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Published in:
BMJ Public Health

DOI:
10.1136/bmjph-2024-001150

Publication date:
2025

Document version:
Final published version

Document license:
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Citation for pulished version (APA):
Grøntved, A., Kristensen, P. L., Brønd, J. C., Gejl, A. K., Møller, N. C., Larsen, K. T., Koch, S., Troelsen, J., Brage, S., & Pedersen, N. H. (2025). Association of digital screen use during recess with physical activity behaviours in 10-year-old to 17-year-old Danish adolescents: a population-based cross-sectional study. *BMJ Public Health*, *3*, Article e001150. https://doi.org/10.1136/bmjph-2024-001150

BMJ Public Health

Association of digital screen use during recess with physical activity behaviours in 10-year-old to 17-year-old Danish adolescents: a population-based cross-sectional study

Anders Grøntved ,[1] Peter Lund Kristensen,[1] Jan C Brønd,[1] Anne Kær Gejl,[1] Niels C Møller,[1] Kristian T Larsen,[1] Sofie Koch,[1] Jens Troelsen,[1] Soren Brage,[1,2] Natascha H Pedersen[1]

To cite: Grøntved A, Kristensen PL, Brønd JC, *et al*. Association of digital screen use during recess with physical activity behaviours in 10-year-old to 17-year-old Danish adolescents: a population-based cross-sectional study. *BMJ Public Health* 2025;**3**:e001150. doi:10.1136/bmjph-2024-001150

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/bmjph-2024-001150).

Received 11 March 2024
Accepted 20 December 2024

[1]Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark
[2]MRC Epidemiology Unit, University of Cambridge, Cambridge School of Clinical Medicine, Institute of Metabolic Science, Cambridge, UK

Correspondence to
Dr Anders Grøntved;
agroentved@health.sdu.dk

ABSTRACT

Background The widespread ownership of digital devices among adolescents presents challenges and opportunities in schools, particularly during recess. This study aimed to examine the association of screen use during recess with physical activity behaviours.

Methods The study was based on a population-based cross-sectional study including 1347 adolescents from 28 schools (2017–2018). Physical activity behaviours were assessed using thigh-attached accelerometers, worn 24/7 for up to 6 weekdays and 2 weekend days. We examined accelerometer data for all recess periods, aligned with each adolescent's school schedule, along with leisure-time activity from the same days. Physical behaviours were classified during recess and leisure-time behaviour (negative control). Frequency of screen use during recess was based on self-report using a 5-point ordinal scale.

Results Greater frequency of screen use during recess was associated with less time engaged in physically active behaviours and more time spent sitting, consistent with dose-dependent associations. In multivariable-adjusted analysis, adolescents with no screen use during recess spent an absolute 11.1% (95% CI 5.4 to 6.8) more of their recess time being physically active compared to those with frequent use. Based on the mean recess duration observed in the sample, adolescents not using screens during recess engaged in physical activities for an average of 44.9 min per day (95% CI 42.3 to 47.6), compared with 35.1 min (95% CI 26.0 to 44.3) for frequent screen users. Leisure time activities, used as a negative control, showed no link to screen use during recess.

Conclusion Increased screen use during recess was associated with lower physical activity levels. These findings suggest that regulating digital device use during recess could enhance physical activity among adolescents.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Concerns about device use in schools, including phones, often relate to issues like bullying and classroom distraction. Yet, how this influences students' physical activity during recess, an important aspect of adolescent physical activity, remains underexplored.

WHAT THIS STUDY ADDS

⇒ This study of adolescents aged 10–17 reveals a dose-dependent association between increased digital screen use during recess and decreased physical activity.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The findings urge policymakers to consider rules on digital device use during recess to prevent recess physical inactivity.

INTRODUCTION

In many countries, a large proportion of adolescents own a personal mobile phone or another handheld screen device and typically carry them at all times. While the use of mobile phones or other handheld devices in schools is not generally prohibited in most countries, individual schools typically have the discretion to determine their own policies and procedures for managing screen usage. A few reasons have been proposed for allowing students to bring their own digital devices to school. These include building digital resilience, incorporating mobile phones to increase engagement in learning, and providing parents opportunities to keep in touch with their children.[1] Yet, many reasons to restrict the use of devices such as phones in school have been highlighted such as prevention of bullying, myopia (nearsightedness), distraction in class and concerns about educational outcomes.[2 3]

Recess plays an important role in providing opportunities for physical activity, social interaction and enrichment activities that may benefit students' emotional well-being and social development[4]; however, these benefits may be absent if students resort to using digital devices during recess. One overlooked possible negative consequence of a more liberal attitude towards digital devices in schools is the impact on students' physical activity behaviours during recess. Adolescents' recess physical activity during is not only integral to promoting their overall physical activity in school but also appears to have an immediate positive effect on inhibitory and interference control,[5 6] which could enhance their learning abilities in the classes that follow. If students use digital devices during recess, this may reduce their engagement in physically active behaviours; however, it is also possible that they only resort to their devices during periods when they are sedentary.[7] Nearly all adolescents today own a smartphone, and data from passive objective sensing—still rarely reported—collected as part of the Adolescent Brain Cognitive Development (ABCD) Study indicate an average daily usage of 5 hours.[8] This suggests that smartphone use during school hours, including recess, could have significant implications for adolescent health and development.

