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Complete List of Authors:	Krist, Lilian; Charité University Medical Center, Institute for Social Medicine, Epidemiology and Health Economics Bürger, Christin; Charité-Universitätsmedizin Berlin, Institute for Social Medicine, Epidemiology and Health Economics Ströbele-Benschop, Nanette; , University of Hohenheim, 3 Institute of Nutritional Medicine Roll, Stephanie; Charité Universitätsmedizin, Institute for Social Medicine, Epidemiology and Health Economics Lotz, Fabian; Charité-Universitätsmedizin Berlin, Institute for Social Medicine, Epidemiology and Health Economics Rieckmann, Nina; Charité Universitätsmedizin, Berlin School of Public Health Muller-Nordhorn, Jacqueline; Universitätsmedizin Berlin, Berlin School of Public Health Willich, Stefan; Charité University Medical Center Müller-Riemenschneider, Falk; National University of Singapore, Saw Swee HOck School of Public Health
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Association of individual and neighborhood socioeconomic status on physical activity and sedentary behavior in 7th graders in Berlin, Germany

Lilian Krist[1], Christin Bürger[1], Nanette Ströbele-Benschop[2], Stephanie Roll[1], Fabian Lotz[1], Nina Rieckmann[2], Jacqueline Müller-Nordhorn[2], Stefan N. Willich[1], Falk Müller-Riemenschneider[1,3]

1. *Institute for Social Medicine, Epidemiology and Health Economics, Charité - Universitätsmedizin Berlin, Germany*
2. *Institute of Nutritional Medicine, University of Hohenheim, Germany*
3. *Institute of Public Health, Charité-Universitätsmedizin Berlin, Germany*
4. *Saw Swee Hock School of Public Health, National University of Singapore*

Corresponding author:

Dr. Lilian Krist
Institute for Social Medicine, Epidemiology and Health Economics
Charité - Universitätsmedizin Berlin
Luisenstr. 57
10117 Berlin, Germany
E-Mail: lilian.krist@charite.de
Tel: +49 30 450 529 109

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ABSTRACT

Objectives Few studies have explored the impact of neighborhood socioeconomic status (SES) on health behavior in youths. Our aim was to investigate the association of individual and neighborhood socioeconomic status on physical activity (PA) and sedentary behavior (SB) in 12-13 years old students in Berlin, Germany.

Design Cross-sectional study.

Setting Secondary schools (high schools and integrated secondary schools) in Berlin, Germany.

Participants A total of 2586 students aged 12-13 years (7th grade).

Main outcome measures Sociodemographics, anthropometric data and health behavior were assessed by self-report during classes. Primary outcomes were daily leisure time PA and daily sedentary time. Students' characteristics were described with means or percentages. Comparisons were performed with Generalized Linear Mixed Model yielding odds ratios with 95% confidence intervals.

Results Mean (±SD) age was 12.5±0.5 years, 50.5% were girls, 34.1% had a migrant background. 12.8% of the students were at least 60 minutes per day active, 74.1% spent more than two hours per day sitting. Multivariable analysis showed that male sex, lower Body Mass Index (BMI), and attending an integrated secondary school were associated with higher levels of PA, whereas female sex, lower BMI, attending a high school and having a higher individual and neighborhood SES were associated with less time spent in SB.

Conclusions Most of the students did not meet recommendations regarding PA and SB. Sex, BMI and school type influenced both, PA and SB. SB was additionally influenced by individual and neighborhood SES. Prevention strategies regarding PA promotion should focus rather on sex or school types than on neighborhood SES.

Strengths and limitations of the study

- This study provides important new insights into the association of neighborhood socioeconomic status with physical activity and sedentary behavior in school students, independent of the individual socioeconomic status.
- The study sample was very large with students recruited from all 12 districts of Berlin. It comprised a variety of neighborhoods with different levels of socioeconomic status. Also, the amount of students with migration background was representative for the population of Berlin.
- Anthropometric data and physical activity were not assessed objectively but via self-report.
- Sedentary behavior was only assessed as screen time and did not include other behaviors like doing homework, talking on the phone and sitting at school.

