Behavioural and social correlates of sedentary time in young people

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Accepted 18 August 2008
Published Online First 23 September 2008

ABSTRACT

Objective In this study, behavioural and social correlates of objectively measured sedentary time in young people were identified.

Design Cross-sectional analysis of data from the European Youth Heart Study (EYHS).

Setting Schools in Denmark, Estonia, Portugal and Norway.

Participants Respondents were invited using a two-stage cluster sampling procedure. Analyses include 2107 children (9–10 years old) and adolescents (14–15 years old).

Assessment of independent variables Seven behavioural and 15 social variables assessed by parental and computerised child questionnaires.

Main outcome measure Sedentary activity as assessed by accelerometry (10 min blocks at <200 counts/min). Analyses were stratified by country, and interactions with grade and sex were investigated.

Results Adolescents were more sedentary than children (335.4 (90.4 min/day) vs 217.2 (75.6 min/day), $p<0.001$). Patterns of associations differed across countries. High computer use and no television viewing before school in Norway, and being sedentary during school breaks in Estonia were positively associated with sedentary time. No behavioural variables were associated with sedentary time in the Danish and Portuguese models. Socioeconomic position was positively associated with sedentary time in Portugal and Estonia, father's body mass index negatively in the Estonian model. Norwegian participants with a game console at home and Portuguese participants with a television in their bedroom were more sedentary.

Conclusions A single strategy aimed at reducing sedentary behaviour is unlikely to be effective across Europe as the target populations and behaviours of focus differ between countries. Targeting high socioeconomic groups in Portugal and Estonia or focusing on reducing computer use in Norway might be effective intervention strategies to reduce overall sedentary time.

Regular physical activity in young people is believed to be associated with various physical and mental health benefits, some of which extend into adulthood.[1–3] Alongside engaging in too little physical activity, it has also been suggested that young people spend too much time in sedentary activities, which further increases their risk of future health problems.[4 5] Although TV viewing is a frequently used proxy measure for overall sedentary activity, the appropriateness of this approach has been questioned.[4–6] Research has shown that only low to moderate correlations exist between sedentary activities,[7 8] suggesting that sedentariness among young people is multifaceted and cannot accurately be represented by one proxy measure. Moreover, no association to weak associations have been reported between TV viewing and physical activity,[7 9] indicating that the behaviours are not two sides of the same coin. There is also a lack of evidence of an association between TV viewing and health indicators, such as body fatness.[10] However, recent research shows that overall time spent in sedentary activities is associated with health outcomes, such as weight gain [11 12] in children and adults, independent of physical activity level,[13 14] whereas interruptions to prolonged periods of sedentary time are beneficially associated with metabolic risk in adults.[15] These results indicate that targeting reductions in overall sedentary time instead of a single behaviour might be more effective.

To develop interventions aimed at reducing sedentary time, an understanding of the determinants of this behaviour is required. These are likely to differ from determinants of physical activity behaviour.[16 17] Research into correlates of sedentary behaviour should be conceptualised within an ecological framework to identify a broad range of intrapersonal, interpersonal and environmental influences.[18] To date, research has mainly focused on TV viewing, with recent reviews showing consistent associations with body mass index (BMI) and sociodemographic factors (eg, ethnicity, socioeconomic status (SES)), but few associations with modifiable factors.[18 19] Previous studies of the correlates of overall sedentary behaviour have relied on self-reported measures of the behaviour. In a British sample of 11–12-year-olds, sedentary behaviour (defined as screen time) was greater among those from minority ethnic backgrounds, living in more deprived neighbourhoods and having psychological problems.[20] Sedentary behaviour was also shown to increase during puberty, independent of ethnicity or SES.[21] In a cross-sectional sample of American 11–15-year-olds, where sedentary behaviour was self-reported but more widely defined (including screen time and activities such as listening to the radio and talking on the phone), age was also positively associated with overall sedentary behaviour.[22] Moreover, sedentary behaviour-specific psychological factors (such as self-efficacy, and perceived pros and cons), family environmental factors and hills in the neighbourhood were associated with high levels of sedentary time (>240 min) in girls, whereas only self-efficacy and barriers to change were associated in boys. No studies have investigated correlates of objectively measured sedentary time, although accelerometry may be a suitable method to assess overall sedentary time,[23] and objectively measured sedentary time has been shown to be associated with

metabolic outcomes in children.[12] Use of a more precise measure of sedentary time also reduces measurement error, increasing the likelihood of detecting associations.[24] The aim of the current paper is to investigate associations of objectively measured sedentary time with self-reported sedentary behaviours and sociocultural factors in a large population-based sample of European children.

