Medical Science

AIMS Medical Science, 10(4): 291–303.
DOI: 10.3934/medsci.2023022
Received: 24 May 2023
Revised: 27 September 2023
Accepted: 07 October 2023
Published: 18 October 2023

http://www.aimspress.com/journal/medicalScience

Research article

Correlates of sedentary behaviors in Austrian children and adolescents

Klaus Greier[1,2], Clemens Drenowatz[3,*], Carla Greier[2], Elisabeth Haas[1], Markus Posch[1], Gerhard Ruedl[2] and Herbert Riechelmann[4]

[1] Division of Physical Education, Private Educational College (KPH-ES), Stams, Austria
[2] Department of Sports Science, University of Innsbruck, Innsbruck, Austria
[3] Division of Sport, Physical Activity and Health, University of Education Upper Austria, Linz, Austria
[4] Medical University of Innsbruck, Innsbruck, Austria

* **Correspondence:** Email: clemens.drenowatz@ph-ooe.at; Tel: +4373274707426.

Abstract: A large proportion of children and adolescents spend their leisure time with predominantly sedentary pursuits and do not reach the WHO physical activity recommendations. As there remains limited research on specific sedentary behaviors in Austrian children and adolescents, we investigated time spent sitting and the utilization of various media during school days and the weekend in 6- to 15-year-old schoolchildren. Data for this cross-sectional study were collected in Spring 2022 with a standardized questionnaire that was based on the "Heidelberger Questionnaire for the Assessment of Sitting Behavior in Children and Adolescents". Questions examined the frequency and duration of different sedentary behaviors separately for weekdays and weekends. A total of 2061 students were included in the analyses. Various factors, including school grade, sex, or recreational behavior, were implemented in a multifactorial ANOVA accounting for 1st order interactions. The mean sitting time of children and adolescents of all eight school grades was 10.4 ± 1.7 hours, with 56.7% associated with school. A significant increase in sitting time was observed from 1st grade (10.0 ± 1.3 h) to 8th grade (12.3 ± 1.2 h; $p < 0.01$), while sleep duration decreased with increasing age ($p < 0.01$). Media use was 1.2 ± 0.7 h in 1st grade and increased to 3.2 ± 1.2 h by 8th grade ($p < 0.01$). Physical activity decreased from 4.5 ± 1.4 h to 3.6 ± 1.0 h during the same period. While the increase in sitting time on weekdays was at the expense of sleep duration, the increase in sitting time on weekend days was at the expense of time spent in physical activity. In summary, there was a substantial increase in sedentary time from 1st to 8th grade, with school-related sedentary time accounting for the largest proportion, followed by a large increase in time spent with electronic media with increasing age. In addition, high sedentary

time may come at the expense of sufficient sleep time, which further emphasizes the need to address sedentary behavior and sleep as important health correlates.

Keywords: sitting time; media use; physical activity; school children; youth; health

1. Introduction

The importance of physical activity for the overall development of children and adolescents has been demonstrated by many studies [1–3]. The promotion of physical activity throughout the lifespan is therefore one of the most pertinent and central challenges of the 21st century [4]. Behavioral choices of children and adolescents, however, have undergone serious changes in almost all industrialized nations in recent decades and they are increasingly characterized by a lack of physical activity [5]. Particularly, sedentary behavior, which refers to activities with an energy expenditure below 1.5 MET and includes recumbent behaviors [6], increased while a large proportion of children and adolescents do not meet the current physical activity recommendations of the World Health Organization [7–9]. Sedentary behavior was further exacerbated by the COVID-19 pandemic due to various lockdowns and homeschooling [10–14].

The sharp increase in sedentary behavior has attracted increased interest from medical and exercise scientists in recent years. For example, numerous studies have demonstrated that daily sedentary time of more than eight hours increases the risk for type 2 diabetes, cardiovascular disease, tumor disease and all-cause mortality [15–22]. In addition, a sedentary lifestyle is associated with overweight and obesity [23–25], as well as a frequent cause of low back pain [26,27]. Furthermore, long sitting times in children and adolescents have been associated with reduced sleep quality and shortened sleep duration [28]. Adequate sleep, however, is essential for optimal health in children and adolescents and the American Academy of Sleep Medicine recommends a daily sleep duration between 9 and 12 hours for children starting at the age of six years and between 8 and 10 hours for adolescents after the age of 13 years [29].