INTRODUCTION

Physical activity has an important impact on health and wellbeing[1]. Low levels of physical activity are associated with higher health risks already among children and adolescents[2] and an increasing number of studies have identified sedentary behavior as an independent risk factor for diseases such as diabetes and obesity in children and adolescents[3].

The guidelines of the World Health Organisation (WHO) recommend that children and adolescents should spend at least 60 minutes every day in moderate to vigorous activity[4]. The American Academy of Paediatrics (AAP) recommends that school-aged children and youth accumulate no more than 2 hours of recreational screen time each day[5].

In the last decades however, sedentary behaviour among children and adolescents (watching TV or playing computer games) is increasing while the rates of children being active (playing outside, doing sports) appears to be decreasing over time[6,7].

In most developed countries, including Germany, a decline in physical activity among children and adolescents can be found with higher age[8]. The percentage of boys and girls in the German Health Interview and Examination Survey for children and adolescents (KiGGS) fulfilling the WHO recommendations for physical activity was 51.5% for the age group 3-6 years (boys 52.2%, girls 50.7%) and 11.5% in the age group 14-17 (boys 15.0%, girls 8.0%). Over half of the girls and nearly three quarters of the boys spent more than two hours per day sitting while using computer, TV or video games[7].

There is evidence on the association of age and sex on physical activity[9], whereas studies exploring the influence of socioeconomic status and built and social environment of children show heterogeneous results[10–12].

A low SES often is associated with a higher BMI and more sedentary time, but not always with low physical activity[13–15]. Studies investigating the social environment of children found evidence of an association with physical activity and diet[16–18]. However, neighborhood socioeconomic status as one aspect of the social environment has not been investigated sufficiently regarding physical activity. Mechanisms through which a lower neighborhood socioeconomic status may influence physical activity and sedentary behavior could be reduced municipal services such as recreational facilities and playgrounds, financial stress or less possibilities to own a gym membership[18]. Studies investigating the

influence of neighborhood SES on health independently from the individual SES showed an association of disadvantaged neighborhoods with worse health status[19] or a higher risk for cardiovascular diseases[20].

The results of existing studies regarding physical activity and sedentary behavior are heterogeneous reporting no association at all, only for special groups or only under certain circumstances[21–23].

Our aim was therefore to investigate the influence of neighborhood socioeconomic status on physical activity and sedentary behavior in a population based sample of 12 to 13 year old secondary school students in Berlin, Germany.

METHODS

Study design and setting

The present cross-sectional analysis is part of the BEST-prevention study, a three armed cluster randomized controlled trial that was conducted from 2010 to 2014 with the aim to evaluate a parent involving smoking prevention program for 7th grade students in Berlin[24]. Here, we report cross-sectional data regarding physical activity and sedentary behavior among the students at baseline.

Participants and Recruitment

Details of the recruitment are described elsewhere[25]. Briefly, prior to recruitment, permission of the Berlin senate of education, youth and research (Senatsverwaltung für Bildung, Jugend und Wissenschaft) was obtained, and school principals and contact teachers from all 12 districts of Berlin were informed about the project. Students were eligible for the study if they: i) were in the 7th grade, ii) attended one of the participating schools, and iii) showed intellectual and physical ability to make an informed decision about study participation. Separate signed written informed consent was required from participating students as well as from at least one parent/caregiver. The study was approved by the ethical review committee of the Charité-Universitätsmedizin Berlin, Germany.

Measurements

The study questionnaire is based on existing and validated questionnaires investigating adolescent health behavior (e.g. Health Behavior in School Aged Children, HBSC[26]; German Children and Youths Survey, KIGGS[27]). It includes questions related to socio-demographics, smoking and other health behaviors, such as alcohol consumption, nutrition, physical activity and sedentary behaviors, as well as height and weight. Our study group has the status of an associated project of the HBSC.

During a first visit, the BEST study was presented and consent forms were distributed to the students by trained research personnel, during thesecond visit, baseline data were assessed with the questionnaire in an entire class.

Outcome measures

Physical activity

Physical activity (PA) was assessed using three adapted items of the HBSC questionnaire. The first question was assessed by asking: 'On how many days in the past week were you physically active for at least 60 minutes?' According to the WHO guidelines, for our primary outcome we defined a student as meeting current guidelines if he or she was active at least 60 minutes on each of the last seven days (yes/no)[4]. The other questions asked for the number of days and hours of physical activity per week.

