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Sedentary activity bout length was associated with BMI and waist circumference in Swedish children aged 5–7 years

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Abstract
Aim: This study examined the pattern of sedentary behaviour during the week and on weekends and associations with health outcomes among children aged 5–7 years in Sweden.

Methods: This cross-sectional study used data from 342 children, many of whom had at least one parent born outside the Nordic region. Physical activity and sedentary time were measured by accelerometry. A sedentary bout was defined as 1–4 and 5–9 min. Diet, time in front of television or computer screen, sleep and physical activity behaviour were measured via parental reports, and anthropometric data by research staff.

Results: The number of sedentary bouts was higher on weekends than on weekdays. Compared to girls, boys had more 1–4 min bouts on both weekdays and weekend days, and more 5–9 min bouts on weekends. A higher number of 5–9 min bouts was associated with a higher body mass index and waist circumference.

Conclusion: This study showed an association between sedentary activity and weight status in children as young as 5–7 years. Reducing time, especially longer bouts, spent in sedentary activities may encourage healthy weight development in children.

KEYWORDS
A Healthy School Start, diet, health promotion, physical activity, screen time

Keynotes
• This study examined associations between sedentary time accumulated in bouts and health outcomes among young Swedish children.
• Sedentary bouts of 5–9 min were associated with a higher body mass index and greater waist circumference.
• Reducing time in sedentary bouts may have important implications for weight development in children.

Abbreviations: BMI-sds, Body mass index standard deviation score; BMI, body mass index.

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1 | INTRODUCTION

Self-reported sedentary behaviour has been associated with several negative health effects and behaviours. These include decreased fitness, lower self-esteem, depressive symptoms, lower quality of life, unhealthy diet, decreased academic performance, unfavourable body composition and less pro-social behaviour among children.\(^1\)\(^2\) Sedentary time is often objectively measured with accelerometry, and a sedentary bout is defined as a period of uninterrupted sedentary activity.\(^3\) There is limited evidence regarding the associations between total time spent in sedentary activity, and the pattern of sedentary time, that is how it is accumulated in bouts, and health outcomes in children.\(^4\)

Several international studies have shown that a higher number of sedentary bouts has been associated with body mass index standard deviation score (BMI-SDS), waist circumference and cardiometabolic risk factors among children.\(^5\)\(^6\) Conversely, other studies have found no associations with health outcomes.\(^6\)\(^8\)\(^9\) It is also unclear whether the length of the bouts is associated with health outcomes.\(^4\)

Different patterns of sedentary bouts between weekdays and weekends have been observed among children.\(^5\)\(^6\)\(^10\) A higher number of sedentary bouts was found on weekdays compared to weekends in children aged 9–13 years.\(^10\)\(^11\) The opposite pattern was observed by Carson et al,\(^5\) where a higher number of bouts was found on the weekends compared to weekdays in children aged 11 years.

More research is needed to investigate how sedentary activity is accumulated in bouts, and how this is related to health outcomes among children. This evidence is required to inform health promotion strategies and interventions. To our knowledge, no study on the patterns of sedentary activity in relation to health outcomes in young children has been conducted in Sweden.

The aim of this study was to examine the pattern of accelerometer-measured sedentary bouts among children aged 5–7 years in Sweden, many of whom had at least one parent of non-Nordic origin. In addition, the study also aimed to examine the cross-sectional associations between sedentary bouts and health outcomes.

2 | METHODS

This study was a cross-sectional study using baseline data from The Healthy School Start II study, collected in 2012.\(^12\) The A Healthy School Start II study was designed as a cluster-randomised controlled trial and has been implemented twice in different areas in Stockholm, Sweden.\(^12\)\(^13\) A Healthy School Start is a parental support programme aiming to promote healthy diet and physical activity behaviours, and to prevent overweight and obesity, among children aged 5–7 years. In the Healthy School Start II study, a total of 378 children from disadvantaged areas participated. Informed consent was collected in writing from parents of all participating children. Ethical approval was granted by the Regional Ethical Review Board in Stockholm, Sweden (2012/877-31/5).