Presently, there is a lack of research that has investigated the association between children's or adolescents' digital screen use during recess and their objectively assessed physical behaviours in these periods. A previous experimental study conducted among fourth to seventh-grade Danish students did find that a 4-week ban on smartphone use during recess led to an increase in physical activity.[9] However, the assessment of activity faced limitations due to reliance on unblinded researchers conducting general observational scans of large groups of children in common recess areas and without the inclusion of a control group for comparison. In the current study, we aim to investigate the association between digital screen use during recess and various physical activity behaviours. These behaviours include sitting, standing and walking, as well as engagement in physical activity within the commonly defined intensity domains. We used thigh-worn accelerometry to measure these behaviours in a large, school-based, population-based sample of Danish adolescents from fifth to ninth grade. We also examined physical activity behaviours during leisure time as negative control outcomes (ie, outcomes that should not be directly affected by screen use during recess) to assess the presence of confounding factors and ensure that any observed associations are specific to recess-related device usage.[10]

METHODS

Study design and population

The Physical Activity in Schools After the Reform (PHASAR) study was launched with the primary aim of evaluating the effectiveness of the Danish Government's school policy, introduced in 2014, which included an ambitious initiative to promote physical activity in all public schools across the country. This policy instituted several structural changes, such as extending the school day and mandating a daily minimum of 45 min of physical activity during school hours. A detailed description of the PHASAR study can be found elsewhere.[11 12] The school policy did not address digital screen use during recess or elsewhere in school, except that individual student plans, detailing each student's learning goals, progress status and follow-up strategies, must be made digital. For the post policy cross-sectional data collection, 36 schools that were part of pre-policy studies were contacted in 2016/17 and invited to participate. 31 schools accepted the invitation with 3426 children and adolescents between 6 and 17 years (1st–9th grade) being invited to participate. Children and adolescents were eligible to participate if they were in 5th–9th grade (10–17 years old) and did not suffer from any physical disabilities or injuries preventing physical activity. Of 2321 eligible 10–17-year-old adolescents from 5th–9th grade in 28 schools, 1716 (74%) participated in the study. The study follows the STROBE Reporting Guidelines. As this study is a secondary analysis of data collected in the PHASAR study, which was originally designed to evaluate the effectiveness of the Danish Government's 2014 school policy promoting physical activity in public schools, a formal sample size calculation specific to the present analysis was not conducted.

Digital screen use during recess

Digital screen use during recess was assessed using self-report based on a 5-point ordinal scale. Adolescents were asked to complete the statement 'How often have you used digital screen media in recess during the past week?' by selecting one of five options: (1) Several times a day, (2) Every day or almost every day, (3) 2–3 times during the week, (4) One day during the week, or (5) Not at all. This question was part of a larger questionnaire filled out in class, administered and supervised by research personnel. This approach was taken to ensure both sufficient confidentiality and that the questions were fully comprehended by the students. The question measures the frequency of digital screen use rather than the specific duration of use. The distribution of responses across different grade levels is detailed in online supplemental figure 1.

Physical activity and physical behaviors during recess and leisure time

Adolescents were asked to wear two Axivity AX3 (Axivity Ltd) triaxial accelerometers (initialised to a 50 Hz sampling frequency with a sensitivity of +/−8 g) using elastic belts 24 hours/day through seven consecutive days. One accelerometer was placed at the right side of the waist above the right hip, and the other was placed on the front of the thigh midway between the hip and knee. For this study, only data from the thigh accelerometer were used. Participants were included in the analysis if they had at least one valid day of accelerometer data,