Even though there are various studies that examined the problem of a sedentary lifestyle in children and adolescents, these have often been collected using different methods, at different ages and in different settings, making them difficult to compare [30]. Using objective measures, LeBlanc et al. [28] observed that 10-year-old Canadian children spend an average of 8.5 hours/day with sedentary pursuits and similar results have been shown in 10- to 12-year-old Australian children [31]. Huber and Köppel [32], on the other hand, determined the sitting times of four- to 20-year-old children and adolescents using a questionnaire and observed mean sitting times of nearly 10 hours/day. It has also been documented that children's sedentary behavior increases with school enrollment [33]. Nevertheless, we still know relatively little about how long and on what occasions children and adolescents sit on school days and during weekends. Therefore, the aim of this study was to survey the daily sitting times of six- to fifteen-year-old Austrian children and adolescents within the federal state of Tyrol as no data in this regard are yet available for this region. It was hypothesized that sitting time increases with age due to an increase in school-related work and time spent on electronic media during the transition from childhood into adolescence.

2. Materials and methods

In the present cross-sectional study, we examine various sedentary behaviors in 6 to 15-year-old primary and secondary school students, which represents the age range when school attendance is mandatory in Austria. For this purpose, 40 elementary schools (= primary level: 1st to 4th grade) and 15 middle schools (= secondary level: 5th to 8th grade) from different districts in the Federal State of Tyrol, Austria were randomly selected and asked to participate in the study. Nine elementary schools and three middle schools refused to participate in the study. In the remaining 43 schools more than 2000 children and adolescents were recruited for the study. The study protocol was approved by the school management, the responsible sponsors of the schools (Education Directorate for Tyrol) and the Review Board of the University of Innsbruck (Certificate of good standing, 30/2022). Parents were notified by letter and provided written informed consent. Data collection occurred between April and May 2022.

The "Heidelberg Questionnaire to Record the Sitting Behavior of Children and Adolescents" [34] was used to determine time spent in various sedentary behaviors. For primary school students (6 to 10 years old) questionnaires were distributed via the participating schools and completed at home by their parents or guardians. Secondary school students (11 to 15 years old) completed the paper-pencil-questionnaire themselves directly in the schools. Specifically, the questionnaire examines how many hours (rounded to 0.5 hours) children and adolescents spend on an average school or weekend day within the following domains, which also meet the requirements of the "Canadian 24-hour Movement Guidelines for Children and Youth" [35]:

1. Sleeping (time spent lying down)
2. Eating (sitting)
3. Sitting at school
4. Seated work at home
5. Time spent sitting during transport
6. Sitting activities during leisure time (playing, computer, TV, cinema, reading)
7. Other activities while sitting
8. Physical activity

Average sedentary time was calculated based on the reported sedentary time on school days and sedentary time on weekends using the following formula:

$$Sedentary\ time = \frac{sedentary\ time\ schoolday \times 5 + sedentary\ time\ weekend \times 2}{7}$$

In addition to sitting times, membership in a sports club was surveyed, as well as ownership of a personal cell phone and whether there was a media device (TV, computer, laptop) in the child's bedroom. Further, data on age (years), height (cm), weight (kg), as well as length (km) and type (passive or active) of travel to school were collected. Anthropometric measurements were used to calculate BMI, which was used to determine weight status using German reference values [36].

2.1. Data cleaning and statistical analysis clinical trial registration

Individual dimensions were first checked for plausibility and questionnaires with logically incomprehensible outliers (e.g., total hours per day > or <24) were excluded from the analysis. Of the total of 2198 returned questionnaires, 2061 questionnaires were included in the analyses.

Frequencies were tabulated and percentages are reported. Frequency comparisons were made using the chi-square test. For metric variables, the number of cases, mean and standard deviation (SD) and minima and maxima are reported. The effects of the influencing variables school grade (1–8), sex (male/female), membership in a sports club (yes/no), having a TV, computer or laptop in the bedroom (yes/no), owning a smartphone, cell phone or tablet (yes/no), walking or biking to school (yes/no) and being overweight (yes/no) on average sedentary time were included in a multifactorial between groups ANOVA, accounting for 1st order interactions. Due to the close relationship between chronological age and school grade, age was not additionally included in the model. Non-significant interactions were dropped from the model. The major effects were sorted according to the effect size (partial eta-squared; η^2p). Following Cohen [37], $0.01 \leq \eta^2p < 0.06$ was considered a small effect, $0.06 \leq \eta^2p < 0.14$ was considered a medium effect, and $\eta^2p \geq 0.14$ was considered a large effect. Data analysis was performed with SPSS 28 (IBM Corp., Armonk, NY).

3. Results

Over the two-month period, a total of 2061 Tyrolean children and adolescents (49.6% male) between 6 and 15 years of age provided complete and valid data. The mean age of the school children was 10.1 ± 2.3 years. The distribution of school grades and the respective average age of the participants are detailed in Table 1.

Table 1. Number of students, average age with standard deviation and minimum and maximum age across the 8 school levels.