Sedentary behavior

Sedentary behavior (SB) was assessed with two questions asking for the screen time of the students per day (week day and weekend day were asked seperately). According to the AAP[5] recommendations we defined more than 2 hours sceen time per day as high sedentary behavior.

Covariates

Individual level

Sex, age and anthropometric data (height and weight) of the students were assessed via self-report. The BMI was calculated using the self-reported data. Subgroups were chosen using the quasi-centile curves (constructed to pass through a defined BMI at a given age) suggested by Cole et. al[28,29]. We

used the age of 18 years as reference since the BMI definition is valid from that age. According to that, underweight was defined as a BMI at the age of 18 of under 18.5 kg/m², normal weight as a BMI between 18.5 and 24.9 kg/m², overweight as a BMI between 25 and 29.9 kg/m², and obesity as a BMI of over 30 kg/m².

Migration background

A student was defined as having a migration background if he or she was not born in Germany or if at least one parent was not born in Germany but moved to Germany after 1949[30].

Individual socioeconomic status

To assess the individual socioeconomic status (SES) of the student, we used the family affluence scale (FAS), a validated instrument to assess the material affluence of the family asking for the number of cars and computers in the family, for holidays during the past 12 months, and whether the child has its own room[31]. The FAS consists of values from zero to seven, with higher values indicating higher affluence, and can be categorized into three categories (low, moderate, and high affluence). The FAS was completely assessed only at the 24 months follow-up, we therefore used the 24 months follow-up FAS to describe family SES at baseline.

Neighborhood socioeconomic status

For the SES of the students' neighborhood, we used the social index defined and implemented by the 'Atlas of Social Structure' (Sozialstukturatlas), an instrument used in Berlin to describe the social situation of Berlin by classifying postal code regions accordingly[32,33]. This social index reflects the distribution of social and health burden in Berlin. Social and health indicators are e.g. unemployment, welfare reception rate, average per capita income and also premature mortality and avoidable deaths. The index ranges from 1 reflecting the best to 7 reflecting the worst social situation of a district.

School types

In Berlin, two types of schools exist: high schools with the possibility to achieve a high-school diploma after 12 years, as well as integrated secondary schools (an integration of different school types) with the possibility to achieve a high-school diploma after 13 years. More often than high schools,

integrated secondary schools are left by the students after the 10th grade with a secondary school leaving certificate. The academic requirements are higher in high schools than in integrated secondary schools[34].

Schools' neighborhood socioeconomic status

Analogous to the individual neighborhood social index, we assessed the social index of the schools' neighborhood.

Statistical analysis

All statistical analyses were performed for the 12 and 13 years old students only due to the small number of students in the other age groups (2.6, 5.1, 0.3 and 0.1% in the age groups 11, 14, 15 and 16 years, respectively). We used all data available for the respective analysis; missing data were not imputed.

Variables were analysed by descriptive statistical methods (e.g. mean and standard deviation (SD), frequencies and percentages).

Because of the nested structure of the data with both fixed and random effects, a generalized linear mixed model (GLMM) was used for the analysis when comparing groups. In general, the random factors 'school' and 'class within school' (as nested factor) were included into the models. For binary outcomes a logit link function was used, for continuous outcomes an identity link function was used (distribution family 'normal'). Results of logistic models are presented as odds ratios (OR) and 95%-confidence intervals (CI), results of linear models as Least-Square Means and 95%- CI.

The same framework was used to determine the association of factors within a set of many factors in multivariable analyses. Here, we included sex, socioeconomic status (FAS-score), and migration background as categorical variables and BMI as continuous variable in our first model to investigate individual influencing factors. In addition we included the respective outcome as covariate (sedentary behavior as covariate for physical activity and vice versa). Afterwards we added in three steps the environmental factors 'student's neighborhood SES', 'school type' and 'schools' neighborhood SES'.

Nominal p-values are reported and are considered exploratory. Analyses were performed using the software package SAS release 9.3 and 9.4 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Baseline characteristics of the study population

We included 2586 students aged 12 and 13 years in our analysis. Figure 1 shows the recruitment process of the schools, classes and students.