METHODS

Study design and participant recruitment

The European Youth Heart Study (EYHS) was designed to study the personal, environmental and lifestyle influences on cardiovascular disease risk factors in European children. A detailed description of the study rationale, aims, design, selection criteria and sample size is provided elsewhere.[25] A brief overview is provided below.

A defined population of children was identified in each study region (Odense, Denmark; Tartu, Estonia; Oslo, Norway; Madeira, Portugal). Children were randomly selected using a two-staged cluster sampling procedure with schools as the primary sampling unit and classes being the secondary sampling unit. Schools were stratified by the sociodemographic characteristics of their local area, and a minimum of 20 schools were randomly selected from local authority lists using probability proportional to school size. Children from grades 3 and 9 (aged 9 and 15 years, respectively) were then randomly sampled within schools using the school register. The overall response to invitations was 72% and was similar across age and sex groups (total n = 4072). Written and verbal explanations of study procedures were provided, and written informed consent was obtained from the child's parent or legal guardian. Ethical approval was obtained from the local ethics committee in each study region.

Data collection

The present cross-sectional analyses uses baseline data collected during school visits between 1997 and 2000. A standardised research protocol was followed in each country in collecting, processing and analysing the data.[25] Child-reported variables were assessed using a validated computer-based questionnaire,[26] and physical activity was assessed for 4 days following the school visit. Parent-reported questionnaires were completed separately by both parents (no parent data was collected for Norwegian grade 9 participants).

Outcome variable—sedentary time

Data on overall activity levels was collected using the MTI accelerometer (model 7164). The MTI is a hip-worn electronic motion sensor comprising a single plane (vertical) accelerometer, which has been validated in both children and adolescents.[25] Verbal and written instructions were given to both the children and their parents regarding its use. Epoch time was set to 60 s, and children were asked to wear the monitor for four consecutive days, including two weekend days, during all waking hours (excluding water-based activities). Upon return, data were downloaded into a computer and stored for further analyses. A Microsoft Excel-based macro was used for data reduction (including exclusion of sequences of 10 or more consecutive minutes with zero counts) and to derive relevant variables. Children who did not manage to record at least 600 min/day for at least 3 days were excluded from analyses. A total of 2107 children (1608 nine-year-olds and 1131 fifteen-year-olds) provided valid accelerometer data and were included in the current analyses.

To assess sedentary time, all recorded activity between 23:00 and 05:00 was excluded to avoid overestimation caused by children sleeping with the monitor. A cut-off of <200 counts/min was used to identify sedentary activity. To date, cut points of 100 counts/min,[27] 500 counts/min,[12 28] and 800[29] have been identified and used to define sedentary activity. A relatively low cut point was selected in this analysis to avoid including minutes of ''very light to light activity'' and because time spent below this threshold has previously been shown to be associated with obesity in 11-year-old children.[30] To minimise the influence of incidental low values, we used the number of sedentary minutes in bouts of at least 10 min, allowing for 1 min exceptions, as our main outcome variable.

Exposure variables

Where relevant, variables were dichotomised based on frequency distributions to reduce the number of dummy variables included in the model and maximise statistical power.

General variables

Height and weight were measured using standard procedures,[25] and BMI was calculated by dividing weight in kilograms by height in metres squared. Child's ethnicity was reported by parents and collapsed into a dichotomous variable (white vs other ethnic background).

Behavioural variables

All variables were child-reported, and previously validated questionnaires were used to assess break-time activity and active travel.[31] A composite variable representing activity level during breaks was constructed from reported activity at morning and lunch break (see appendix 1). Travel mode to school was dichotomised into active travel (walking, cycling) and non-active travel (car, bus, train). Frequency of eating meals while watching TV was reported in five categories and dichotomised into nearly everyday (everyday, most days) or less frequent. The four categories of reported TV viewing before school and computer use were dichotomised into less than 1 or 1 h or more. TV viewing after school was reported in five categories and dichotomised at 2 h. Previous EYHS analyses have shown these measures of TV viewing to be associated with waist circumference[32] and metabolic syndrome.[33]

Parental variables

All parental variables were self-reported by mothers and fathers separately, including height and weight. Parental sports participation was measured by asking parents whether they participated in regular physical activity or sports (yes/no). In each country, parental education was classified into four categories (basic/primary; secondary/trade apprentice; higher vocational qualifications; university) and income into eight categories. Socioeconomic position was assessed by summing the score for mother's and father's educational level and the mean score for mother's and father's income.