Grade	N	Age (years)	Minimum	Maximum
1	211	6.6 ± 0.5	6	9
2	292	7.7 ± 0.6	6	10
3	330	8.7 ± 0.6	7	10
4	282	9.7 ± 0.6	7	11
5	242	10.6 ± 0.5	10	12
6	252	11.9 ± 0.7	11	14
7	228	12.7 ± 0.7	12	15
8	224	13.8 ± 0.7	12	15

Across the entire sample, 1115 participants (54.1%) were in the elementary school level (grades 1–4) and 946 (45.9%) were in the secondary school level (grades 5–8). Concerning weight status, 69 participants (3.4%) were severely underweight, 116 participants (5.6%) were underweight, 1624 participants (78.8%) were of normal weight, 178 participants (8.6%) were overweight and 74 participants (3.6%) were obese. A total of 1021 participants (49.5%) were sports club members, 897 participants (43.5%) had a TV, computer, or laptop in their bedroom and 1498 participants (72.6%)

had their own smartphone, cell phone or tablet. Walking or biking to school was reported by 1285 children and adolescents (62.3%).

3.1. Sedentary pursuits, sleeping time and physical activity

Average daily sedentary time across all grades was 10.4 ± 1.7 hours, increasing from 9.0 ± 1.3 hours in grade 1 to 12.3 ± 1.2 hours in grade 8 (Figure 1a). Average sleep time per night decreased from 10.5 ± 0.7 hours to 8.1 ± 0.8 hours and physical activity time decreased from 4.5 ± 1.2 to 3.6 ± 1.0 hours per day (Figure 1a). When sedentary time, sleep time and physical activity were examined separately by weekday and weekend day (Figure 1b and 1c), it was found that across school grades, daily sedentary time on weekdays increased from 9.4 ± 1.3 in school grade 1 to 12.8 ± 1.4 hours in school grade 8, mainly at the expense of sleep time (from 10.3 ± 0.8 to 7.3 ± 1.0 hours). Physical activity time differed only slightly between grade levels on weekdays (from 3.3 ± 1.3 to 3.1 ± 1.1 hours; Figure 1b). On weekends, on the other hand, sedentary time increased from 7.1 ± 1.8 hours in school grade 1 to 10.2 ± 1.9 hours in school grade 8, primarily at the expense of physical activity (from 6.1 ± 1.8 to 3.6 ± 1.4 hours), while sleep time remained largely unchanged across school grades (from 10.7 ± 0.9 to 9.8 ± 1.1 hours; Figure 1c).

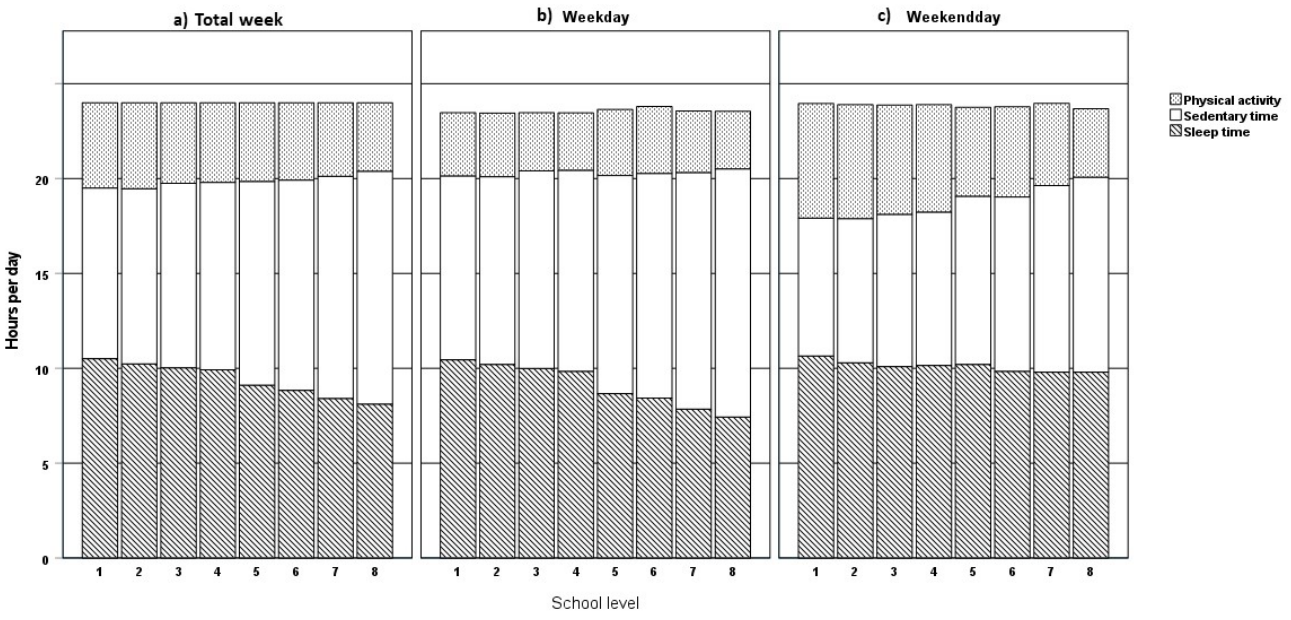

Figure 1. Average self-reported time sleeping, in sedentary pursuits and in physical activity of 2061 students across the entire week (a), on weekdays (b) and on weekend days (c). Bars represent mean values of hours. Small deviations from 24 hours per day are due to rounding errors.