defined as a minimum of 10 hours of awake wear time per day. Physical behaviours were classified second-by-second using algorithms by Brønd *et al*.[13] Physical behaviours classified from the accelerometer data included sitting or lying; standing still or with minor movement; and walking or running. The intensity of physical activity was categorised into sedentary, light and moderate-to-vigorous intensity derived from ActiGraph counts in 10 s epochs.[14] The thresholds for sedentary, light, moderate and vigorous were established using an internal calibration study[15] involving 67 participants aged 10–16 years. During the structured protocol, energy expenditure was measured via indirect calorimetry, and accelerometry data were collected from Axivity AX3 worn on the thigh. Moderate intensity was defined as the average accelerometer counts observed during self-paced walking, corresponding to 30%–35% of VO_2-max. Vigorous intensity was set at the threshold above which 95% of accelerometer counts during running were classified as vigorous, representing activities exceeding 60% of VO_2-max. The specific cut points for sedentary, moderate and vigorous activity were established at 100, 4940 and 8756 counts per minute, respectively. A more detailed description of the physical activity data processing is also provided elsewhere.[16] We analysed accelerometer data during all recess periods, in accordance with each adolescent's school timetable, which was obtained through the individual schools. Based on the timetables of each student, we also paired the timestamped accelerometer data with the start and finish of the school day, enabling us to process accelerometer data for leisure time on the same school days. We divided the time spent on each activity during recess and leisure time by the wear time during wakefulness of the same period. This calculation allowed us to determine the proportion of recess and leisure time engaged in the respective activity behaviour.

Other background data

Height, weight and waist circumference were measured using standardised protocols by research personnel on the same days that the adolescents began wearing accelerometers, and age and sex were obtained from their personal identification numbers.

Statistics

Given that the outcome variables were proportions, binomial generalised linear models with identity link function were used to estimate absolute differences in proportions (subsequently expressed in percentage) of time spent with physical activity behaviours during recess across frequency of digital screen use during recess. This modelling approach was chosen to directly estimate the absolute changes in the proportion of time spent on physical activities, providing a more intuitive and straightforward interpretation of the associations compared with models that estimate relative differences. The analyses were adjusted for age, grade, sex, season of assessment and duration of daily recess. We accounted for the school-based sampling of participants by estimating robust standard errors with the vce (cluster) option in Stata (18.0 MP; StataCorp). Tests for linear trend across categories of frequency of screen use were performed by modelling frequency of screen use as an ordinal variable. We also conducted subgroup analyses by school grade, sex and season, and evaluated the statistical interaction between recess digital screen use and each of these factors in relation to recess physical activity behaviours. To test our models for bias due to confounding, we selected several negative control outcomes. These included the proportion of leisure time spent on physical activity behaviours during the same weekdays as those assessed for physical activity behaviours during recess. We selected these based on the premise that digital screen use during recess is not a direct determinant of leisure time activity. Furthermore, both behaviours may be shaped by similar confounding factors, including socioeconomic status, personal preferences like innate interests in physical activities, as well as social and parental influences. The negative control outcome analyses were adjusted for age, grade, sex and season of assessment. We also estimated the association of recess activity with leisure time activity to examine the extent to which these outcomes were associated. In sensitivity analyses, we repeated the main analyses with missing values imputed using chained equations[17] including all covariates and respective outcomes, and analyses using weekend physical activity behaviour as a negative control outcome. Statistical analyses were conducted using Stata MP version 18 (StataCorp). A two-sided p value <0.05 was considered significant.

Public and patient involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

RESULTS

Among the 1716 adolescents from 5th–9th grade participating in the PHASAR study, full data were available for 1347 adolescents aged 10–17 years (see flow chart in online supplemental figure 2). This analytical sample encompassed accelerometry-assessed physical activity during recess, self-reported digital screen use during recess, and various covariates. The physical activity of adolescents during recess and leisure time was measured over an average of 4.3 days. The median daily recess duration was 75 min. Most of the data (66.9%) were collected during the spring and summer seasons. The self-reported frequency of digital screen use increased with age and grade (table 1 and online supplemental figure 1). Among the 5th-grade and 9th-grade adolescents, 8.3% and 52.9% respectively reported using digital screens several times per day during recess. Conversely, 52.9% of 5th graders and 3.3% of 9th graders reported not using digital screens at all during recess (online supplemental figure 1). The distribution of recess activity behaviours across

Table 1 Descriptive statistics by frequency of recess digital screen use

	Frequency of digital screen use in recess during the past week				
	Several times a day	Every day or almost every day	2–3 times during the week	One day during the week	Not at all
N	395	257	178	167	350
Age (years)	14.4 (1.3)	13.9 (1.5)	13.2 (1.4)	12.9 (1.3)	12.1 (1.0)
Sex (male%/female%)	44/56	50/50	53/47	48/52	46/54
Weight (kg)	57.3 (11.6)	54.4 (11.9)	50.0 (12.2)	50.8 (11.5)	46.5 (11.3)
Height (cm)	165.9 (10.0)	163.9 (10.7)	158.9 (11.5)	160.1 (10.4)	154.8 (9.3)
Waist (cm)	71.4 (8.3)	70.6 (8.0)	69.4 (8.6)	69.7 (8.9)	67.6 (9.1)
Season (winter%/summer%)	50/50	39/61	22/78	16/84	24/76
Duration of daily recess (min)	72.3 (14.1)	69.5 (15.4)	70.2 (12.0)	72.0 (9.7)	73.9 (11.4)
Days of accelerometry assessment	4.4 (1.0)	4.3 (0.9)	4.3 (0.8)	4.0 (0.8)	4.2 (0.9)

Data are means (SD) or percentage.

grade is shown in violin plots in figure 1. The proportion of time spent in physically active behaviours decreased with grade level. On average, 5th grade adolescents spent 64.6% of their recess time engaged in behaviours considered physically active, while 9th graders spent 45.6% of their time being active. Among adolescents in the 7th–9th grades, sitting was the most prevalent behaviour observed during recess. In the total study sample, boys and girls respectively spent a mean of 60.3% and 52.1% of their time on physically active behaviours during leisure.

