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Effect of nationwide school policy on device-measured physical activity in Danish children and adolescents: a natural experiment

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Summary

Background A new Danish school policy with a requirement for 45 min physical activity daily during school hours was introduced in 2014. The objective of this natural experiment was to evaluate the effect of this nationwide school policy on physical activity in Danish children and adolescents.

Methods Four historical studies completed between 2009 and 2012 comprised the pre-policy study population. Post-policy data were collected in 2017/18. All post-policy schools were represented in the four pre-policy studies. Age-groups and seasons were matched. In total, 4816 children and adolescents aged 6–17 were included in the analyses (2346 pre-policy and 2470 post-policy). Children and adolescents were eligible if they had accelerometer measurements and did not have any physical disabilities preventing activity. Physical activity was measured by accelerometry. Main outcome was any bodily movement. Secondary outcomes were moderate to vigorous physical activity and overall movement volume (mean counts per minute).

Findings The school policy interrupted a linear decreasing pre-policy trend in physical activity during school hours. All activity outcomes increased post-policy during a standardized school day (8:10 am–1 pm). Increases were more pronounced in the youngest children. Specifically, we observed a daily increase during a standardized school day in 2017/2018 of 14.2 min of movement (95% CI: 11.4–17.0, $p < 0.001$), 6.5 min of moderate to vigorous physical activity (95% CI: 4.7–8.3, $P < 0.001$), and 141.8 counts per minute (95% CI: 108.5–175.2, $P < 0.001$).

Interpretation A national school policy may be an important strategy to increase physical activity during school hours among children and adolescents.

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Keywords: Physical activity; School policy; Health policy; Children and adolescents

Introduction

A large body of evidence supports that physical activity (PA) is essential in health promotion and disease prevention.[1] Nevertheless, most children and adolescents are not achieving the recommended amount of PA. On a global scale, 81% of 11–17 year olds are not being sufficiently physically active,[2] and in Denmark 74% of 11–15 year olds are not achieving a minimum of 60 min

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Research in context

Evidence before this study

Insufficient physical activity among children and adolescents is a major public health concern. A few countries, states, and regions have introduced policies to promote physical activity in schools with the aim of getting all children and adolescents to be regularly physically active. However, evidence of the effect of such policies on device-measured physical activity in children and adolescents is scarce. Physical activity promoting school policies have been introduced in some provinces of Canada, Norway, and Hungary, among others. To our knowledge, only one study from Canada has examined the effect of a province-wide physical education policy on device-measured physical activity. More research is needed to shed light on the effects of nationwide policies mandating daily physical activity during school hours.

Added value of this study

In a natural experiment, we investigated the effect of a new Danish school policy introduced in 2014 with a requirement for an average of 45 min physical activity daily (5 days a week) during school hours. Using device-measured data on physical activity from historical pre-policy studies and newly collected carefully matched post-policy data, our study suggests that a school policy requiring an average of 45 min of daily physical activity was able to interrupt a declining pre-policy trend in physical activity during school hours in Danish children and adolescents.

Implications of all the available evidence

Results from our study provide evidence that a nationwide school policy that requires schools to integrate 45 min of physical activity daily into the school days was effective in increasing school children's physical activity during school hours. Our results are particularly relevant for planners and decision-makers at all levels, who in the future will be responsible for implementing initiatives that ensure that children and adolescents are sufficiently physically active.

of moderate to vigorous PA daily.[3] The World Health Organisation (WHO) has emphasized national PA policies or programs as an essential strategy to tackle insufficient PA.[4] School-based initiatives to promote PA play a pivotal role in this strategy.[4] Children and adolescents from all socioeconomic strata spend a large part of their waking hours in school making it a popular setting for population-wide promotion of PA. While the effectiveness of many school-based intervention programs has been examined,[5] little evidence is available on the impacts of nationwide school-based policies to promote PA.