Specifically, participants spent an average of 4.7 ± 0.7 hours sitting in school, 0.2 ± 0.2 hours sitting while traveling to school, 1.1 ± 0.5 hours sitting at home for schoolwork, 1.6 ± 0.5 hours sitting while eating, 1.2 ± 0.7 hours of sitting for media use and 1.6 ± 0.8 hours of other sitting activities

during leisure time on weekdays. Particularly sitting in school increased from 4.1 ± 0.6 hours in grade 1 to 5.1 ± 0.3 hours in grade 8 and sitting for media use increased from 1.2 ± 0.7 to 3.2 ± 1.2 hours (Figure 2).

On weekend days, sedentary time averaged over all 8 school levels was 0.4 ± 0.6 hours for work, 1.9 ± 0.6 hours sitting while eating, 2.1 ± 1.0 hours sitting for media use and 2.9 ± 1.3 hours other sitting for other leisure activities.

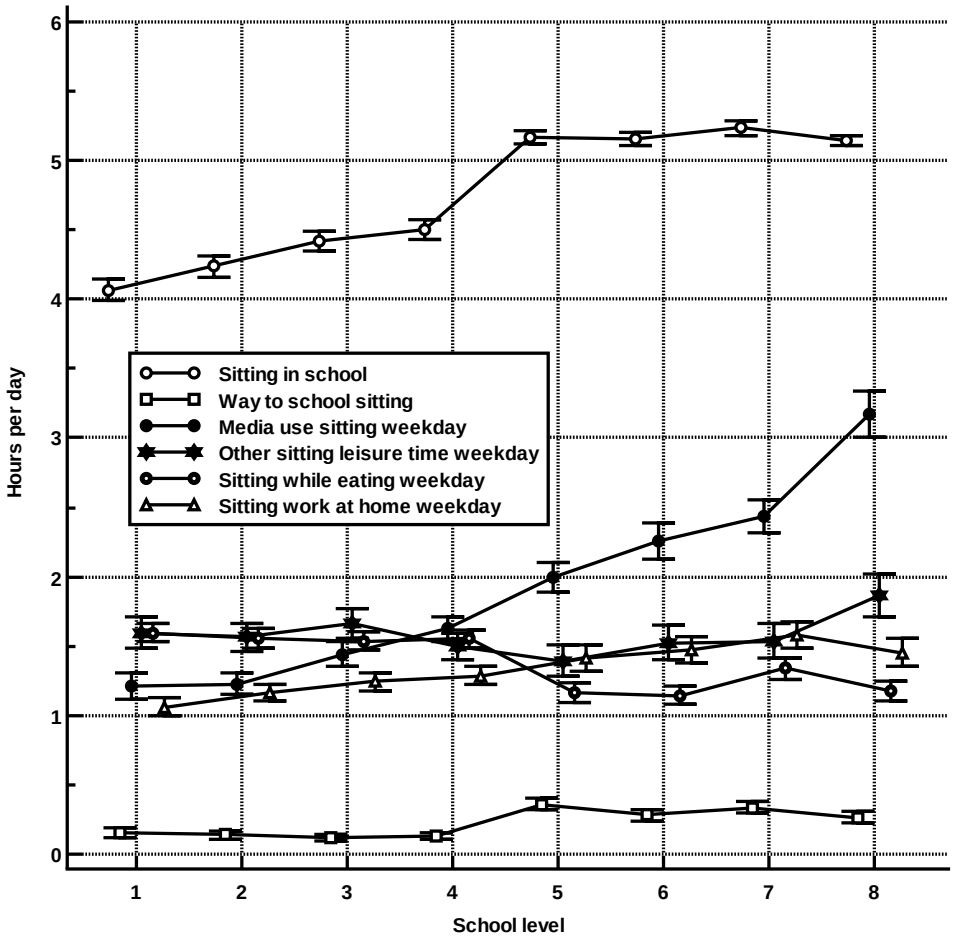

Figure 2. Sedentary time in different pursuits from 1st to 8th grade on weekdays. Values are mean with 95% confidence intervals.

3.2. Additional factors influencing average sedentary time

To investigate the influence of the variables gender, sports club membership, TV, computer or laptop in the bedroom and owning a smartphone, cell phone or tablet on average daily sedentary time, a multi-factorial between groups ANOVA was formed (Table 2). In addition, the variables school level, walking/biking to school vs. public transport/car and weight status were included in this model. Initially, all major effects and 1st order interactions were included. However, the interactions were eliminated due to lack of significance.