Figure 2 illustrates the estimated association between digital screen use during recess and physical behaviours. Adolescents who reported more frequent use of screens during recess spent a larger proportion of their time sitting. Conversely, they spent less time engaged in other activities, such as standing still or with minor movement,

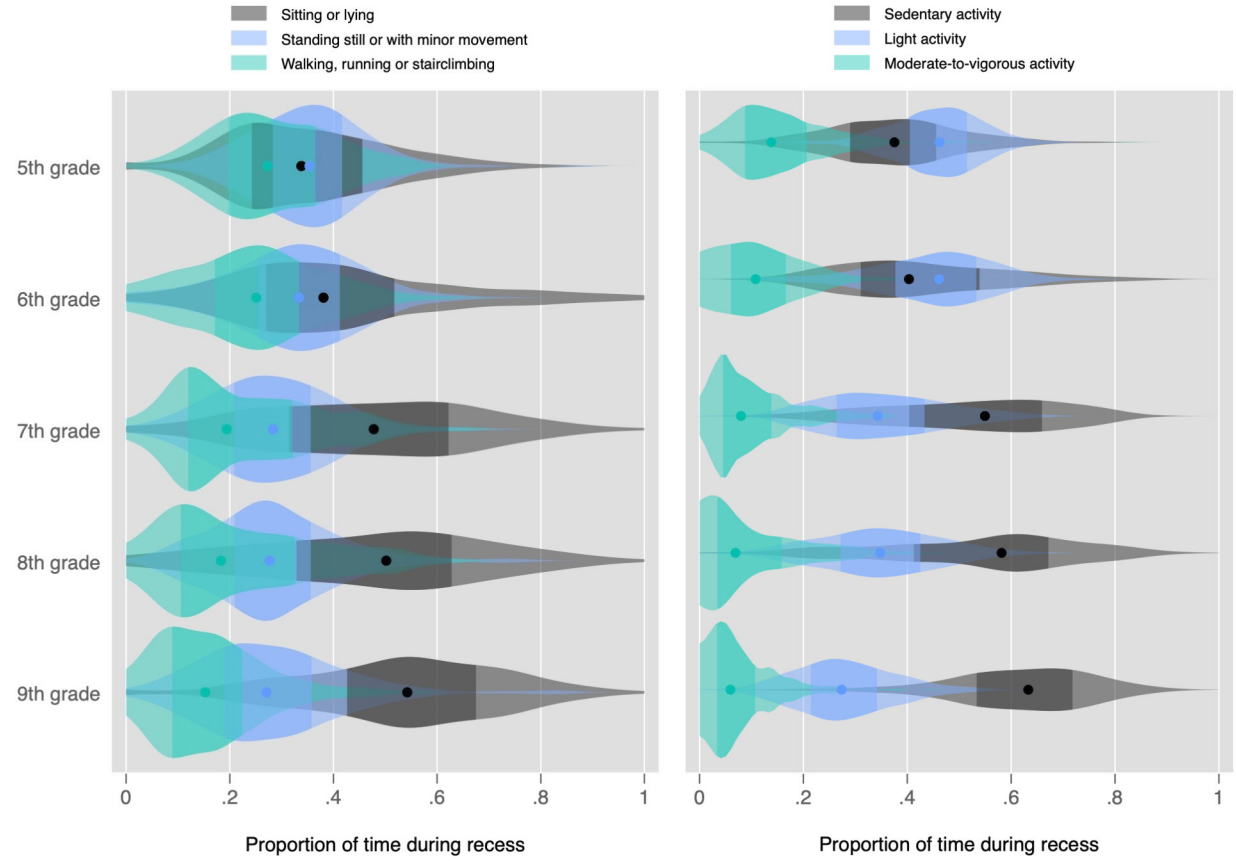

Figure 1 Distribution of time spent with physical behaviours and in activity domains during recess by school grade. Violin plots displays the estimated density of the proportion of time spent with physical activity behaviours during recess. The median (point) and interquartile range (the darker area) are shown within the transparent body of the violin plots.