Sedentary opportunity variables

Children self-reported the number of TVs in the household and if they had a games computer or a video at home or a TV in their bedroom (yes vs maybe/no).

Psychosocial variables

Children self-reported on a four-point scale how often (1) they could choose what TV programme to watch; (2) the TV was on when they returned home and (3) they felt that they were not allowed to play outside because of parental safety concerns (hardly ever or never, once or twice a week, most days, everyday). All scales were dichotomised by combining the first two and the last two categories.

Data analyses

Country distinct relationships in this data set have been reported previously,[34] therefore all analyses (conducted in 2006) were stratified by country. Initial analyses were conducted using univariate linear regression analyses with sedentary time as dependent variable. Differences in effect between sexes or grades were investigated by creating two-way interaction terms and separately including these in the univariate model. Analyses including BMI were adjusted for grade to take into account that BMI increases with age during youth. All single-term exposures and interaction terms achieving a probability of less than 0.20 were subsequently entered into multivariable models. A manual backward stepwise regression method was used to build the final models, with decision on removal of variables based on the p-value of the exposure variable. Where relevant, non-significant interaction terms were removed before single terms. The significance level for remaining in the model was set at 0.05. Initially, a country-specific model including sex, grade and other remaining significant general variables was built. The subsequent four models were built by adding to the base model: model 2, plus parental variables; model 3, plus sedentary opportunity variables; model 4, plus psychosocial variables; model 5, plus behavioural variables.

RESULTS

Descriptive characteristics

On average, EYHS participants spent 262 (99.7 minp/day) in sedentary time (just under 4.5 h) (fig 1). Danish participants were the most sedentary, compared with participants from the other three countries (all $p<0.05$). No other differences were observed. In all countries, adolescents were more sedentary than children (335.4 (90.4 min/day) vs 217.2 (75.6 min/day), $p<0.001$). Table 1 shows the frequency and distribution of the exposure variables across the different countries. Between-country differences were observed for almost all variables. Remarkable observations include the low level of sports participation in Portuguese mothers and fathers and the higher proportion of children in Norway that have a game console at home and are not allowed to play outside because of safety reasons.

Univariate analyses

The results of the univariate analyses are reported in table 2. A significant difference between sexes was only observed in Estonia, with boys being less sedentary than girls. Grade-adjusted BMI was positively associated with sedentary activity in Portugal, negatively in Estonia and not associated in other countries. Out of the 19 behavioural and social factors considered, in each country, less than half were significantly associated with sedentary time in the univariate analyses (seven in Denmark, six in Estonia, nine in Norway and six in Portugal).

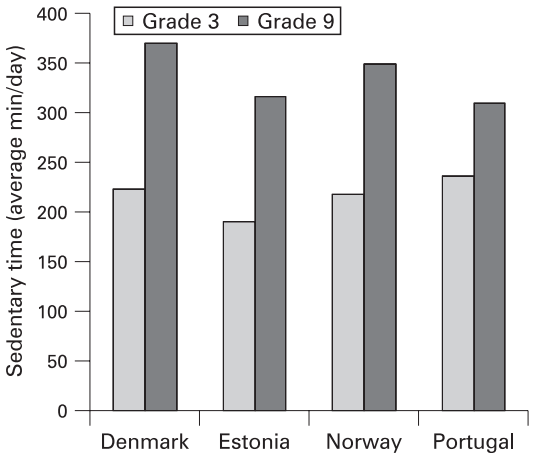

Figure 1 Average sedentary time per day for grade 3 and grade 9 children in the EYHS cohorts in Denmark, Estonia, Norway and Portugal (measured with Actigraph accelerometer). Grade differences are significant within countries at $p<0.001$.

Multivariable analyses

Table 3A–D presents the results of the country-specific multivariable models.

Parental, opportunity and psychosocial correlates

Only one social correlate was retained in the Danish and Norwegian models. In the Danish model, this was a significant interaction between father's reported sports participation and sex, although stratified analyses showed that the association was non-significant in both boys ($\beta = 15.35$, 95% confidence interval (CI) −4.25 to 34.95) and girls ($\beta = -17.26$, 95% CI −35.21 to 0.69). The model for Estonia retained two social variables (a positive association with father's BMI and a negative association with socioeconomic position), while four were retained in the Portuguese model (positive associations with mother's sport participation, socioeconomic position and having a TV in the bedroom and a negative association with finding the TV on when arriving home).