Results showed significant effects of the included variables on average sedentary time ($F = 125.3$; $df = 13$; $p < 0.001$; $\eta^2p = 0.44$). School level, which is inherently closely correlated with age, had the strongest effect on average sedentary time ($\eta^2p = 0.2$; $p < 0.001$; Table 2), followed by overweight and

transport to school. Media in the bedroom; owning a smartphone/tablet and sex had weak effects on average sedentary times. Sports club membership was not significant in this model ($p > 0.1$).

Table 2. Results of the multi-factorial between groups ANOVA.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2531.6	13	194.7	125.3	<0.001	0.443
Intercept	76509.8	1	76509.8	49240.5	<0.001	0.960
School level	896.6	7	128.1	82.4	<0.001	0.220
Overweight	53.1	1	53.1	34.2	<0.001	0.016
Transport to school	33.2	1	33.2	21.3	<0.001	0.010
Media in own room	30.3	1	30.3	19.5	<0.001	0.009
Has own smartphone	15.6	1	15.6	10.0	0.002	0.005
Gender	9.4	1	9.4	6.0	0.014	0.003
Sports club member	4.0	1	4.0	2.6	0.107	0.001
Error	3180.6	2047	1.6			
Total	228000.4	2061				
	5712.3	2060				

Note: Only major effects are reported, due to the lack of significance of 1st order interactions. Higher-order interactions were not tested. df: degrees of freedom; F: F-distribution; Sig.: Significance (p-value).

4. Discussion

Our aim of the present study was to examine daily sedentary pursuits among 2061 Tyrolean children and adolescents between 6 and 15 years of age. One of the main findings of this study was the steady age-related increase in sitting time among children and adolescents. This positive relationship between sitting time and grade level or age was also observed in other studies [32,38,39]. The average daily sitting time increased from 9 hours in first grade to 12 hours in eighth grade, which corresponds to an annual increase of about 25 minutes per day. Ortega et al. [40] came to similar conclusions in their longitudinal study of 9- to 15-year-old Swedish and Estonian children. The mean daily sitting times of 10.4 hours on weekdays and 8.6 hours on weekends collected in this study, however, differ from some other studies, which used objective measurements of sedentary time and observed 1 to 2.5 hours shorter sitting times across the entire week [41–43]. Comparable sitting times to our results, on the other hand, were reported by Huber and Köppel [32] in a recent international study that used questionnaire data from over 4000 children and adolescents. One reason for the higher sitting times in the present study could be attributed to the “aftermath” of the COVID-19 pandemic. As observed in recent studies in Tyrolean children and adolescents [10,11], sedentary behavior increased significantly during the implementation of movement restrictions during the COVID-19 pandemic (e.g., homeschooling, closure of sports facilities, etc.). This sedentary behavior may still be reflected in the waning months of the pandemic when data collection occurred. The variables of sex, BMI, media in the bedroom and route to school (active or passive) also had a significant influence on average sitting times. However, the effect sizes of media in the child’s bedroom and sex were only small.

While sitting time increased with increasing age, sleep duration decreased. Especially on weekdays (school days), a strong decrease was observed from the first to the eighth school grade. Children starting school had an average sleep duration of 10.5 hours while adolescents in eighth grade slept only 7.5 hours/night. Considering the recommendations of the American Academy of Sleep Medicine [29], the average sleep duration on weekdays was too short from the seventh grade onward, especially in the eighth grade. During weekends, average sleep time, on the other hand, was in line with the recommendations.

The detailed analyses further show that there is a considerable difference between weekdays (school days) and weekend days in terms of sedentary pursuits, sleep duration and physical activity. The longer sitting times on weekdays are naturally due to school-related activities. It was observed that the daily sitting time on school days increased from 9.5 hours in the 1st grade to more than 12 hours in the 8th grade. In the lower school levels, daily school time consists of at least 4 classes per day, and from the 5th school level onwards, there are at least 5 to 6 classes per day. While the increase in sitting time on weekdays was mainly at the expense of sleeping time (decrease from 10 to 7 hours), time spent on physical activities on weekdays changed only slightly (from 3.3 to 3.1 hours). The maintenance of PA may at least partly be attributed to mandatory physical education in Austrian schools. Furthermore, the structured days hypothesis suggests that formal structure and pre-planned activities during the day facilitate physical activities [44]. On weekends, on the other hand, the increase in sedentary time came primarily at the expense of physical activity (reduction from 6 to 3.6 hours over the course of school attendance), while sleep time remained largely unchanged. These results are also in line with the structured days hypothesis [44], which states that obesogenic behaviors such as low PA are more pronounced on weekends compared to weekdays and these behaviors may become more pronounced with increasing age due to the reduction in parental supervision.