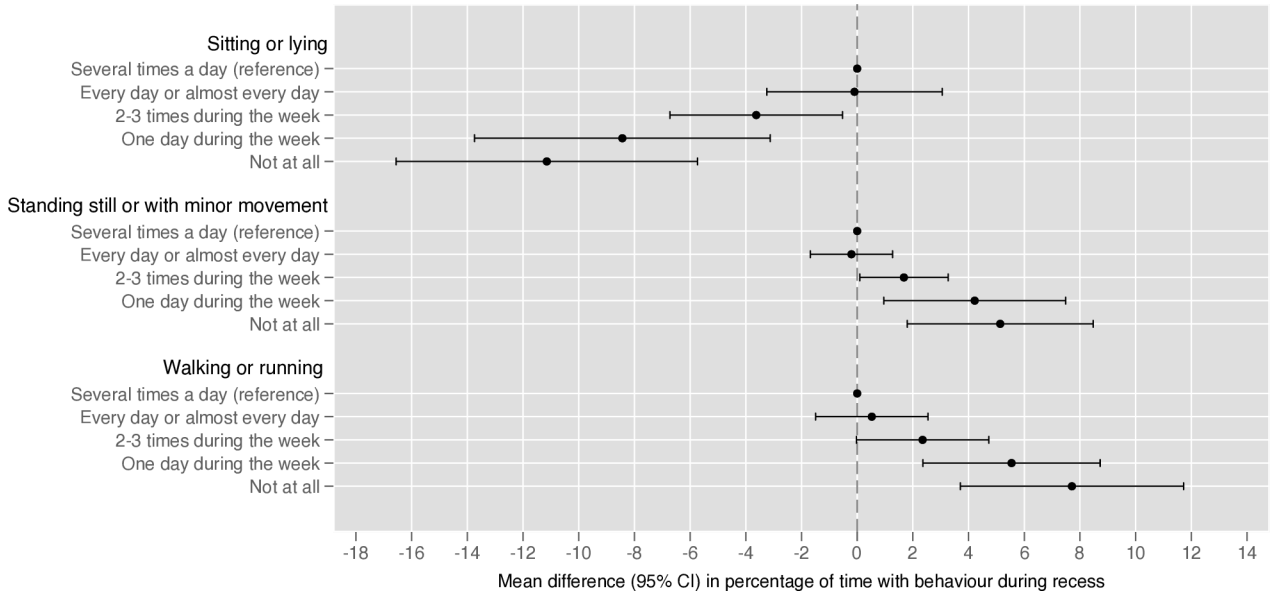

Figure 2 Adjusted mean difference in percentage point (absolute) of time with physical behaviours during recess across frequency of recess digital screen use. Estimates of mean differences in proportions expressed in percentage are from binomial generalised linear models with identity link adjusted for age, grade, sex, season of assessment, and duration of daily recess and accounting for the school-based sampling of participants (robust standard errors).

and significantly less time walking, or running during recess. These associations appeared consistent with a dose-dependent linear trend (p<0.01 for linear trend). When combining all physically active behaviours, adolescents who reported no screen use during recess were active an additional 11.1% (95% CI 5.4 to 16.8) of the time in absolute terms compared with adolescents who reported using screens several times during recess per day. Based on the mean recess duration observed in the sample, adolescents without screen use during recess had a predicted mean of 44.9 min/day (95% CI 42.3 to 47.6) spent being engaged in physically active behaviours in recess, compared with 35.1 min (95% CI 26.0 to 44.3) for their peers using screens several times during recess. Dose-dependent associations were also evident in our analysis of the proportions of recess time spent in different physical activity intensity domains, including sedentary, light and moderate-to-vigorous physical activity (figure 3, p<0.01 for linear trend). In our subgroup analyses by age, sex and season, we found