Behavioural correlates

In both the Danish and Portuguese behavioural models, none of the variables or interaction terms was retained. In the Estonian model, one behavioural correlate was retained (negative association with activity during break), as well as a significant interaction between sex and TV viewing before school. Stratified analyses, however, did not show a significant association for either girls ($\beta = 14.17$, 95% CI −12.32 to 40.66) or boys ($\beta = -28.41$, 95% CI −59.40 to 2.58). Two significant correlates were retained in the Norwegian behavioural model (positive association with TV viewing before school and negative association with hours of computer use per day).

DISCUSSION AND CONCLUSION

The aim of the current study was to investigate behavioural and social correlates of objectively measured sedentary time in Danish, Estonian, Norwegian and Portuguese youth. The results indicated that participants from the four countries spent different amounts of time in sedentary activities, with Danish participants being the most sedentary. On average, participants spent 262 min/day in sedentary activity, which is lower than previously reported in 12-year-old American girls.[35] Whether this is because of a true difference or differences in data collection

Table 1 Descriptive data for exposure variables, per country. Values are percentages within country or mean (SD)

Exposure variable	Denmark	Estonia	Norway	Portugal
N	590	603	440	474
General variables				
Sex (% boys)	45.6	56.1	48.0	51.5
Grade (% grade 3)	62.7	52.4	68.9	67.1
BMI (kg/m^2)	18.5 (3.0)	18.4 (3.1)	18.1 (2.9)	19.2 (3.5)
Child's ethnicity (% Caucasian)	95.2	83.3	84.2*	98.5
Parental variables				
Mother participate in sport (% yes)	39.2	26.0	48.6*	8.4
Father participate in sport (% yes)	41.9	21.0	46.8*	9.5
BMI mother (kg/m^2)	23.5 (3.7)	24.1 (4.4)	23.0 (3.2)*	25.7 (4.0)
BMI father (kg/m^2)	25.0 (3.1)	25.9 (3.7)	25.3 (3.1)*	26.4 (3.5)
SES (mean of education and income) (score: 3–16)	9.4 (2.8)	9.2 (2.5)	10.8 (2.4)*	6.7 (2.2)
Sedentary opportunity variables				
⩾2 TVs at home	81.1	43.7	74.2	68.9
TV in bedroom (% yes)	57.1	25.9	67.8	37.7
Video at home	86.9	46.6	91.2	70.2
Game console at home	55.4	33.8	70.6	43.7
Psychosocial variables				
Most days can choose TV programmes	52.0	67.9	79.4	63.4
Most days TV on when coming home	7.3	34.3	16.6	21.3
Not allowed play outside (not safe), % yes	50.7	54.3	80.8	16.9
Behavioural variables				
Active travel to school	72.5	55.1	88.2	43.4
Activity level during breaks				
Mostly sedentary	23.7	27.7	15.6	28.1
Variable	37.7	45.9	26.1	26.0
Mostly active	38.6	26.4	58.3	45.9
(Almost) every day meals in front of TV	40.0	58.8	43.4	46.4
Bed time at school day				
Before 21.00	36.7	22.9	32.9	23.5
Between 21.00 and 22.00	27.7	39.0	39.1	41.3
After 22.00	35.6	38.2	28.0	35.2
TV viewing before school, ⩾1 h	4.2	13.6	9.2	15.0
TV after school, ⩾2 h	15.4	42.2	25.4	30.9
Computer use per day, ⩾1 h	15.2	16.4	27.3	26.8

*Data only available for grade 3 participants.

and processing is difficult to ascertain. For example, the American study not only used a lower cut point to define sedentary time (⩽100 counts/min) but also imputed missing data and did not exclude accidental night-time wearing. Consistent with previous reports, sedentary time was higher in adolescents than in children,[4 20 22] suggesting that early intervention may be needed to prevent this increase. While Estonian boys were less sedentary than Estonian girls in both age groups, no sex differences in sedentary time were observed in the three remaining countries. This is in contrast to physical activity research, which consistently shows boys being more active than girls.[36–38] However, previous research has shown no difference between sexes in self-reported total sedentary time either,[22] although the children did engage in different behaviours.

Despite considering a wide range of potential correlates of sedentary time, only a few significant associations were observed in the multivariable analyses, as most of the univariate observations were attenuated after controlling for age and sex. This was mainly due to the fact that the prevalence of many of the exposure variables differed per age group. For example, adolescents reported going to bed later than children, explaining the observed positive association with bed time in the univariate analyses. Nevertheless, the observed associations were consistent across age groups and sex.