School is mandatory from age 6 to 16 in Denmark, and most children and adolescents (75.1%) attend public schools free of charge. The Danish Government introduced a new school policy in 2014 that included an ambitious PA-promoting initiative targeting all public schools throughout the country. The overall aim of the school policy was to ensure that the school setting supported all children and adolescents in meeting their full learning potential by minimizing the significance of social background and ensuring wellbeing among school children and adolescents. The strategy was to achieve this by alternating between regular lessons and activities (play, movement, projects, and workshops). The school policy entailed several structural changes including a longer school day and a requirement of 45 min PA daily during school-time. In Denmark, the municipalities have the school governance responsibility. Thus, interpretation and implementation of the 45 min of daily PA were outsourced to municipalities and school leaders. The school policy did not specify the intensity or type of PA, and the activities could be integrated in the existing academic lessons or in lessons dedicated to PA (e.g., physical education). Nevertheless, the health potential of this policy-driven PA-promoting school policy is considerable as it targets most children and adolescents in Denmark.

Internationally, similar school policies have been introduced in Hungary, Norway, and some provinces of Canada, among others.[6–8] To our knowledge, no one has examined the effectiveness of a nationwide school policy on device-measured PA. *The primary objective* of the present study was to examine the effect of a nationwide school policy on device-measured school-time PA in Danish children and adolescents aged 6–17. *The secondary objective* was to examine the effect of the school policy on PA during a full day, including both school and out-of-school hours.

Methods

Study design

A natural experiment evaluating PA before and after the introduction of a PA-promoting school policy.[9]

Study populations

Pre-policy populations

Data from four historical studies completed between 2009 and 2012 formed the basis for an assessment of PA before the school policy; i) EYHS: The European Youth Heart Study (2009/10),[10] ii) CHAMPS: Childhood Health, Activity and Motor Performance Study (2009, 2010, and 2012),[11] iii) WCMC: When Cities Move Children (2010 and 2012),[12] and iv) SPACE: School site, Play

Spot, Active transport, Club fitness and Environment (2010 and 2012).[13] Sampling and recruitment strategies in the four historical studies have been described elsewhere.[10–13] The pre-policy studies included data from 2346 children and adolescents between 6 and 16 years from 42 schools located in two out of five regions in Denmark. Each of the studies contributed with data from different age-groups and areas of Denmark. From EYHS, 278 9th graders from 26 schools located in the Municipality of Odense were included. From CHAMPS, 585 1st–8th graders from 4 schools located in the Municipality of Svendborg were included. From WCMC, 776 5th–8th graders from 5 schools located in the Municipality of Copenhagen were included. From SPACE, 707 5th–8th graders from 7 schools located in the Municipalities of Sønderborg, Northern Funen, Esbjerg, and Vejle were included. A map showing the geographical representation is presented in Supplement.

Post-policy population

The PHASAR study (Physical Activity in Schools After the Reform) was initiated to provide comparable post-policy assessments of PA. Thirty-six schools were contacted in 2016/17 and invited to participate. All invited schools were represented in the pre-policy studies, and age-groups were matched. Thirty-one schools accepted the invitation: 20 schools representing the EYHS population, four schools representing the CHAMPS population, two schools representing the WCMC population, and five schools representing the SPACE population. The five schools that declined to participate did not have the time and/or resources to participate. Details on recruitment and data collection are described in the study protocol.[9] Children and adolescents received oral information at the schools, and parents/guardians received a written invitation explaining objectives, content, and procedures. It was emphasized that participation was voluntary, and it was possible to withdraw at any time. A total of 3426 children and adolescents between 6 and 17 years (1st–9th grade) were invited to participate in the post-policy data collection. Children and adolescents were eligible to participate if they did not suffer from any physical disabilities or injuries preventing PA. Participants with ≥1 valid days were included. Sample size justification is described elsewhere.[9]

Data collection

Data collection procedures in the historical studies have been described elsewhere.[10–13] Post-policy data was collected between August 2017 and October 2018, and for each study post-policy data were collected during the same seasons as in the pre-policy data collection. E.g., CHAMPS data was collected during fall pre-policy, and thus schools recruited to match CHAMPS were tested during fall post-policy.

Accelerometry

In pre- and post-policy studies PA was assessed with a waist-mounted accelerometer attached with an elastic belt. Participants were asked to wear the accelerometer for seven consecutive days. In pre-policy studies, ActiGraph monitors (GT1M and GT3X) were used. The ActiGraph monitors have previously been validated against energy expenditure and found to be a valid and reliable method to assess PA in children.[14] In the PHASAR study, Axivity AX3 accelerometers were used. The Axivity AX3 stores raw acceleration, whereas ActiGraph monitors store acceleration information as counts per time unit. The raw Axivity AX3 acceleration files were converted to binary compatible GT3X data files, and ActiGraph counts were generated with the same ActiLife software as used to generate counts data for all ActiGraph devices. An epoch duration of 10 s was used. Observations with more than 10% non-wear were excluded to avoid underestimation of outcomes (n_{id} = 175, n_{days} = 33,484). Non-wear was defined as 60 min of consecutive stillness.