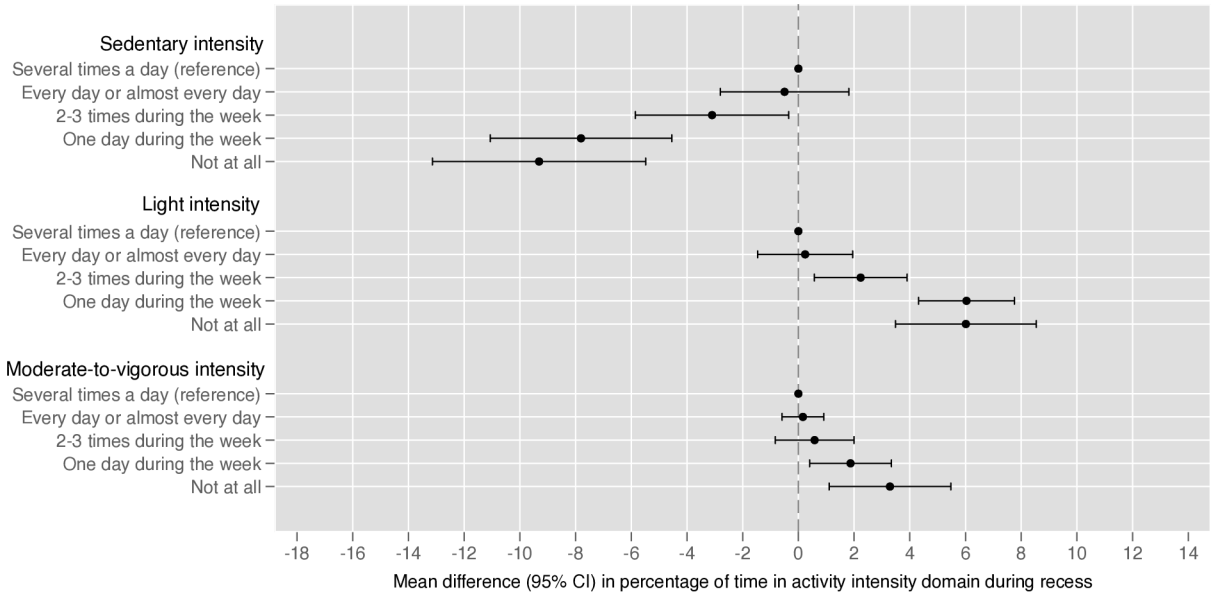

Figure 3 Adjusted mean difference in percentage point (absolute) of time with physical activity of different intensities during recess across frequency of recess digital screen use. Estimates of mean differences in proportions expressed in percentage are from binomial generalised linear models with identity link adjusted for age, grade, sex, season of assessment, and duration of daily recess and accounting for the school-based sampling of participants (robust standard errors). The ActiGraph cut points for sedentary, moderate and vigorous activity were 100, 4940 and 8756 counts per minute, respectively.