In addition to school grades, which are naturally closely correlated with age, media use had the strongest influence on average sedentary time on weekdays. For example, the duration of media use increased from 1.2 hours in grade 1 to over 3 hours in grade 8. The increase in media use over the course of age has also been confirmed in other studies [45,46]. Given the health-endangering effect of long periods of sitting [19,27], there is an urgent need to increase physical activity and reduce sedentary time in children and adolescents. The school itself provides an opportunity for intervention, as all children can be reached in this setting. The first step is to reduce the amount of time spent sitting at school and to create more incentives for physical activity. Physical education, active walking to school, daily activity times and cooperation with sports clubs are proven measures [47]. Quality physical education that focuses on motor competence may also facilitate engagement in PA during leisure time and, accordingly, could have beneficial effects on behavioral choices during the weekend as well [48].

There are also some limitations of this study that should be considered when interpreting the results. Information on sitting times was obtained via questionnaires at a single point in time. Although questionnaires are often used in large samples, there is the risk of misreporting due to social desirability as well as a risk for recall errors. Moreover, even though the study population consisted of a random sample it was drawn from the Western part of Austria, and there was no information on the socioeconomic background and living situation of the participants. Nevertheless, the large sample with over 2000 subjects, the inclusion of 8 school grades and the use of a proven and validated questionnaire are strengths of the present study.

5. Conclusions

One of the main findings of this study was the positive correlation between sitting time and school level or age. An increase in sitting time of about 3 hours was observed from grade 1 to grade 8. Another significant influence on daily sitting time was media use, which also increased significantly with age. Since different lifestyle habits manifest during childhood and adolescence, it is particularly important to create opportunities for physical activity sessions at this age. In addition to breaking up sedentary time in school, it is important to facilitate active recreational activities after school. Further, children and adolescents need to learn how to use media wisely while being encouraged to engage in a more active lifestyle. Of additional concern is the fact that the amount of time spent sitting increased with age at the expense of sleep time, especially on school days. As sufficient sleep is important for the psychophysical health of children and adolescents, efforts targeting sitting time may also address sleep habits. Schools, politicians and parents are therefore called upon to offer children and adolescents an active living environment during weekdays and weekends in order to encourage the adoption of a more active lifestyle that contributes to their future health.

Use of AI tools declaration

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

Authors' contributions

KG and HR conceived the study. CG, EH and MP organized data collection. KG and HR conducted the statistical analyses. KG and CD wrote the manuscript with critical feedback from CG, EH, MP, GR and HR.

Conflict of interest

The authors declare no conflict of interest.

References

1. Janssen I, Leblanc AG (2010) Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act* 7: 40. https://doi.org/10.1186/1479-5868-7-40
2. Donnelly JE, Hillman CH, Castelli D, et al. (2016) Physical activity, fitness, cognitive function, and academic achievement in children: A systematic review. *Med Sci Sports Exerc* 48: 1197–1222. https://doi.org/ 10.1249/MSS.0000000000000901
3. Warburton DER, Bredin SSD (2017) Health benefits of physical activity: A systematic review of current systematic reviews. *Curr Opin Cardiol* 32: 541–556. https://doi.org/10.1097/HCO.0000000000000437
4. Blair SN (2009) Physical inactivity: the biggest public health problem of the 21st century. *Br J Sports Med* 43: 1–2.