Data processing and accelerometry outcomes

Three PA outcomes were constructed from the waist accelerometer (vertical axis). *Time spent with movement* was the primary outcome (elaborated below). *Time spent with moderate to vigorous PA (MVPA)* and overall movement volume expressed as *mean counts per minute (CPM)* were secondary outcomes.

In the policy, PA intensity was not specified. Thus, a new *Time spent with movement* outcome was generated to capture any bodily movement. The new accelerometer cut-point was established by combining thigh- and waist-worn data from the post-policy population, where participants wore two accelerometers. With a thigh-worn accelerometer it is possible to objectively classify different activity types with high accuracy.[15] These activity types were used to classify periods of minor or no movement (from activity classifications *sitting*, *standing*, and *move*) and periods of bodily movements (from *walking*, *running*, and *biking*). A movement threshold for the waist-accelerometry data was determined using a ROC-analysis that identified activity counts at the thigh that corresponded to the mentioned activity categories. Data from n = 2369 children and adolescents were used. With a threshold of 753 CPM the sensitivity and specificity for distinguishing between activities with minor or no movements from activities with bodily movements were 0.908 and 0.899, respectively (data not shown). *Time spent with MVPA* was generated based on the validated Evenson cut-point (>2296 CPM).[16]

All PA data were analyzed for two different time periods: *standardized school-time (8:10 am–1 pm)* and *full day*. In addition, *Leisure time* was included in a post hoc analysis. School timetables were not available in all pre-policy studies. School hours were determined by aggregating acceleration data by age-group and study to create PA intensity time trajectories for each weekday. A clear pattern appeared during school hours due to the constant shift between class and recess. Thus, *wake time*, *bedtime*, and *school-start and -end* could be identified and used to define *leisure time* and *full day*. The school day was prolonged as a part of the school policy and the total school-time available to accumulate PA changed during the period 2009–2018. Consequently, data on school-time PA were not directly comparable pre- and post-policy. A standardized 8:10 am–1 pm school-time variable was constructed to control the effect of school day length.

Grouping of studies by year of measurement

All data were grouped by year across studies using primarily the school calendar. Four data periods were generated: 2009/10, 2010/11, 2012, and 2017/18. Data were only collected during the mid-two quarters in 2012 and not across the whole school year.

Ethical considerations

The need for ethical approval was waived by the Regional Scientific Ethical Committee (The Region of Southern Denmark, Damhaven 12, 7100 Vejle) since no intervention was provided and the study did not contain human biological material (cf. guidelines). Consent took form of an oral and written informed passive consent from children and adolescents and parents/guardians. Children and adolescents were included in the study unless they or their parents/guardians decided to withdraw. It was emphasized that participation was voluntary, participants could withdraw at any stage, and data would be treated confidentially and anonymously. Before collecting data, the project was notified and approved by the Danish Data Protection Agency (2015-57-0008), who confirmed the legal basis of the informed passive consent. All data are stored and treated in accordance with Danish law for protection and the General Data Protection Regulation.

Statistical analyses

All statistical analyses were conducted in StataBE 17 (StataCorp), and Matlab R2021b (Mathworks Inc.) was used for accelerometry data processing. A statistical analysis plan was developed and preregistered (https://www.clinicaltrials.gov/ct2/show/NCT03946241?term=NCT03946241&draw=2&rank=1).

Movement, MVPA and mean CPM were continuous variables. A linear mixed-effect regression approach was used to examine changes in PA levels over time. Time was treated as a categorical variable (2009/10, 2010/11, 2012 and 2017/18). Analyses were adjusted for age, sex, and season of year (spring/summer vs. fall/winter). Random effects were included for projects, schools, and individuals due to the assumption that observations within these clusters were not independent. We assumed that the effect of the policy might be different in various age-groups. Thus, stratification was utilized to account for this in the primary analysis.