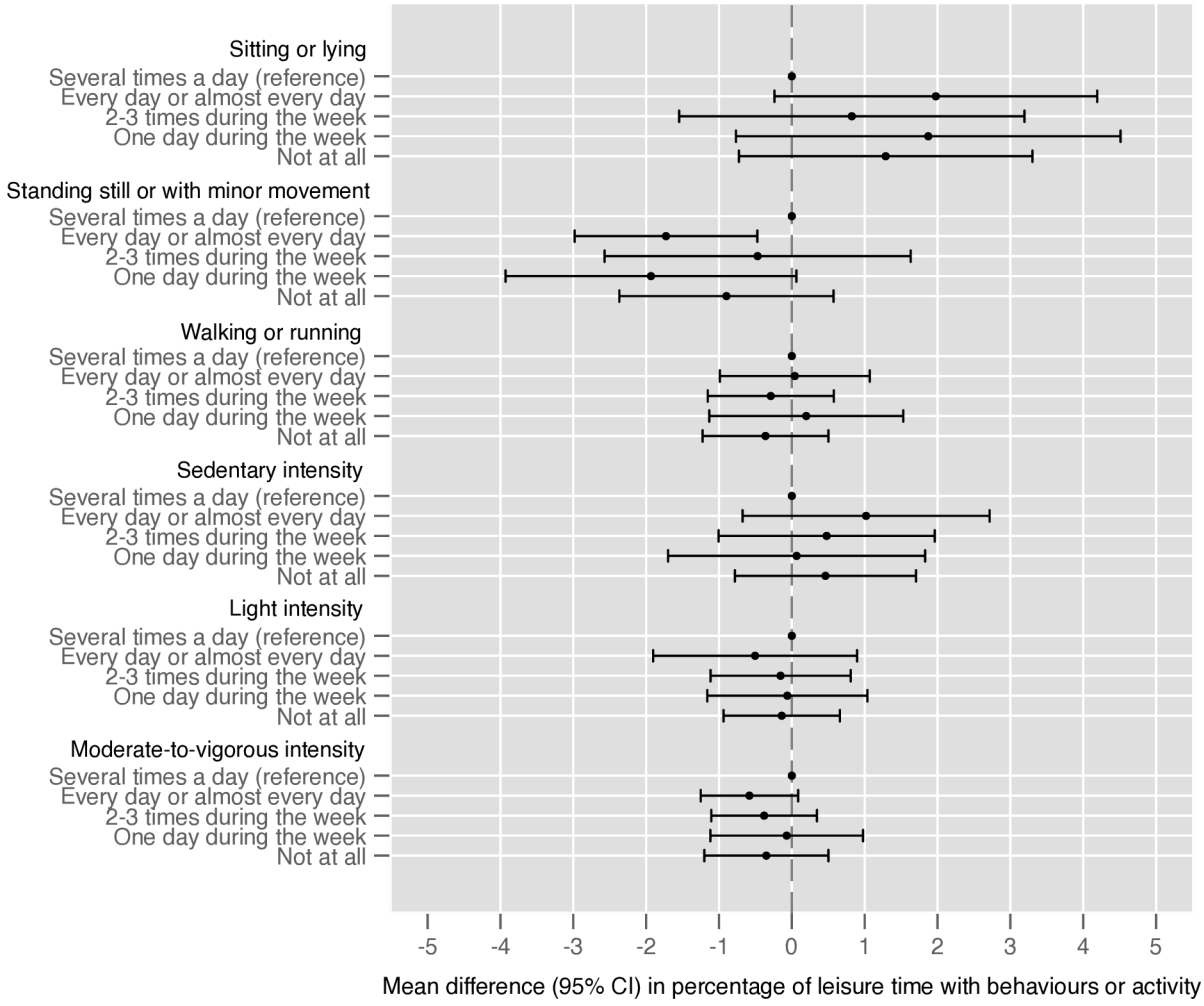

Figure 4 Negative control outcomes: estimates are adjusted mean difference in percentage point (absolute) of time with leisure time (weekdays) physical behaviours or activity across frequency of recess digital screen use. Estimates of mean differences in proportions expressed in percentage are from binomial generalised linear models with identity link adjusted for age, grade, sex and season of assessment, and accounting for the school-based sampling of participants (robust standard errors).

no statistical evidence of an interaction between these factors and screen use during recess on the proportion of time spent engaged in any physical activity (p>0.2 for all interactions) (online supplemental figure 3). In analyses restricted to the fall and winter seasons, no significant association was observed. Repeating the analysis with missing data imputed using chained equations provided very similar results (online supplemental table 1).

For the negative control, we observed an association between recess activity and activity during leisure. A 10 percentage-point increase in time spent engaged in physically active behaviour during recess was associated with a mean increase of 1.5 percentage points (95% CI 1.0 to 2.0) with physically active behaviour during leisure, after adjusting for age, sex, grade, recess duration and season. In the negative control outcome analyses, which included the same physical activity behaviours and intensity domains measured during leisure time on the same weekdays as recess, we found no consistent association between screen use during recess and any of the outcomes (figure 4). Weekend engagement in physical activity behaviour (proportion of time with physically active behaviour and proportion of time with moderate-to-vigorous physical activity), used as a negative control, was also unrelated to screen use during recess (online supplemental table 2). For a visual representation of the distribution difference in engagement in physically active behaviours across frequency of recess digital screen use, we refer to age-adjusted, sex-adjusted and season-adjusted kernel density function plots in the online supplemental material for active behaviours in recess and the negative control outcome (leisure time on weekdays) respectively (online supplemental figure 4).

DISCUSSION

In this population-based cross-sectional study among adolescents aged 10–17 years, we identified a consistent dose-dependent association between the frequency of digital screen use during recess and the proportion of

recess time spent engaged in physically active behaviours. Children who reported not using screens during recess were found to spend approximately 11%-points more time, on average, being engaged in active behaviours in recess compared with those who reported using screens several times per day. In our study sample, this difference translates to an estimated 9.8 additional mean minutes of physically active behaviours per school day. Although the magnitude of this difference may exert only a modest impact on physical health, it could have meaningful implications for other outcomes, including academic performance, social development and emotional health.

We found no association between recess screen use and any of our selected negative controls, which supports our confidence that the results were not explained by residual or unknown confounding. Should confounding factors be responsible for the association between recess screen use and physical activity behaviours, a similar pattern would likely emerge with leisure time physical activity behaviours, given the expected shared confounding. The observed association between activity levels during recess and leisure time indeed suggests the influence of shared confounding factors in both settings. Furthermore, the slight tendency for an association between more frequent screen use during recess and less sedentary behaviour and more standing in leisure time suggests the potential for negative confounding, implying that the true association between recess screen use and physical activity behaviours may be more pronounced than our findings indicate. Although analyses using negative control outcomes may reveal confounding unaccounted for, they may not adequately address the issue of reverse causation (eg, more sitting time leading to more screen use during recess). Nevertheless, our findings from a previous randomised trial, which showed that reducing screen use during leisure time resulted in increased physical activity in children and adolescents,[15] support the notion that frequent screen use during recess may indeed contribute to more sitting and less engagement in physically active behaviours during recess.

The associations between recess screen use and physical activity behaviours were evident in both younger and older adolescents and across both sexes. Previous descriptive studies have consistently found older adolescents and girls to be at a higher risk of physical inactivity,[7 18] a pattern also revealed in our study with large differences in active behaviours during recess between different age groups and genders. Previous research has shown that recess is a vital part of the school day, providing opportunities for physical activity, social interaction, and even contributing to cognitive functioning, academic achievement, emotional well-being and social skills.[4 19 20] However, the increasing use of screens during recess may disrupt these benefits, particularly in older adolescents, who were found to use screens more frequently during recess in our study sample. This trend towards sedentary behaviour, coupled with the potential other harmful effects such as a decrease in social interaction, suggests that policymakers and school authorities should consider these findings when shaping policies on recess screen use. A well-managed recess screen use policy may be particularly beneficial for older adolescents and adolescent girls, who are more at risk of inactivity. More research, however, is needed to fully understand the effects of limiting recess screen use on various aspects of adolescents' health, behaviour and academic outcomes.