To our knowledge, this is the first study aiming to identify which specific behaviours contribute to overall sedentary time. We considered seven self-reported behaviours ranging from various screen-based behaviours to active travel. Results were inconsistent across countries. No associations with behavioural factors were observed in Denmark or Portugal. In Estonia, activity during school breaks was associated with sedentary time, suggesting that decreasing sedentary activities during school break times might be a target for intervention. This might be achieved by environmental changes to the playground or by providing more equipment.[39] In Norway, both high computer use during leisure time and having a games console were associated with higher sedentary time, independent of age and sex. An intervention targeting reductions in computer use during leisure time might therefore be an effective strategy to reduce sedentary time in Norway. In contrast, Norwegian participants reporting television viewing for more than 1 h before school were less sedentary than those who watched less, independent of computer usage, age and sex. Only 9% of Norwegian participants reported longer periods of TV viewing before school, and it might reflect behaviour of highly active

Table 2 Results of univariate analyses between general, behavioural, parental, sedentary opportunity and psychosocial exposures and sedentary activity (unstandardised β coefficient and 95% CI)

Exposure variable	Denmark	Estonia	Norway	Portugal
General variables				
Sex (1 = boys)	−10.7 (−27.8 to 6.4)	−59.6 (−76.5 to −42.7)***	−14.0 (−31.1 to 3.1)****	−13.6 (−28.1 to 0.9)****
Grade (1 = grade 9)	147.3 (134.2 to 160.4)***	123.5 (109.2 to 137.8)***,†	130.8 (116.9 to 144.7)***,†	73.4 (59.3 to 87.5)***
BMI (kg/m^2)§	−1.46 (−4.03 to 1.11)	−6.42 (−9.38 to −3.46)***,†	0.81 (−1.86 to 3.48)	3.34 (1.22 to 5.46)**,†,‡
Child's ethnicity (% Caucasian)	−10.2 (−50.6 to 30.2)	18.6 (−5.7 to 42.9)****	−20.7 (−41.1 to −0.3)*	−1.5 (−61.5 to 58.5)
Parental variables				
Mother participate in sport (% yes)	7.2 (−10.6 to 25.0)‡	−13.1 (−34.1 to 7.9)†,‡	−1.4 (−16.3 to 13.5)	34.9 (9.2 to 60.6)**
Father participate in sport (% yes)	2.1 (−15.7 to 19.9)†	4.2 (−19.7 to 28.1)	5.2 (−10.9 to 21.3)	1.9 (−23.0 to 26.8)
BMI mother (kg/m^2)	−1.6 (−4.0 to 0.8)****	1.7 (−0.5 to 3.9)****,†	−1.4 (−3.8 to 1.0)†	1.1 (−0.9 to 3.1)