To evaluate the effect of the school policy on PA outcomes, a two-step approach was used: Step 1: the three pre-policy annual measurement periods were investigated for pre-policy trends in PA. Step 2: post-policy data were included and the effect of the school policy on PA outcomes was evaluated.

Initially, pre-policy linearity was tested. If t_x denote time (2009/10, 2010/11 or 2012) and $b(t_x)$ denote reference category contrast describing PA at time t_x relative to the reference category t_0 = 2009/10, the null hypothesis of a linear pre-policy trend was tested using the postestimation command *test* in Stata (i.e., testing the following linear hypothesis for the regression coefficients H0: b(2010/11) = b(2012)/2.5 years). In case of linearity, a test of constant pre-policy levels in PA was applied: (H0: b(2010/11) = b(2012) = 0). If the pre-policy trend was linear, the second step was to evaluate the effect of the school policy by including post-policy data to the mixed-effect linear regression model and test whether linearity continued post-policy (H0: b(2010/11) = b(2012)/2.5 years = b(2017/18)/8 years) or whether the constant pre-policy level continued post-policy (H0: b(2010/11) = b(2012) = b(2017/18) = 0). If no linear trend existed in the pre-policy data, a bootstrap method with 1000 replications was implemented testing whether b(2017/18) significantly exceeded all pre-policy estimates simultaneously, i.e., b(2009/10), b(2010/11) and b(2012). As bootstrap test statistic, the distance between b(2017/18) and the largest pre-policy estimate was used together with normal bootstrap confidence intervals. Using the bootstrap method, no assumptions were made regarding pre-policy trends in b(t). Trends were plotted using marginal means with 95% confidence intervals based on linear mixed-effect regression analyses. In the main analysis, age was stratified in two groups (1st–5th and 6th–9th) based on tabulations to ensure that each data point (year group) contained enough observations.

In outcomes with linear pre-policy trends, post-hoc analyses were completed estimating the difference between the observed 2017/18 post-policy estimate and the predicted 2017/18 post-policy estimate as it would have been if pre-policy trends had continued post-policy. The same mixed-effect linear regression model was used, but the time variable was changed to a continuous variable and a binary pre- and post-policy variable was added to the model.

To obtain a simplified measure of the difference between pre- and post-policy, post hoc analyses were conducted, where pre-policy time points were collapsed. Time was now treated as a binary variable testing post-policy data against one collapsed pre-policy time point. In addition, the binary model was completed on all outcomes during leisure-time, and marginal means were plotted to investigate trajectories in PA outcomes during leisure-time (data in Supplement).

Data were checked for all statistical assumptions concerning the mixed-effect models; normality and homoscedasticity of residuals and linearity between dependent and independent variables.

Role of funding source

TrygFonden had no role in study design, data collection, analysis, interpretation, writing, or submission.

Results

Participation rates in historical projects were 65–89% in SPACE,[13,17] 56% in EYHS,[18] 84% in NBBB,[19] and 87–89% in CHAMPS.[20] 2672 children and adolescents consented to participate in the post-policy data collection (78%), and 2470 participants provided one or more valid days (72.1%). Reasons for missing data were problems with accelerometers (technical or uncertainty of wear location) or not meeting the non-wear criterion. A higher mean age and a different distribution of sex (more boys) were observed in the group of participants that did not provide valid measurements compared to the participants included in analyses.

Table 1 provides a descriptive overview of the number of individual assessment days and participants included in the study by year of measurement. From 2009 to 2018, a total of 4816 children and adolescents contributed with one or more valid observations (days). Boys and girls were equally distributed between years, whereas the distribution of data across seasons and age-groups varied between years.

Pre-policy trends

Between 2009/10 and 2012, negative pre-policy trends were observed within movement, MVPA, and CPM during a standardized school day (test for linearity: $p > 0.05$) (data in Supplement). When main outcome (movement) was stratified by age-groups; 1st–5th grade and 6th–9th grade, pre-policy trends maintained linear in both groups (data in Supplement). Pre-policy trends were not linear for neither movement, MVPA nor CPM (test for linearity: $P < 0.05$) during a full day (data in Supplement).