5. Guthold R, Stevens GA, Riley LM, et al. (2020) Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1.6 million participants. *Lancet Child Adolesc Health* 4: 23–35. https://doi.org/10.1016/S2352-4642(19)30323-2
6. Sedentary Behaviour Research Network (2012) Letter to the editor: standardized use of the terms "sedentary" and "sedentary behaviours". *Appl Physiol Nutr Metab* 37: 540–542. https://doi.org/10.1139/h2012-024
7. Manz K, Schlack R, Poethko-Müller C, et al. (2014) Physical activity and electronic media use in children and adolescents: results of the KiGGS study: first follow-up (KiGGS wave 1). *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz* 57: 840–848. https://doi.org/10.1007/s00103-014-1986-4 (Article in German language)
8. Tremblay MS, Barnes JD, González SA, et al. (2016) Global Matrix 2.0: report card grades on the physical activity of children and youth comparing 38 countries. *J Phys Act Health* 13: S343–S366. https://doi.org/10.1123/jpah.2016-0594
9. Van Hecke L, Loyen A, Verloigne M, et al. (2016) Variation in population levels of physical activity in European children and adolescents according to cross-European studies: A systematic literature review within DEDIPAC. *Int J Behav Nutr Phys Act* 13: 70. https://doi.org/10.1186/s12966-016-0396-4
10. Cocca A, Greier K, Drenowatz C, et al. (2021) Relationship between objectively and subjectively measured physical activity in adolescents during and after COVID-19 restrictions. *Behav Sci* 11: 177. https://doi.org/10.3390/bs11120177
11. Greier K, Drenowatz C, Bischofer T, et al. (2021) Physical activity and sitting time prior to and during COVID-19 lockdown in Austrian high-school students. *AIMS Public Health* 8: 531–540. https://doi.org/10.3934/publichealth.2021043
12. Ammar A, Brach M, Trabelsi K, et al. (2020) Effects of COVID-19 home confinement on eating behaviour and physical activity: results of the ECLB-COVID19 international online survey. *Nutrients* 12: 1583. https://doi.org/10.3390/nu12061583
13. Kovacs VA, Starc G, Brandes M, et al. (2022) Physical activity, screen time and the COVID-19 school closures in Europe—An observational study in 10 countries. *Eur J Sport Sci* 22: 1094–1103. https://doi.org/10.1080/17461391.2021.1897166
14. Jarnig G, Jaunig J, van Poppel MNM (2021) Association of COVID-19 mitigation measures with changes in cardiorespiratory fitness and body mass index among children aged 7 to 10 years in Austria. *JAMA Netw Open* 4: e2121675. https://doi.org/10.1001/jamanetworkopen.2021.21675
15. Proper KI, Singh AS, van Mechelen W, et al. (2011) Sedentary behaviors and health outcomes among adults: A systematic review of prospective studies. *Am J Prev Med* 40: 174–182. https://doi.org/10.1016/j.amepre.2010.10.015
16. Lynch BM (2010) Sedentary behavior and cancer: A systematic review of the literature and proposed biological mechanisms. *Cancer Epidemiol Biomarkers Prev* 19: 2691–2709. https://doi.org/10.1158/1055-9965.EPI-10-0815
17. Patel AV, Bernstein L, Deka A, et al. (2010) Leisure time spent sitting in relation to total mortality in a prospective cohort of US adults. *Am J Epidemiol* 172: 419–429. https://doi.org/10.1093/aje/kwq155
18. Biswas A, Oh PI, Faulkner GE, et al. (2015) Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: A systematic review and meta-analysis. *Ann Intern Med* 162: 123–132. https://doi.org/10.7326/M14-1651

19. Edwardson CL, Gorely T, Davies MJ, et al. (2012) Association of sedentary behaviour with metabolic syndrome: A meta-analysis. *PLoS One* 7: e34916. https://doi.org/10.1371/journal.pone.0034916
20. de Rezende LFM, Rodrigues Lopes M, Rey-López JP, et al. (2014) Sedentary behavior and health outcomes: An overview of systematic reviews. *PLoS One* 9: e105620. https://doi.org/10.1371/journal.pone.0105620
21. Suchert V, Hanewinkel R, Isensee B (2015) Sedentary behavior and indicators of mental health in school-aged children and adolescents: A systematic review. *Prev Med* 76: 48–57. https://doi.org/10.1016/j.ypmed.2015.03.026
22. Biddle SJH, Bennie JA, Bauman AE, et al. (2016) Too much sitting and all-cause mortality: is there a causal link? *BMC Public Health* 16: 635. https://doi.org/10.1186/s12889-016-3307-3
23. Santaliestra-Pasías AM, Mouratidou T, Reisch L, et al. (2015) Clustering of lifestyle behaviours and relation to body composition in European children. The IDEFICS study. *Eur J Clin Nutr* 69: 811–816. https://doi.org/10.1038/ejcn.2015.76
24. LeBlanc AG, Katzmarzyk PT, Barreira TV, et al. (2015) Correlates of total sedentary time and screen time in 9–11-year-old children around the world: the international study of childhood obesity, lifestyle and the environment. *PLoS One* 10: e0129622. https://doi.org/10.1371/journal.pone.0129622
25. Katzmarzyk PT, Barreira TV, Broyles ST, et al. (2015) Physical activity, sedentary time, and obesity in an international sample of children. *Med Sci Sports Exerc* 47: 2062–2069. https://doi.org/10.1249/MSS.0000000000000649
26. Kett AR, Sichting F, Milani TL (2021) The effect of sitting posture and postural activity on low back muscle stiffness. *Biomechanics* 1: 214–224. https://doi.org/10.3390/biomechanics1020018
27. Mahdavi SB, Riahi R, Vahdatpour B, et al. (2021) Association between sedentary behavior and low back pain; A systematic review and meta-analysis. *Health Promot Perspect* 11: 393–410. https://doi.org/10.34172/hpp.2021.50
28. LeBlanc AG, Broyles ST, Chaput JP (2015) Correlates of objectively measured sedentary time and self-reported screen time in Canadian children. *Int J Behav Nutr Phys Act* 12: 38. https://doi.org/10.1186/s12966-015-0197-1
29. Paruthi S, Brooks LJ, D'Ambrosio C, et al. (2016) Recommended amount of sleep for pediatric populations: A consensus statement of the American academy of sleep medicine. *J Clin Sleep Med* 12: 785–786. https://doi.org/10.5664/jcsm.5866
30. Altenburg TM, Chinapaw MJM (2015) Bouts and breaks in children's sedentary time: currently used operational definitions and recommendations for future research. *Prev Med* 77: 1–3. https://doi.org/10.1016/j.ypmed.2015.04.019
31. Abbott RA, Straker LM, Mathiassen SE (2013) Patterning of children's sedentary time at and away from school. *Obesity* 21: E131–133. https://doi.org/10.1002/oby.20127
32. Huber G, Köppel M (2017) Analysis of sitting times in children and adolescents between 4 and 20 years of age. *Dtsch Z Sportmed* 68: 101–106. https://doi.org/10.5960/dzsm.2017.278 (Article in German language)
33. Carson V, Salmon J, Crawford D, et al. (2016) Longitudinal levels and bouts of objectively measured sedentary time among young Australian children in the HAPPY study. *J Sci Med Sport* 19: 232–236. https://doi.org/10.1016/j.jsams.2015.01.009