2.1 | Data collection

Physical activity was objectively measured using accelerometry. Anthropometrical measurements were made by research staff. Other health behaviours were reported by a questionnaire, completed by the parents.

Sedentary time was assessed using accelerometry which is considered to be a valid and reliable instrument in children.\(^14\) Children were asked to wear an Actigraph GT3 X+ accelerometer (Actigraph, LCC) during all waking hours for 7 consecutive days. They were to remove it during any water-based activity and when sleeping. The epoch length was set to 15 s. At least 500 min of registered activity per day on at least 2 days was required in order to be included in the analyses. Activity before 7 a.m. and after 9 p.m. was excluded. Non-wear time was defined as 10 or more minutes of consecutive zero counts and excluded from registered activity. Sedentary activity was defined as all activity under 100 counts per minute.\(^15\) A sedentary bout was defined as a period of 1–9 consecutive minutes of sedentary activity. These bouts were subdivided into two groups of 1–4 min and 5–9 min. Previous studies have shown that it is of interest to also look at sedentary bouts of 10–14 min, 15–19 min and more than 30 min.\(^5\)\(^7\) However, few bouts were longer than 10 min, and therefore, longer bouts were too scarce to be used in more in-depth analyses. Bouts of 10–19 min are included in the descriptive analyses only. Sedentary bouts refer to the mean number of sedentary bouts occurring per day. The mean number of bouts per day was calculated between 7 a.m. and 9 p.m. for weekdays and weekend days. Moderate-to-vigorous physical activity was defined as all activity above 2000 counts per minute, which corresponds to a walking pace of approximately 4 km/h in children.\(^16\) Children’s membership of sports clubs, and screen time, was measured via the parental questionnaire. Parents responded yes or no to whether their child was active in a sports organisation and also reported how many minutes their child had spent in front of the television or computer the previous weekday.

The children’s dietary intake was measured using The Eating and Physical Activity Questionnaire.\(^17\) Parents reported their child’s intake of a selected number of items during the previous weekday. The food items considered healthy were fruits and vegetables. The food items considered unhealthy were crisps or salty snacks, sweets or chocolate, ice-cream, and cakes, buns or cookies. The drink items considered unhealthy were soft drinks, flavoured milk and fruit juice. The response scale for food items was whole servings from zero to five or more and for drink items whole servings from zero to six or more. Examples of a serving size expressed as volume were provided for each item. For example, for drinks, it was 1.5 dl (a decilitre is 100 ml), and for vegetables, it was 2 dl of...
grated carrots or cabbage, or a big tomato, or 2–3 broccoli stalks. The total intake of unhealthy foods, healthy foods and unhealthy drinks was calculated by summing the individual items. Only intakes of fruit juice above one serving were included, as at the time of data collection national dietary guidelines from the Swedish Food Agency included up to 1 dl of fruit juice. An Australian validation of the Eating and Physical Activity Questionnaire against 24-h recall found significant correlations ranging between 0.57 and 0.88 for different items.  

2.2 | Sleep

Sleep was measured via the questionnaire. Parents indicated the number of hours per night their child normally slept (6–7 h, 7–8 h, 8–9 h, 9–10 h, more than 10 h per night). The variable was dichotomised as sleeping more or less than 9 h per night.

Weight, height and waist circumference were measured by two trained research assistants using a standardised protocol. Body mass index (BMI) was calculated by weight in kilograms divided by height in meters. Overweight and obesity were defined according to the International Obesity Task Force. Swedish age and sex specific reference values were used to calculate BMI-SDS. Parents reported their highest attained level of education as either low (12 years or less of schooling) or high (more than 12 years of schooling). Parental level of education was calculated at family level, where the highest self-reported educational level attained by either parent was used. Parental region of birth was also calculated at family level using a dichotomised variable, Nordic or non-Nordic. The family was categorised as being of non-Nordic origin if at least one parent was born outside the Nordic region, that is somewhere other than Sweden, Norway, Finland, Denmark or Iceland.