Estimated effect of the school policy

Linear pre-policy trends

Effect estimation was performed differently depending on linearity in pre-policy trends. A negative linear pre-policy trend was observed for standardized school-time movement, MVPA, and CPM. In Table 2, estimated mean differences with 2009/2010 as reference category are presented. In all analyses, a decreasing pre-policy trend was evident (data in Supplement). When 2017/18 was included in the analyses, the decreasing linear trends were interrupted (Table 2), and upward shifts were observed between 2012 and 2017/18 in all outcomes (Fig. 1, a–c).

When movement during a standardized school day was stratified into two age-groups (1st–5th grade and 6th–9th school grade), a steeper increase between 2012 and 2017/18 was observed in younger children compared to older ones. Post-policy levels in the youngest significantly exceeded the 2009/10 reference estimate (data in Supplement).

Using a linear trajectory approach, effect sizes were calculated assuming that pre-policy trends would continue with the same slope post-policy. The

			2009/10	2010/11	2012	2017/18
			N_{days} (N_{id})	N_{days} (N_{id})	N_{days} (N_{id})	N_{days} (N_{id})
Standardized school-time (8:10 am–1 pm)	Sex	Girls	3819 (942)	1284 (287)	2654 (645)	5054 (1297)
		Boys	3682 (924)	1153 (271)	2400 (635)	4342 (1170)
	School level	1st–5th grade	3938 (952)	1880 (407)	1401 (321)	4900 (1279)
		6th–9th grade	3563 (914)	557 (151)	3653 (959)	4496 (1188)
	Season	Spring/summer	4272 (1132)	1291 (283)	4345 (1123)	3504 (937)
		Fall/winter	3229 (738)	1146 (275)	709 (157)	5892 (1530)
Full day	Sex	Girls	2535 (851)	881 (265)	1379 (529)	4734 (1264)
		Boys	2267 (796)	760 (240)	1132 (448)	3763 (2561)
	School level	1st–5th grade	2639 (866)	1267 (380)	785 (284)	4612 (1239)
		6th–9th grade	2163 (781)	374 (125)	1726 (693)	3885 (1102)
	Season	Spring/summer	2677 (972)	883 (266)	2097 (841)	3053 (883)
		Fall/winter	2125 (675)	758 (239)	414 (136)	5444 (1458)

N_{days}: Number of days, N_{id}: Number of participants.

Table 1: **Characteristics of participants from 2009/10, 2010/11, 2012 and 2017/18.**

	Outcome	Year	β (95% CI)	P-value	P-value (linearity)
Standardized school day	Movement (min/school day)	2009/10 (reference)	–	–	
		2010/11	−3.9 (−5.0; −2.8)	<0.001	
		2012	−4.2 (−5.1; −3.3)	<0.001	
		2017/18	0.4 (−0.6; 1.3)	0.444	<0.001
	MVPA (min/school day)	2009/10 (reference)	–	–	
		2010/11	−1.3 (−2.0; −0.6)	0.001	
		2012	−1.9 (−2.5; −1.3)	<0.001	
		2017/18	0.4 (−0.2; 0.9)	0.225	<0.001
	CPM (counts/min/school day)	2009/10 (reference)	–	–	
		2010/11	−31.0 (−44.4; −17.7)	<0.001	
		2012	−42.9 (−53.6; −32.3)	<0.001	
		2017/18	2.8 (−8.0; 13.7)	0.611	<0.001

Estimates obtained from mixed-effect linear regression analyses. P-value (linearity) is based on a post estimation test of a linear combination of coefficients: b(2010/11) = b(2012)/2.5 = b(2017/2018)/8. MVPA: moderate to vigorous physical activity. CPM: Mean counts per minute.

Table 2: **Estimated mean differences in PA outcomes during a standardized school day.**

differences between the 2017/18 estimate and the predicted 2017/18 estimate (if pre-policy trends had continued post-policy) were 14.2 min of movement daily (95% CI: 11.4–17.0, $p < 0.001$), 6.5 min of MVPA daily (95% CI: 4.7–8.3, $P < 0.001$), and 141.8 CPM daily (95% CI: 108.5–175.2, $P < 0.001$) (data in Supplement).