Although there is little research available for comparison, our findings align with those from an uncontrolled experimental study conducted with 4th–7th-grade Danish students.[9] They reported an increase in the intensity and frequency of students' physical activity during recess, after a period with a restriction on smartphone use. The assessment was conducted using a direct observer method, focusing on large groups of students in areas typically used during recess rather than observing individuals. While our study was observational, we extend the findings of the previous research by employing a thoroughly validated methodology to assess physical behaviours objectively in a large population-based sample with a high participation rate. We used a thigh-worn accelerometer, allowing for accurate second-by-second classification of common physical behaviours, in addition to assessing time spent on physical activities of varying intensities.[13–15] Furthermore, by collecting school time schedules from each participant, we were able to accurately classify accelerometer data to the specific periods of recess. These methodological strengths, combined with the consistent associations observed across different age groups and genders, suggest that our findings have wider generalisability to the broader adolescent population.

Our study has certain limitations that warrant consideration. First, we developed a self-reported question to assess recess screen use, acknowledging that while this measure has not undergone formal validation, it may be subject to a degree of social desirability bias, potentially leading to some misclassification in response categories. Moreover, because we did not obtain data on the duration of screen use during recess, there may be substantial variability in actual usage time within each frequency category, potentially making comparisons less clear. We expect that some participants, particularly those with more frequent daily use, may have underestimated their screen use, which can bias our estimated association towards the null. This underestimation is particularly consequential if individuals less active during recess are disproportionately represented among those underreporting, due to the potential inverse causal relationship between screen use and physical activity. Second, the cross-sectional design introduces limitations. Even though we employed several negative control outcomes to exclude bias due to confounding, the results may still be partly influenced by reverse causation as previously explained. Additionally, using leisure time activity behaviour as a negative control may present challenges. If engagement in activity during recess causally affects leisure time activity, then using leisure time activity as a negative control outcome could be problematic. Despite observing an association between recess and leisure time activity, we do not believe

this relationship to be causal. Instead, we attribute the association to common confounding factors. The consistent null associations found with leisure time activity behaviours on both weekdays and weekend days provide reassurance that these limitations may not significantly affect our results. Finally, despite a high participation rate and a population-based sample, we did encounter missing data, which may introduce some selection bias. However, the multivariate imputation analysis did not suggest discordant results, mitigating this concern.

CONCLUSION

In this population-based study of Danish adolescents aged 10–17 years, we identified a consistent dose-dependent association between higher frequency of digital screen use during recess and lower engagement in physically active behaviours. While policies that limit recreational screen device use in schools are often introduced to help students focus on their education and enhance social interactions with peers and staff, our findings suggest that such limiting screen use may also have the important benefit of increasing physical activity during recess. These findings highlight the need for policymakers to acknowledge physical activity as a significant outcome when balancing the potential benefits and harms of limiting recreational screen use in schools.

Contributors AG, PLK, JCB, AKG, NCM, KTL, SK, JT, SB and NHP contributed to the design of the study. NHP, SK and KTL completed the data collection. JCB processed all accelerometer data. AG, NHP and PLK verified data. AG completed all statistical analysis and drafted the manuscript. All authors interpreted data and critically revised the manuscript and approved the final version. AG (gurantor) accepts full responsibility for the finished work and the conduct of the study, had access to the data and controlled the decision to publish.

Funding The study was funded by TrygFonden (ID 115606 and ID: 130081) and Novo Nordisk Foundation (Grant number NNF20SH0062965). The funding organizations had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The Region of Southern Denmark Ethical Committee waived ethical approval as no interventions or human biological materials were involved, per guidelines. An informed passive consent process was conducted both orally and in writing with participants and their parents or guardians. Participants were included in the study unless they or their guardians chose to withdraw, and it was emphasised that participation was voluntary, with the option to withdraw at any time, and that all data would be treated confidentially and anonymously. Prior to data collection, the Danish Data Protection Agency (approval reference 2015-57-0008) reviewed and approved the project, validating the legal framework for obtaining informed passive consent.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Send an application to the PHASAR Steering Committee (agroentved@health.sdu.dk). Anonymised data will be available only if approved by the Steering Committee and the Danish Data Protection Agency.

ORCID iD

Anders Grøntved http://orcid.org/0000-0003-1584-679X

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