BMI father (kg/m^2)	0.2 (−2.7 to 3.1)	−3.6 (−6.1 to −1.1)**	−0.3 (−2.8 to 2.2)	0.7 (−1.5 to 2.9)
SES (mean of education and income) (score: 3–16)	1.4 (−1.7 to 4.5)	1.5 (−2.0 to 5.0)†,‡	4.2 (1.1 to 7.3)**	1.5 (−2.0 to 5.0)‡
Sedentary opportunity variables				
⩾2 TVs at home	25.7 (3.7 to 47.7)*	4.6 (−13.0 to 22.2)	19.7 (−0.1 to 39.5)****	−15.4 (−32.6 to 1.8)****
TV in bedroom (% yes)	−48.5 (−65.6 to −31.4)***,‡	12.6 (−7.4 to 32.6)	0.6 (−18.0 to 19.2)	26.7 (10.2 to 43.2)**,†,‡
Video at home	−12.2 (−37.7 to 13.3)‡	8.1 (−9.5 to 25.7)†	−14.2 (−45.0 to 16.6)	3.6 (−14.0 to 21.2)
Games console at home	4.8 (−12.6 to 22.2)†,‡	16.4 (−2.2 to 35.0)****,†	22.3 (3.3 to 41.3)*,†	0.6 (−15.7 to 16.9)†,‡
Psychosocial variables				
Most days can choose TV programmes	56.7 (40.0 to 73.4)***	43.9 (25.5 to 62.3)***	45.1 (23.9 to 66.3)***	−1.9 (−18.6 to 14.8)‡
Most days TV on when coming home	−31.7 (−64.8 to 1.4)****	−15.4 (−33.8 to 3.0)****	3.3 (−20.0 to 26.6)	−27.0 (−46.4 to −7.6)**
Not allowed play outside (not safe), % yes	22.7 (5.5 to 39.9)*	12.8 (−4.8 to 30.4)****,†	−42.6 (−64.4 to −20.8)***,‡	0.3 (−21.3 to 21.9)
Behavioural variables				
Active travel to school	45.3 (26.3 to 64.3)***,†,‡	11.0 (−6.6 to 28.6)‡	−41.6 (−68.3 to −14.9)**	−15.9 (−32.2 to 0.4)****,‡
Activity level during breaks (reference: mostly sedentary)				
Variable	−37.2 (−58.4 to −16.0)**,‡	−8.9 (−29.3 to 11.5)‡	−20.2 (−44.1 to 3.7)****,‡	−21.8 (−42.6 to −1.0)*,‡
Mostly active	−95.3 (−116.3 to −74.3)***,‡	−74.9 (−97.8 to −52.0)***,‡	−105.5 (−126.9 to −84.1)***,‡	−59.4 (−77.6 to −41.2)***,‡
(Almost) every day meals in front of TV	−4.7 (−22.3 to 12.9)	1.3 (−16.5 to 19.1)	−6.6 (−24.2 to 11.0)	−17.1 (−33.2 to −1.0)*,‡
Bed time at school day (reference: before 21:00)				
between 21:00 and 22:00	29.7 (11.7 to 47.7)**,‡	57.7 (35.6 to 79.8)***,†	39.0 (20.8 to 57.2)***	44.1 (23.9 to 64.3)***,‡
after 22:00	134.2 (117.3 to 151.1)***,‡	89.6 (67.5 to 111.7)***,†	108.4 (88.6 to 128.2)***	48.4 (27.6 to 69.2)***,‡
TV viewing before school, ⩾1 h	−6.5 (−49.8 to 36.8)‡	−20.1 (−45.8 to 5.6)****,†	−37.5 (−67.3 to −7.7)*,†	6.8 (−15.7 to 29.3)
TV after school after school, ⩾2 h	14.0 (−9.9 to 37.9)	28.1 (10.5 to 45.7)**	30.2 (10.4 to 50.0)**	−10.9 (−28.3 to 6.5)
Computer use per day, ⩾1 h	22.5 (−1.4 to 46.4)****	−31.2 (−54.7 to −7.7)**,†	9.0 (−10.6 to 28.6)†	−5.8 (−24.0 to 12.4)