Non-linear pre-policy trends (bootstrap method)
Non-linear pre-policy trends were observed in all outcomes during a full day. When post-policy data were included in the analysis, the post-policy estimates did not exceed maximal pre-policy estimates but were significantly lower (Table 3). Thus, the test criterion for a positive effect of the school policy were not met for either movement, MVPA, or CPM during a full day (Table 3, Fig. 1, d–f).

Post-hoc analyses
A binary pre- and post-policy (pre-policy data collapsed) comparison was completed during a standardized school day, a full day, and during leisure-time. Results revealed significant positive changes between pre- and post-policy in all outcomes during a standardized school day. During a full day, a significant decrease was observed in movement and mean CPM. During leisure-time, significant decreases were observed in all outcomes (Table 4).

Discussion
This study found that the introduction of a nationwide school policy in 2014 requiring that school children and adolescents should achieve an average of 45 min of daily PA during school hours was associated with an increase in movement, MVPA, and CPM during a standardized 8:10 am–1 pm school day. When evaluated across a full day, no clear effect of the school policy on PA was observed.

The present investigation was conducted as a natural experiment with no control group. Similar time-series designs have previously been used to evaluate nationwide policy changes.[21,22] Such comparisons may be subject to confounding from other societal changes affecting PA during the time span of evaluating the implementation of the policy. In this study, it was possible to investigate changes on leisure-time PA, which were expected to be either unaffected by the policy change or decrease as a consequence of more school PA due to compensation as previously reported.[20,23] Thus, leisure-time PA was used as a negative control outcome.[24] If a similar positive change in leisure-time PA occurred, this could indicate uncontrolled confounding. This study showed a decrease in PA during leisure-time post-policy in contrast to an increase during school hours, which suggests a causal interpretation of our findings for PA during school-time.

This study adds to a large body of evidence reporting no or small effects of school interventions on MVPA measured during a full day.[5,25] In binary pre-post analyses in the present study, movement and CPM even decreased during a full day. Unlike a school day, which has a very fixed structure, there are many factors that may have influenced leisure PA, which makes it difficult to draw definitive conclusions about the effect of the school policy on PA during an entire day. For example, sedentary activities (especially screen use) seem to have become a greater part of leisure activities during the spanning of this study. In a Norwegian setting, a recent study reported an increase between 2005 and 2018 by 29 and 21 min/day in time spent sedentary among boys aged 9 and 15, respectively.[26] In a recent randomized trial, an intervention to reduce screen time in children and adolescents resulted in a significant increase in leisure-time PA,[27] which supports the possible causal role