Sociodemographic baseline characteristics of all participating students are presented in Table 1a, the characteristics of the schoos are presented in Table 1b. The mean (±SD) age of participants was 12.5 ± 0.5 years and the distribution between girls and boys was similar (50.5% vs. 49.5%). Of the entire sample, 34.1% were defined as having a migrant background.

Table 1a: Baseline Characteristics of Students

Individual level	Boys	Girls	Total	p-value
	Mean ± SD or n (%)			
Number of students, n (%)	1279 (49.5)	1307 (50.5)	2586	
Age (years, mean ± SD) (n=2586)	12.5 ± 0.5	12.4 ± 0.5	12.4 ± 0.5	<0.001
12 years, n (%)	651 (50.9)	775 (59.3)	1426 (55.1)	<0.001
13 years, n (%)	628 (49.1)	532 (40.7)	1160 (44.9)	
Height (cm, mean ± SD) (n=2440)	161.1±9.5	160.1±7.3	160.6 ± 8.4	0.003
Weight (kg, mean ± SD) (n=2360)	49.5 ± 10.9	47.0 ± 8.9	48.3 ± 10.0	<0.001
BMI* (kg/m^2, mean ± SD) (n=2296)	18.9 ± 3.1	18.3 ± 2.7	18.6 ± 2.9	<0.001
BMI range	11.8 – 30.9	11.7 – 33.8	11.7 – 33.8	
Underweight (BMI <10^{th} percentile)**	126 (11.1)	218 (18.8)	344 (15.0)	<0.001
Normal weight (BMI 10^{th} - <90^{th} percentile)**	822 (72.2)	843 (72.6)	1665 (72.4)	
Overweight (BMI 90^{th} - <97^{th} percentile)**	166 (14.6)	90 (7.8)	256 (11.1)	
Obesity (BMI ≥97^{th} percentile)**	24 (2.1)	10 (0.9)	34 (1.5)	
Migrant background (n=2423)	396 (33.1)	429 (35.0)	825 (34.0)	0.307
Socioeconomic status (family affluence scale) (n=2139)				
6-7 (high SES***)	569 (53.7)	500 (46.3)	1069 (50.0)	0.003
4-5 (moderate SES***)	371 (35.0)	441 (40.9)	812 (38.0)	
0-3 (low SES***)	120 (11.3)	138 (12.8)	258 (12.1)	
Student's neighborhood SES (n=2240)	1114	1126	2240	
Mean±SD	4.0 ± 1.9	4.1 ± 1.9	4.0 ± 1.9	0.526
1	127 (11.4)	123 (10.9)	250 (11.2)	
2	182 (16.3)	194 (17.2)	376 (16.8)	
3	143 (12.8)	119 (10.6)	262 (11.7)	
4	215 (19.3)	229 (20.3)	444 (19.8)	
5	162 (14.5)	160 (14.2)	322 (14.4)	
6	134 (12.0)	134 (11.9)	268 (12.0)	
7	151 (13.6)	167 (14.8)	318 (14.2)	
School type (n=2586)				
High School[a] students *(15 schools)*	507 (39.6)	624 (47.7)	1131 (43.7)	<0.001
Integrated Secondary School[b] students *(32 schools)*	772 (60.4)	683 (52.3)	1455 (56.3)	

*Body Mass Index (kg/m^2)
** BMI percentiles according to Cole et al. [35,36]
*** Socioeconomic Status
[a] High schools (5^{th} or 7^{th} grade to 12^{th} grade, graduation with high school diploma after 12^{th} grade)
[b] Integrated secondary schools (integration of different school types, 7^{th} grade to 13^{th} grade, graduation with secondary school leaving certificate after 10^{th} grade or high school diploma after 13^{th} grade)

Table 1b: Baseline characteristics of schools

School level				
	High Schools[a]	Integrated Secondary Schools[b]	Total	
Schools' neighborhood SES*, Mean±SD	3.5±1.4	3.2±1.6	4.0±1.8	<0.001
n (%)				
1	1 (6.7)	3 (9.4)	4 (8.5)	
2	4 (26.7)	3 (9.4)	7 (14.9)	
3	2 (13.3)	4 (12.5)	6 (12.8)	
4	4 (26.7)	7 (21.9)	11 (23.4)	
5	2 (13.3)	4 (12.5)	6 (12.8)	
6	2 (13.3)	5 (15.6)	6 (12.8)	
7	0 (0.0)	6 (18.8)	6 (12.8)	
Student's neighborhood SES*, Mean±SD (n=2240)	3.1±1.6	4.6±1.9		<0.001
SES* (family affluence scale) (n=2139)				
6-7 (high SES*)	65.8%	36.5%		<0.001
4-5 (moderate SES*)	29.9%	44.8%		
0-3 (low SES*)	4.3%	18.7%		