*p<0.05; **p<0.01; ***p<0.001; ****p<0.2.
†Interaction with sex (p<0.20).
‡Interaction with grade (p<0.20).
§Adjusted for grade.

Table 3 Results of the final multivariable analyses between general, behavioural, parental, sedentary opportunity, and psychosocial exposures and sedentary activity, stratified by country (presenting general model and additionally statistically significant single terms and interactions)

Exposure variables	β Coefficient (95% CI)	p-Value
A: Denmark*		
General		
Sex (0 = girls, 1 = boys)	−4.39 (−17.17 to 8.39)	0.501
Grade (0 = grade 3, 1 = grade 9)	147.14 (133.99 to 160.29)	0.000
	Adjusted $r^2 = 0.450$	
Parental		
Father's sport participation†	−17.26 (−35.21 to 0.69)	0.060
Sex* father's sport participation†	32.61 (5.95 to 59.27)	0.016
	Adjusted $r^2 = 0.454$	
Opportunity	–	
Psychosocial	–	
Behavioural	–	
B: Estonia*		
General		
Sex (0 = girls, 1 = boys)	−19.39 (−38.32 to −0.46)	0.045
Grade (0 = grade 3, 1 = grade 9)	162.54 (141.10 to 183.98)	0.000
Sex* Grade	−48.23 (−76.10 to −20.36)	0.001
BMI	−5.57 (−8.43 to −2.71)	0.000
	Adjusted $r^2 = 0.390$	
Parental		
BMI father	−2.41 (−4.49 to −0.33)	0.023
Socioeconomic position	4.88 (1.86 to 7.90)	0.002
	Adjusted $r^2 = 0.413$	
Opportunity	–	
Psychosocial	–	
Behavioural		
Activity during break (ref: sedentary)	−21.11 (−37.79 to 4.43)	0.013
Variable	−1.57 (−22.37 to 19.23)	0.882
Mostly active	14.17 (−12.33 to 40.67)	0.295
TV viewing before school (≥1 h)†	−42.58 (−83.29 to −1.87)	0.041
Sex* TV before school†	Adjusted $r^2 = 0.394$	
C: Norway		
General		
Sex (0 = girls, 1 = boys)	−2.47 (−15.43 to 10.49)	0.709
Grade (0 = grade 3, 1 = grade 9)	130.50 (116.53 to 144.47)	0.000
	Adjusted $r^2 = 0.435$	
Parental‡		
Opportunity		
Games console at home	15.24 (0.64 to 29.84)	0.041
	Adjusted $r^2 = 0.438$	
Psychosocial	–	
Behavioural		
TV viewing before school (≥1 h)	−26.62 (−49.36 to −3..88)	0.022
Computer use per day (≥1 h)	20.89 (5.41 to 36.37)	0.009
	Adjusted $r^2 = 0.446$	
D: Portugal*		
General		
Sex (0 = girls, 1 = boys)	−88.93 (−162.23 to −15.63)	0.018
Grade (0 = grade 3, 1 = grade 9)	161.11 (65.85 to 256.37)	0.001
BMI	2.65 (−0.54 to 5.84)	0.105
Sex* BMI	3.97 (0.21 to 7.73)	0.039
Grade* BMI	−4.78 (−9.37 to −0.19)	0.042
	Adjusted $r^2 = 0.209$	
Parental		
Mother's sport participation	28.74 (4.30 to 53.18)	0.022
Socioeconomic position	3.96 (0.69 to 7.23)	0.019
	Adjusted $r^2 = 0.222$	
Opportunity		
TV in bedroom	18.77 (4.03 to 33.51)	0.013
	Adjusted $r^2 = 0.233$	
Psychosocial		

Continued

Table 3 Continued

Exposure variables	β Coefficient (95% CI)	p-Value
(Almost) always TV on when come home	−20.14 (−37.51 to −2.77) Adjusted $r^2 = 0.230$	0.024
Behavioural	–	

*Final general model is base model; subsequent models are adjusted for variables presented in this general model.
†Stratified analyses showed non-significant effects in both boys and girls.
‡Parental variables only for grade 3, excluded in multivariable model.

participants. Previous work has shown that high sedentary time can coexist with high levels of physical activity.[7 8]

We studied social correlates of sedentary time in three main groups of influence; factors related to the parents, factors providing opportunities for engaging in sedentary behaviour and psychosocial factors. Parental factors were only retained in the Estonian and Portuguese multivariable models with higher socioeconomic status being associated with more sedentary time. This is in contrast with previous work, which tends to show that children from lower socioeconomic backgrounds spend more time on sedentary activity[20] or watching TV.[18 40] This evidence, however, mostly comes from work in Western (Anglo-Saxon) countries, with different cultural and socioeconomic backgrounds than Portugal and Estonia. Previous work has shown that in rapidly developing countries, health problems such as childhood obesity are more likely to occur in children from higher socioeconomic backgrounds than in those from lower socioeconomic backgrounds.[41] Previous EYHS analyses also showed that higher family income and parental educational attainment were associated with increased insulin resistance in Portugal and Estonia, while the opposite was true for Danish participants.[34] These results indicate that the role of socioeconomic status in influencing health behaviours across countries is complex and warrants further investigation.

Child's BMI was not associated with sedentary time in three of the four countries, in contrast to previous work consistently showing positive associations.[18 22] Unexpected and independent inverse associations with child's and father's BMI were observed in the Estonian participants. BMI is known to be a fairly crude measure of body composition, influenced by fat mass as well as fat-free mass.[42] It could be hypothesised that both these children and their fathers are highly active, but also engage in substantial amounts of sedentary behaviour. This is supported by the observation that among Estonian participants, no correlation was observed between minutes spent in at least moderate intensity physical activity and sedentary time ($r = -0.03$; data not shown).

Sedentary time in Portuguese participants was influenced by factors from all three categories. Unexpectedly, children with active mothers and those who reported that the TV was only on twice a week or less when they came home, spent more time in sedentary activities. This might indicate that Portuguese children who have more autonomy to decide what sedentary activities they do, such as watching TV after school, are more likely to choose to spend more of their time being sedentary. Portuguese children who reported having a TV in their bedroom were also more sedentary than those who did not, a finding not observed in the other countries. Mixed results on the association between having access to your own television and TV viewing have previously been reported,[18 40 43 44] and the current analyses seem to support the idea that these associations might be culturally dependent.