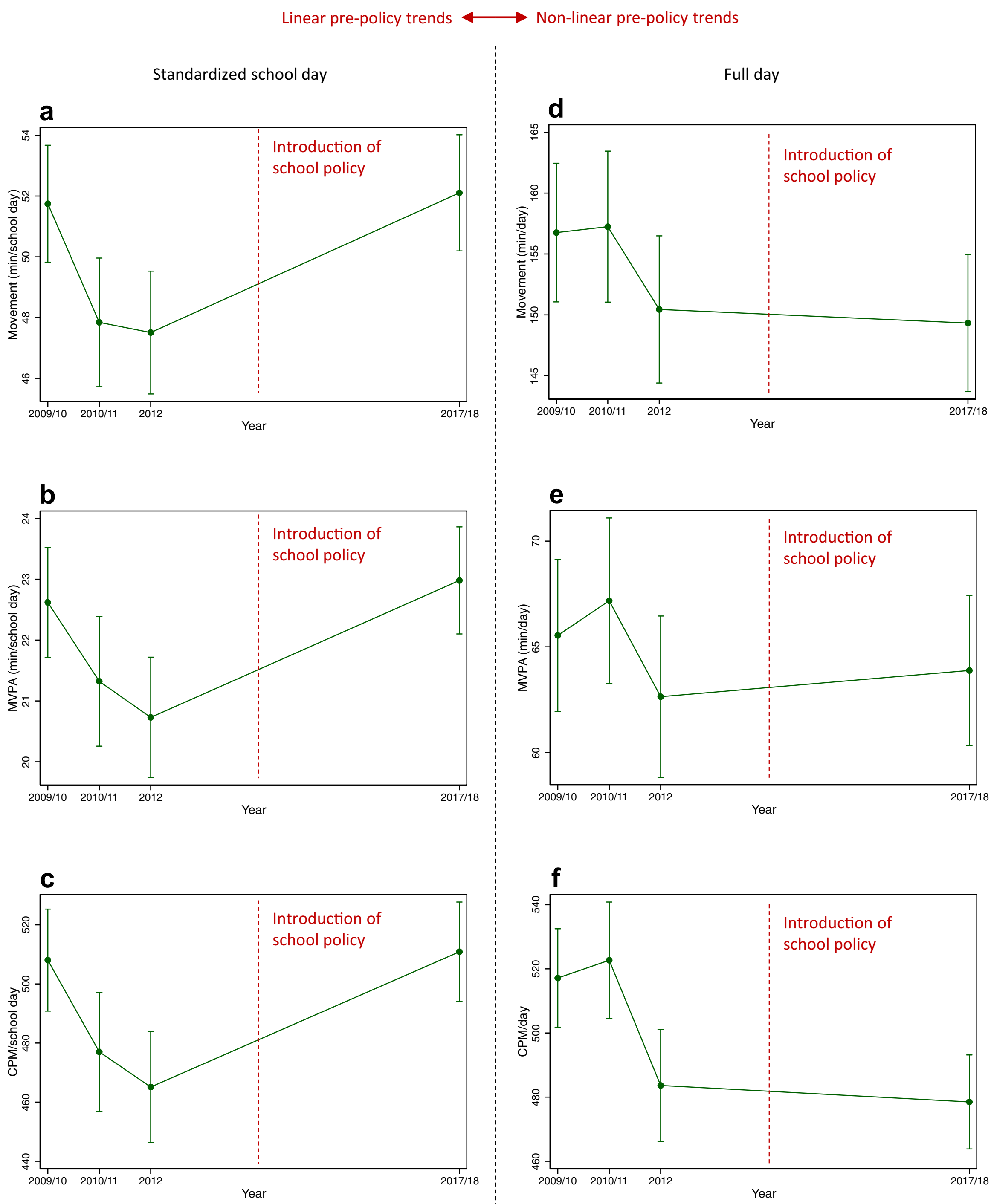

Fig. 1: **Marginal means with 95% CI of pre- and post-policy movement, MVPA and CPM during a standardized school day (a–c) and during a full day (d–f).** CPM: Mean counts per minute. MVPA: moderate to vigorous physical activity.

of increasing screen use on the decline of young people's leisure-time PA found in this study. The school policy introduced a series of other structural changes including a longer school day, which may have deprived children and adolescents of leisure-time opportunities to be active as they have less time to accumulate PA after school.

In 2017, a Canadian study examined the effect of a province-wide physical education policy on device-

	Outcome	Year	β (95% CI)	P-value	Bootstrap	
					Observed coefficient (normal based 95% CI)	P-value
Full day	Movement (min/school day)	2009/10 (reference)	–	–		
		2010/11	0.5 (−2.6; 3.6)	0.756		
		2012	−6.3 (−9.0; −3.6)	<0.001		
		2017/18	−7.4 (−10.0; −4.8)	<0.001	−7.9 (−10.6; −5.2)	<0.001
	MVPA (min/school day)	2009/10 (reference)	–	–		
		2010/11	1.6 (−0.3; 3.6)	0.097		
		2012	−2.9 (−4.6; −1.2)	0.001		
		2017/18	−1.7 (−3.3; −0.1)	0.043	−3.3 (−5.3; −1.3)	0.001
	CPM (counts/min/school day)	2009/10 (reference)	–	–		
		2010/11	5.5 (−6.8; 17.9)	0.379		
		2012	−33.5 (−44.4; −22.6)	<0.001		
		2017/18	−38.7 (−48.9; −28.4)	<0.001	−44.2 (−56.3; −32.1)	<0.001

Estimates obtained from mixed-effect linear regression analyses. Bootstrap testing b(2017/18) minus maximum of (2009/10), b(2010/11) or b(2012) based on the mixed-effect linear regression analyses. CPM: Mean counts per minute. MVPA: moderate to vigorous physical activity.