* Socioeconomic Status

[a]High schools (5th or 7th grade to 12th grade, graduation with high school diploma after 12th grade)

[b]Integrated secondary schools (integration of different school types, 7th grade to 13th grade, graduation with secondary school leaving certificate after 10th grade or high school diploma after 13th grade)

Physical activity and sedentary behavior

Of the total sample, 12.8% fulfilled the WHO criteria being active for at least 60 minutes per day. The proportion of boys fulfilling the criteria was higher than in girls (15.9% of the boys vs. 9.8% of the girls, OR 1.7 [1.4;2.2]; p<0.001) and boys were more active outside school than girls (0.9±0.8 versus 0.6±0.6 hours per day, mean difference 0.3 hours [0.2;0.3], p<0.001), Table 2. More than 80% of the boys and almost two thirds of the girls reported sitting for more than 2 hours per day (outside of school), OR 2.2 [1.8;2.6]; p<0.001. Sedentary behavior on weekend days was higher than on week days among all students (5.7±3.6 versus 3.5±2.7).

Table 2. Comparison of boys and girls aged 12-13 years

	Boys	Girls		p-value (boys vs. girls)	Total
	Proportion	Proportion	Odds ratio [95% CI]		Proportion
WHO recommendations fulfilled: 60min/day every day per week (%)	15.9	9.8	1.7 (1.4;2.2)	<0.001	12.8
Sitting 2 hours or more per day (%)	81.5	66.9	2.2 (1.8;2.6)	<0.001	74.1
(hours ± SD per week)	Mean±SD	Mean±SD	Mean difference [95% CI]	p-value	Mean±SD
Leisure time physical activity per day (hours± SD)	0.9±0.8	0.6±0.6	0.3 (0.2;0.3)	<0.001	0.8±0.7
Sedentary behavior TV (hours± SD)					
school day	2.2 ± 1.8	1.9 ± 1.6	0.3 (0.2;0.4)	<0.001	2.0 ± 1.7
weekend day	3.4 ± 2.0	2.9 ± 2.0	0.4 (0.3;0.6)	<0.001	3.1 ± 2.0
Sedentary behavior Computer (hours± SD)					
school day	1.8 ± 1.8	1.3 ± 1.6	0.5 (0.4;0.7)	<0.001	1.5 ± 1.7
weekend day	3.1 ± 2.2	2.0 ± 2.0	1.1 (1.0;1.3)	<0.001	2.6 ± 2.2
Overall sedentary behavior (hours± SD)					
school day	3.9 ± 2.7	3.1 ± 2.5	0.8 (0.6;0.97)	<0.001	3.5 ± 2.7
weekend day	6.5 ± 3.6	4.9 ± 3.4	1.6 (1.3;1.8)	<0.001	5.7 ± 3.6

Multivariable analysis

In model 1 of the multivariable analysis we included the individual variables sex, BMI, socioeconomic status and migration background. Sex and BMI were statistically significantly associated with both outcomes, physical activity and sedentary behavior (Figure 2 and 3; suppl. table 1 and 2). Boys had higher odds to be active but at the same time they were also more likely to sit compared to girls. Higher BMI was associated with less activity and more sedentary time. A higher socioeconomic status and having no migration background were associated with less sedentary time but were not associated with physical activity. We saw no association of sedentary behavior on physical activity (and vice versa). There was no interaction effect between gender and sedentary behavior regarding physical activity, nor between gender and physical activity regarding sedentary behavior (data not shown).

Subsequently, the students' neighborhood SES (model 2a), school type (model 2b) and schools' neighborhood SES (model 2c) were separately included in three different models. Students' neighborhood SES was not associated with physical activity, but students with a lower neighborhood SES were more likely to sit more than two hours per day than students with a higher neighborhood SES. Students of the integrated secondary schools were more active but reported also more sedentary time than high school students. Schools' neighborhood SES had no effect on physical activity nor on sedentary behavior.