The analyses presented in this paper were conducted in a large data set and allowed for investigating differences in associations between various European countries. In addition, we included a large number of exposure variables as potential correlates of sedentary time and studied effect modification by age and sex. However, we conducted a large number of individual statistical tests, which might have led to type 1 errors. Due to the cross-sectional nature of the design, no conclusion regarding direction of associations can be drawn. Half of the recruited sample did not provide valid data on sedentary time, with a higher proportion of dropout in Portugal. Those not included did not differ on BMI but were more likely to be adolescent boys (data not shown), limiting the generalisability for male adolescent populations. As mentioned previously, there is no consensus regarding cut-off points to use for defining sedentary activity in children. As a sensitivity analysis, we re-ran our final models using a cut-off point of 500 counts/min. In general, results were consistent with those presented here. A few significant associations disappeared, however, possibly indicating that this higher cut-point also includes behaviours with an intensity level higher than sedentary. A lack of behaviour-specific validity of the exposure measures may explain why only few associations were observed. The questionnaire administered was validated, but is primarily aimed at assessing physical activity correlates.[26]

As in previous studies on correlates of sedentary behaviour,[18] most of the variance in objectively measured sedentary time was explained by the general demographic variables included in the models rather than the behavioural or sociocultural factors. This is consistent with studies investigating correlates of objectively measured physical activity, in which only small amounts of variance could be explained.[45 46] Sedentary time clearly represents a wide range of independent behaviours which are culturally distinct. A more diverse range of behaviours should be considered in future studies to accurately capture sedentary time, such as computer use for homework versus gaming, mobile phone use and reading, aiding the identification of useful intervention targets.

CONCLUSION

The aim of the current paper was to study behavioural and social correlates of overall sedentary time. Sedentary time increased substantially with increasing age, indicating that early intervention is needed to prevent the development of health problems associated with sedentary behaviour. Culturally distinct profiles of sedentary behaviours and correlates emerged from the analyses, indicating that target populations and behaviours should differ between the countries. Future work should aim to use objective measures of sedentary time to study larger populations that are homogeneous on key non-modifiable exposures (such as age, sex and country) to identify suitable targets for intervention within these populations. In addition, they should focus on increasing the precision of the exposure measures and on identifying the most appropriate behaviours that represent time spent in sedentary activity. This strategy should help identify suitable targets for intervention efforts and

What is already known on this topic

Sedentary activity appears to be associated with health outcomes, independent of physical activity. Previous work have focussed on studying correlates of TV viewing, whereas two studies identified various correlates of self-reported sedentary activity.
To date, no study has studied correlates of objectively measured sedentary activity.

What this study adds

Sedentary activity is associated with a variety of behavioural and social factors, and associations are different for different countries. A single strategy aimed at reducing sedentary behaviour is therefore unlikely to be effective across Europe as the target populations and behaviours of focus differ between countries.

how to promote positive changes to reduce time spent in sedentary activity in youth.

Acknowledgements The authors thank the children and their parents for their participation in the European Youth Heart Study, and those involved in the collecting of the data for their effort.

Funding This study was supported by the following grants—Denmark: Danish Heart Foundation, Danish Medical Research Council, Health Foundation, Danish Council for Sports Research, Foundation of 17-12-1981, Foundation in Memory of Asta Florida Bolding née Andersen, and Faculty of Health Sciences, University of Southern Denmark; Estonia: Estonian Science Foundation grant nos. 3277 and 5209; Norway: Norwegian Council of Cardiovascular Diseases and Eckbo Legacy; Portugal: European Social Fund. None of the funders had an involvement in the study itself or its interpretation.

Competing interests None.

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APPENDIX 1

Description of how data on activity during morning break and lunch break were combined to create the new variable ''activity during breaks'' and new categories ''sedentary'', ''variable'' and ''active''

Morning break*	Lunch break*	Activity during breaks
Sit down (talking, reading)	Sit down (talking, reading)	Sedentary
	Stand, walk around	
	Go home for lunch	
Sit down (talking, reading)	Run around playing games	Variable
Stand, walk around	Sit down (talking, reading)	Sedentary
Stand, walk around	Stand, walk around	Variable
	Go home for lunch	
Stand, walk around	Run around playing games	Active
Run around playing games		
Run around playing games	Sit down (talking, reading)	Variable
Run around playing games	Stand, walk around	Active
	Go home for lunch	

*Morning break: what do you normally do at morning break? Lunch break: what do you normally do at lunch break (apart from eating lunch)?