2.3 | Statistics

The programme ActiLife version 6.11.5 (Actigraph, LCC, Pensacola, Florida, USA) was used to identify, calculate and summarise sedentary bouts. Statistical analysis was done using IBM SPSS statistics for Windows version 22.0 (IBM Corp.). The level of significance was set to \( p < 0.05 \). A \( t \) test was performed to detect sex differences in sedentary behaviour, number of 1–4 min bouts, 5–9 min bouts and 10–19 min bouts. One-way analysis of covariance (ANCOVA) was performed to explore sex differences in sedentary bouts across the week, both for 1–4 min bouts and 5–9 min bouts. A test for an interaction effect between sex and bouts was performed. To explore associations between sedentary bouts, both 1–4 min bouts and 5–9 min bouts, and other health behaviours and anthropometrical outcomes, linear regression was performed for continuous outcomes: BMI-SDS, waist circumference, time in front of television or computer, intake of unhealthy food and drink, and intake of healthy food. Logistic regression was performed for binary outcomes: sleep and participation in sports clubs. All analyses were adjusted for sex, moderate-to-vigorous physical activity and accelerometer wear time.

3 | RESULTS

The mean age of the children was 6.3 years of age. The mean BMI-SDS was 0.66. The majority (87%) of families were of non-Nordic origin (Table 1). This is relatively high as nationally the proportion of individuals residing in Sweden who were born outside the Nordic region was 17.5% in 2019 according to Statistics Sweden. Approximately 50% of the children came from families where both parents had 12 years or less of schooling and high, families where at least one parent had more than 12 years of schooling. Of the participating children, 52% were girls and 25% had overweight or obesity. In total, 342 children had valid accelerometer data—defined as more than 2 days with valid accelerometer data—and provided on average 5.5 days of valid data. Almost all (88%) of the children reached the World Health Organization recommendation of at least 60 min per day of moderate-to-vigorous physical activity.
3.1 | Patterns of sedentary bouts

The children spent an average of 322 min per day in sedentary activity across all days of the week (Table 1). The mean number of sedentary bouts of 1–4 min, 5–9 min and 10–19 min was highest at weekends for the whole group. Significant differences between girls and boys regarding sedentary bouts of 1–4 min were seen, where boys had more bouts in 1–4 min than girls on both weekdays and weekends. Boys had more sedentary bouts in 5–9 min than girls on weekdays only. There were no differences between boys and girls regarding sedentary bouts of 10–19 min (Table 2).

Regarding patterns of bouts across the week, the number of sedentary bouts was higher on the weekend for both boys and girls (Figure 1). A significant difference was seen in the pattern during the week (p < 0.001) but no significant interaction effect with sex was found (p = 0.06).

3.2 | Associations between sedentary behaviour and health outcomes

Regarding bouts of 1–4 min on weekdays, a significant relationship was found between number of bouts and longer time spent in front of television or computer (0.7 min, p = 0.04) (Table 2). Regarding bouts of 1–4 min on weekends, significant relationships were found between number of bouts and a higher waist circumference (0.38 centimetres, p = 0.02) and a lower intake of unhealthy foods (~0.2 servings, p = 0.02) (Table 3).

Regarding bouts of 5–9 min on weekdays, significant relationships were found between number of bouts and a higher BMI-SDS (0.08 SDS, p = 0.05), higher waist circumference (0.48 centimetres, p = 0.002) and longer time spent in front of television or computer (7.7 min, p = 0.001) (Table 2). Regarding bouts of 5–9 min on weekends, a significant relationship was found between number of bouts and higher waist circumference (0.22 centimetres, p = 0.02). An association was seen between bouts and BMI-SDS (0.05 SDS) but this was not significant (p = 0.07) (Table 3).

4 | DISCUSSION

This study examined the patterns of sedentary activity during the week and the associations between sedentary bouts and health outcomes, among children aged 5–7 years in Sweden from families with a high proportion of parents with a non-Nordic origin. This study found that the number of sedentary bouts was higher on weekends compared to weekdays. In addition, sedentary bouts of 5–9 min were associated with a higher BMI and waist circumference, whereas shorter bouts of 1–4 min were not associated with the health outcomes to the same extent. Interestingly, few of the bouts were 10 min or longer, in fact so few that it did not permit for statistical analysis of the relationship with health outcomes.