After including all covariates for model 3, physical activity was influenced by sex, BMI, and school type, while sedentary behavior was additionally influenced by the individual and the neighborhood socioeconomic status of the student. In summary: boys, students with a low BMI, and secondary school students, were more likely to meet WHO recommendations regarding 60 minutes of physical activity per day, and boys, students with a high BMI, secondary school students, and students with a low individual or neighborhood socioeconomic status were more likely to exceed the 2 hours of sedentary time per day. To exclude eventual associations between school type and other outcomes we calculated one model without the covariate school type which did not change the results (data not shown).

DISCUSSION

In our study sample, fewer than 20% of boys and 10% of the girls fulfilled the WHO recommendations for physical activity. These results are in line with the most recent results of the KiGGS Study (KiGGS wave 1) and the German subsample of the HBSC study[7,37].

More than 80% of the boys and 2/3 of the girls spent more than 2 hours per day sitting (in addition to sitting time at school), which is exceeding international screen viewing recommendations[5]. In many other countries, the numbers of children and adolescents engaging in more than 2 hours of screen time per day are comparable with German youths[8]. The ENERGY project (participating countries were Belgium, Greece, Hungary, the Netherlands and Switzerland) showed that girls aged 10-12 years spent more time sitting than boys[38].

Students of integrated secondary schools spent more time sitting, but were more active than high school students. This is in contrast to a study from Germany, where high school students were more likely to achieve a healthier lifestyle including regular physical activity than students from other school types[14]. The neighborhood SES as well as the SES of the students was correlated with the school type which is a common fact in Germany[39]. However, school type remained an independent influencing factor regarding physical activity, while neither individual nor neighborhood SES were associated.

The SES of the students in our study sample was only significantly associated with sedentary behavior, but not with physical activity. The HBSC data for Germany also did not show any influence of the SES on physical activity, but a positive correlation between lower SES and higher sedentary time was found[37]. However, the influence of family affluence is very heterogeneous across different countries. In Eastern countries for instance, watching TV is associated with higher affluence, whereas in Western and Northern countries, the opposite is the case[8].

In contrast to the study of Lampert et al., students' migration background had no influence on physical activity in our study[40].

A new aspect of our study was the investigation of the neighborhood SES as influencing factor of physical activity and sedentary behavior. Similar to the individual SES, an association was only found for sedentary behavior, while physical activity was not affected.

There is one study using the social index of Berlin, too, showing an association of a lower neighborhood SES with a higher BMI in 5-6 years old children living in Berlin. The authors did not include, however, health behaviors like physical activity or sedentary time in their analyses[41].

Another study used unemployment rate and overcrowding as indicators of neighborhood SES. The authors found a correlation between the unemployment rate and low physical activity in different urban districts in Germany and the Czech republic defining low physical activity as being active less than once a week which is a very broad definition[21].

A study from Switzerland reported different settings while engaging in physical activity and sedentary behavior among children of low and high neighborhood SES, whereas the overall time spent active or sedentary did not differ essentially between the two groups[22].

Apparently, physical activity is hardly influenced by neighborhood SES, whereas sedentary behavior is more likely to be affected. Up to now, the measurement of neighborhood SES is very heterogeneous. To further investigate this topic, a more detailed definition of neighborhood SES should be implemented for European countries. Further research should focus on this to achieve a better comparability of study results among different countries and to facilitate the investigation of its asscociations.

Strengths and limitations

Size and representativity of our sample including migration background, socioeconomic status and gender distribution are important strenghts of our study[42]. However, the results are only valid for regions with similar characteristics as Berlin: an urban region with high walkability and good infrastructure for transportation and cycling.

Some limitations have to be considered as well. Anthropometric data and physical activity were not measured objectively. Self-report sometimes leads to distorted results through misreporting[43]. However, children and adolescents seem to be as reliable in providing accurate information as adults[44]. Another limitation is that we assessed sedentary behavior only as screen time and did not include other behaviors like doing homework, talking on the phone or others.