Table 3: **Estimated mean differences in PA outcomes during a full day.**

measured PA. The policy was introduced in Manitoba and the Alberta province was used as control. No policy effect on MVPA was observed.[28] Previous school-based PA interventions that were deemed successful have found increases in the intervention group of 4 and 11 min of MVPA during school-time, respectively.[29,30] In the present study, we observe a population mean change of 6.5 min of MVPA during a standardized school day. Increasing MVPA is especially relevant, since PA at this intensity is highly related to numerous health outcomes.[1] Considering that the pre-policy crude mean and standard deviation in MVPA during a standardized school day were 22.0 and 15.5 min/day, respectively (Supplement), this change is relevant in a health perspective. However, the estimated effect size and its' possible health effects should be interpreted in the light of an observed decline during leisure-time and no overall change during a full day. An evaluation of the policy implementation was conducted simultaneously and revealed that the school policies' PA requirement was only partly implemented, and the potential may be greater.[31]

The greatest strength in this study is that it is based on carefully harmonized device-measured physical activity measures in a rather large sample. However, only two of five Danish regions were represented, which limits geographical representativeness and may affect external validity. An additional limitation is unavailability of data from non-responders, which potentially could affect generalizability to the wider population.

Our results suggest that the Danish school policy introduced in 2014 requiring that school children should engage in 45 min of PA daily during school hours was associated with an increase in PA during school-time. No increase was observed during a full day; however, this may be a consequence of other concurrent events (e.g., screen media development) affecting leisure time PA. This study includes only one post-policy time-point and no measurements close to the introduction of the policy in 2014. Thus, we cannot conclude whether the school policy caused a level change, slope change, or whether the change is delayed or short-lived. Our findings may inform public health authorities and policy makers on multiple levels considering the current problem of physical inactivity in children and adolescents.

		β (95% CI)	P-value
Standardized school day	Movement (min)	1.7 (0.8; 2.5)	<0.001
	MVPA (min)	0.9 (0.3; 1.4)	0.002
	CPM	14.7 (4.3; 25.2)	0.006
Full day	Movement (min)	−6.6 (−9.1; −4.1)	<0.001
	MVPA (min)	−1.5 (−3.1; 0.1)	0.058
	CPM	−34.6 (−44.5; −24.7)	<0.001
Leisure-time	Movement (min)	−19.9 (−21.8; −17.9)	<0.001
	MVPA (min)	−7.1 (−8.3; −5.9)	<0.001
	CPM	−111.0 (−137.0; −85.1)	<0.001

Estimates obtained from mixed-effect linear regression analyses. CPM: Mean counts per minute. MVPA: moderate to vigorous physical activity.

Table 4: **Estimated mean differences in PA outcomes between pre- and post-policy measurements (binary analysis) during a standardized school day, leisure-time, and a full day.**

Contributors

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Schipperijn, Lars B. Christiansen, Niels Wedderkopp, Niels C. Møller, Anders Grøntved, Peter L. Kristensen, Jens Troelsen, and Kristian T. Larsen all contributed to the conception, design, and data collection of one or more of the pre-policy studies (EYHS, WCMC, CHAMPS and SPACE). Jan C. Brønd processed and harmonized all accelerometer data. Natascha H. Pedersen and Peter L. Kristensen verified data, completed all statistical analysis and interpretation of these with support from Birgit Debrabant. All authors have had access to data. All authors critically revised the manuscript and approved the final version.

Data sharing statement

Data will not be publicly available. Send an application to the PHASAR Steering Committee (agroentved@health.sdu.dk). Anonymized data will be available only if approved by the Steering Committee and the Danish Data Protection Agency. Statistical analysis plan is available at (https://www.clinicaltrials.gov/ct2/show/NCT03946241?term=NCT03946241&draw=2&rank=1), and study protocol is published.

Declaration of interests

Competing interests: All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/disclosure-of-interest/ and declare no conflict of interest. Århus University hospital, Neurochirurgical department made payment to BD's institution (i.e., to IMADA, University of Southern Denmark). Göteborgs universitet, Institut of clinical science, made payment to BD's institution (i.e., to IMADA, University of Southern Denmark). UK Medical Research Council and NIHR provided support for SB's institution (Program grant and Centre grant, respectively). Moreover, S.B. was invited speaker at Yonsei University at two symposia (pro rata academic speaker fee), and Nanyang Technical University Singapore supported travelling costs for S.B. for attending meetings with local researchers. J.S. is president for the International Society for Physical Activity and Health (ISPAH), which is an unpaid volunteer position.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanepe.2022.100575.

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