The results showed that the number of sedentary bouts of 1–4 min, 5–9 min and 10–19 min were higher during weekends compared to weekdays. Similar results have been reported in a study by Carson et al who found that bouts of 5–9 min were higher during the weekends compared to weekdays in Canadian children aged 11 years (n = 787). In a study of European children aged 9–13 years (n = 1057), the opposite was observed, and in a study with Belgian children aged 10–12 years (n = 577), they showed that bouts of 5–10 min and bouts of at least 10 min were higher on weekdays than on weekends. The length of sedentary time accumulated in sedentary bouts has varied largely between studies but children have generally been found to engage in short sedentary bouts of 2–5 and 5–10 min.

In this current study, it was observed that sedentary bouts of 5–9 min were more strongly associated with health outcomes compared to shorter bouts of 1–4 min. Bouts of 5–9 min on weekdays were significantly associated with a higher BMI (β = 0.08) and a higher waist circumference (β = 0.48), and bouts on weekends with a higher waist circumference (β = 0.22). The present results can

<table>
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<th>N</th>
<th>Boys (n = 163)</th>
<th>Girls (n = 179)</th>
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<tr>
<td>Bouts 1–4 min</td>
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<tr>
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<td>279</td>
<td>58.6</td>
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<td>48.1</td>
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<td>Bouts 5–9 min</td>
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<td>Weekdays&lt;sup&gt;b&lt;/sup&gt;</td>
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**Note:** p — Difference between boys and girls.
<sup>a</sup>Weekends (Saturday and Sunday) between 7 a.m. and 9 p.m.
<sup>b</sup>Weekdays (Monday to Friday) between 7 a.m. and 9 p.m.
Another study showed a negative association between bouts of 5–9 min and waist circumference ($\beta = –0.355$) in girls aged 8–11 years and a positive association between bouts of 10–14 min and BMI $z$-scores ($\beta = 0.169$) in boys. Conversely, there are other studies that have not found any associations between bouts of this length and health outcomes. The comparability between studies may be limited, as previous studies have applied different accelerometer data processing decisions for assessing sedentary time and patterns in children. Earlier studies have shown that there seems to be a difference between active and passive sedentary activities in relation to health and academic performance in children. Corder et al reported that different sedentary activities showed varied relationships with academic performance. Objective measurement of sedentary time and time spent on homework and reading was related to higher academic scores, whereas screen time was associated with lower academic performance. In addition, the effects of screen time on physical health, psychological and educational outcomes have been shown to be moderated by the type of screen time, where passive screen time had the most detrimental effects in...
children. Therefore, the type of screen time may be important to consider when formulating in health promotion messages in relation to sedentary behaviours.

Due to the low frequency of sedentary bouts of 10–19 min in the sample, this study did not allow for investigation of the relationship between longer bouts and health outcomes. This is a topic which requires further study as longer periods of sedentary time could hypothetically have a stronger adverse effect on health than shorter periods. However, this study showed that even sedentary time in what can be considered shorter time periods, of 5–9 min, was adversely associated with health in children as young as 5–7 years.

The present results showed that there were positive associations between time spent in front of television or computer and bouts of 1–4 min, but with a small estimate of less than a minute of time in front of television or computer (β = 0.66) and 5–9 min (β = 7.69). Also, there was a negative association between bouts of 1–4 min and an unhealthy dietary intake (β = -0.016) but no other associations between sedentary bouts and diet, sleep and participation in a sports club were observed. The reason for the lack of associations may be due to the fact that the children in the present study were quite young and had few bouts of accumulated sedentary time, especially in bouts of 10 min or more. The results indicated that young children do not engage in prolonged sedentary time.

4.1 | Strengths and limitations

One major strength of the present study was the objective measurement of sedentary time patterns. Limitations included the inability to adequately measure specific physical activities such as cycling and water-based activities, which are both popular activities among children. In addition, another limitation was the cross-sectional design of the study.

5 | CONCLUSION

This study showed that sedentary bouts were associated with a higher BMI and waist circumference in children as young as 5–7 years. These results indicate that reducing time spent sedentary activity, especially in bouts of 5–9 min may have important implications for weight development in children.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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