CONCLUSION

In our study sample, the majority of the students did not meet the WHO recommendations regarding physical activity and sedentary time. Sex, BMI and school type influenced both, physical activity and sedentary behavior. Sedentary behaviour was additionally influenced by individual and neighborhood SES. Future prevention strategies regarding physical activity promotion should focus rather on different approaches for boys and girls or schooltypes than on the neighborhood SES.

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CONTRIBUTORS

LK drafted the manuscript with intellectual input from SR, NR, JMN, NSB and FMR, carried out the data collection and parts of the data analysis. FL and SR were responsible for data assessment and statistical analyses, CB, NR, JMN and NSB were responsible for the design of the recruitment methods and the assessment tools, SW and FMR participated in the conception of the study. All authors read and approved the final manuscript.

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COMPETING INTERESTS

None declared.

ETHICS APPROVEL

The study was approved by the ethical review committee of the Charité-Universitätsmedizin Berlin, Germany.

DATA SHARING STATEMENT

No additional data available.

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Figures

Figure 1. Flowchart of the recruitment process

Figure 2. Multivariable analysis of influencing factors on physical activity of 12 and 13 year old students

Figure 3. Multivariable analysis of influencing factors on sedentary behavior of 12 and 13 years old students

Supplementary files

Supplementary table 1. Multivariable analysis of influencing factors on physical activity of 12 and 13 year old students.

Supplementary table 2. Multivariable analysis of influencing factors on sedentary behavior of 12 and 13 year old students.

