other studies [35,36]. The same can be said for the sleep time, as previous research also indicated an inverse association between sleep time and BMI [37,38]. Accordingly, insufficient sleep has been associated

with an increased risk of obesity in children and adolescents [37]; therefore, ensuring adequate sleep in addition to physical activity appears to be a critical component in the prevention of adverse health outcomes later in life [39].

Preventive efforts should also consider dietary habits, as they are associated with sleep habits [40,41] and body weight, in addition to the promotion of physical activity, particularly in children and adolescents with excess body weights. Schools can play a vital role in the promotion of a healthy lifestyle, particularly when considering that a large amount of a students' sitting time has been attributed to schoolwork. Moreover, schools can reach out to most youths independent of their socio-economic background, and a potential collaboration of physical education with club sports may facilitate regular engagements in physical activities beyond the school setting. The benefits of school-based interventions in the promotion of physical activity and fitness, as well as their potential for the prevention of overweight/obese individuals, have been shown in a recent review [42]. Higher fitness levels may also facilitate an engagement in physical activity during leisure times, which may be particularly important during the weekends, when sitting times increased in the entire study population due to an increase in the time spent in sedentary recreational choices.

However, some limitations of the present study should be considered when interpreting the results. Even though a validated questionnaire was used to assess various sedentary behaviors in the youths, questionnaires have an inherent risk of misreporting due recall errors as well as social desirability. Further, BMI does not directly assess body fat, though it has been shown to be a strong predictor of total fat mass in adolescents [43]. There was also no information on the socioeconomic background, living situation, or other health conditions that are associated with the body weights and sedentary behaviors in the youths. However, it should be pointed out that the participants were drawn from a rural region in Western Austria, which most likely resulted in a relatively homogeneous sample. A sample size of more than 1000 participants across the entire adolescent period should also be considered a strength of the study.

5. Conclusions

The key findings of this study were that adolescents spend the majority of their day with sedentary behaviors. In addition, it was shown that the recreational sitting time was higher for overweight and obese adolescents, while differences in work-related sitting time were limited. On the other hand, the sleeping time was lower for participants with excess body weights, which may further contribute to health problems. Additionally, the obese participants showed a more pronounced increase in the recreational sitting time during the weekends, where there was a greater freedom for their behavioral choices due to the lower amount of time spent for school or work. Given the high amount of sitting time in schools and for schoolwork, schools can play a vital part in the promotion of an active lifestyle. School-based interventions can also reach a majority of young people, which is a critical period for the establishment of lifestyle behaviors. Therefore, facilitating physical activity in schools and promoting active leisure time choices, along with emphasizing the importance of adequate sleep, can have lasting beneficial health effects throughout the adolescents' lifespan.

Author contributions

Klaus Greier and Herbert Riechelmann conceived the study. Klaus Greier and Carla Greier organized data collection. Klaus Greier, Clemens Drenowatz and Herbert Riechelmann conducted the statistical analyses. Klaus Greier and Clemens Drenowatz wrote the manuscript with critical feedback from Carla Greier, Gerhard Ruedl and Herbert Riechelmann. All authors have read and approved the final version of the manuscript for publication.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare no conflict of interest.

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