34. Lerchen N, Köppel M, Huber G (2016) Heidelberger questionnaire for the assessment of sitting behavior in children and adolescents between the ages 5 and 20 years. *Bewegungstherapie Gesundheitssport* 32: 109–112. https://doi.org/10.1055/s-0042-106337 (Article in German language)
35. Tremblay MS, Carson V, Chaput JP, et al. (2016) Canadian 24-hour movement guidelines for children and youth: An integration of physical activity, sedentary behaviour, and sleep. *Appl Physiol Nutr Metab* 41: S311–327. https://doi.org/10.1139/apnm-2016-0151
36. Kromeyer-Hauschild K, Wabitsch M, Kunze D, et al. (2001) Body mass index percentiles for children and adolescents using different German sample populations. *Monatsschr Kinderheilkd* 149: 807–818. https://doi.org/10.1007/s001120170107 (Article in German language)
37. Cohen J (1988) *Statistical power analysis for the behavioral sciences,* 2 Eds., Hillsdale: Lawrence Erlbaum Associates.
38. Matthews CE, Chen KY, Freedson PS, et al. (2008) Amount of time spent in sedentary behaviors in the United States, 2003–2004. *Am J Epidemiol* 167: 875–881. https://doi.org/10.1093/aje/kwm390
39. Ruiz JR, Ortega FB, Martínez-Gómez D, et al. (2011) Objectively measured physical activity and sedentary time in European adolescents: the HELENA study. *Am J Epidemiol* 174: 173–184. https://doi.org/10.1093/aje/kwr068
40. Ortega FB, Konstabel K, Pasquali E, et al. (2013) Objectively measured physical activity and sedentary time during childhood, adolescence and young adulthood: A cohort study. *PLoS One* 8: e60871. https://doi.org/10.1371/journal.pone.0060871
41. Carson V, Tremblay MS, Chaput JP, et al. (2016) Associations between sleep duration, sedentary time, physical activity, and health indicators among Canadian children and youth using compositional analyses. *Appl Physiol Nutr Metab* 41: S294–S302. https://doi.org/10.1139/apnm-2016-0026
42. Larouche R, Garriguet D, Gunnell KE, et al. (2016) Outdoor time, physical activity, sedentary time, and health indicators at ages 7 to 14: 2012/2013 Canadian health measures survey. *Health Rep* 27: 3–13.
43. Marques A, Ekelund U, Sardinha LB (2016) Associations between organized sports participation and objectively measured physical activity, sedentary time and weight status in youth. *J Sci Med Sport* 19: 154–157. https://doi.org/10.1016/j.jsams.2015.02.007
44. Brazendale K, Beets MW, Weaver RG, et al. (2017) Understanding differences between summer vs. school obesogenic behaviors of children: the structured days hypothesis. *Int J Behav Nutr Phys Act* 14: 100. https://doi.org/10.1186/s12966-017-0555-2
45. Drenowatz C, Greier K (2019) Cross-sectional and longitudinal association of sports participation, media consumption and motor competence in youth. *Scand J Med Sci Sports* 29: 854–861. https://doi.org/10.1111/sms.13400
46. Kaiser-Jovy S, Scheu A, Greier K (2017) Media use, sports activities, and motor fitness in childhood and adolescence. *Wien Klin Wochenschr* 129: 464–471. https://doi.org/10.1007/s00508-017-1216-9
47. Greier K, Drenowatz C, Ruedl G, et al. (2020) Effect of daily physical education on physical fitness in elementary school children. *Adv Phys Educ* 10: 97–105. https://doi.org/10.4236/ape.2020.102009

48. Drenowatz C, Greier K (2018) The role of motor competence in the promotion of physical activity and a healthy body weight in youth. *Ann Pediatr Child Health* 6: 1155. https://doi.org/10.47739/2373-9312/1155

AIMS Press