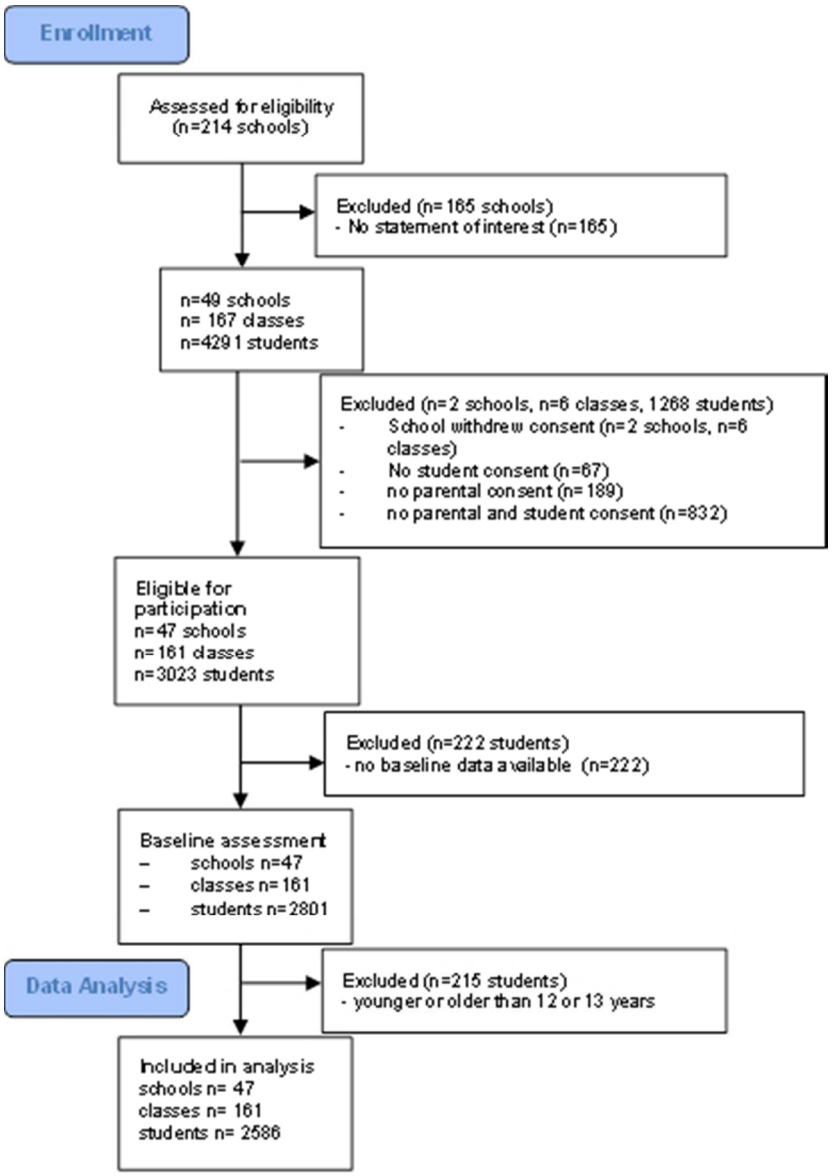

Figure 1. Flowchart of the recruitment process

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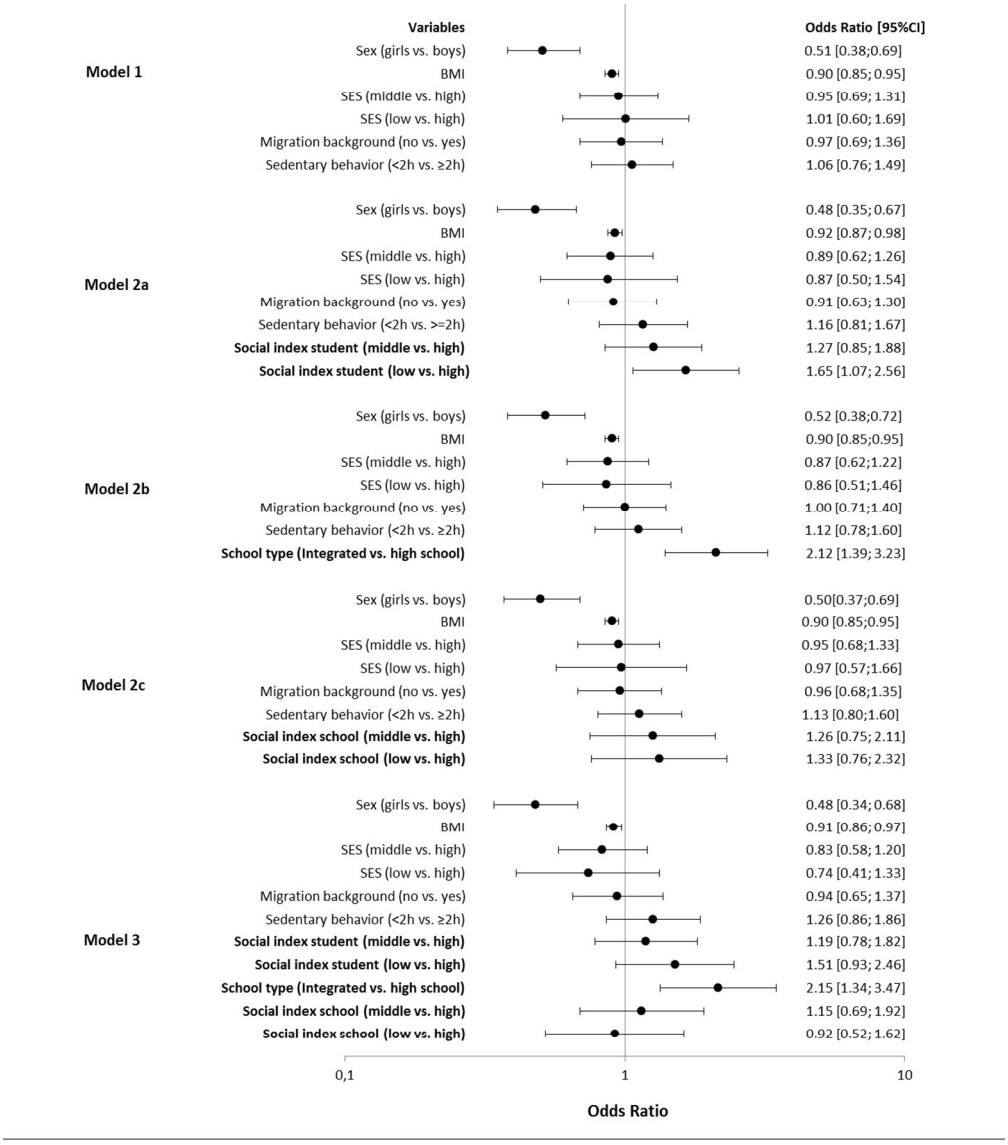

Figure 2. Multivariable analysis of influencing factors on physical activity of 12 and 13 year old students

369x425mm (96 x 96 DPI)

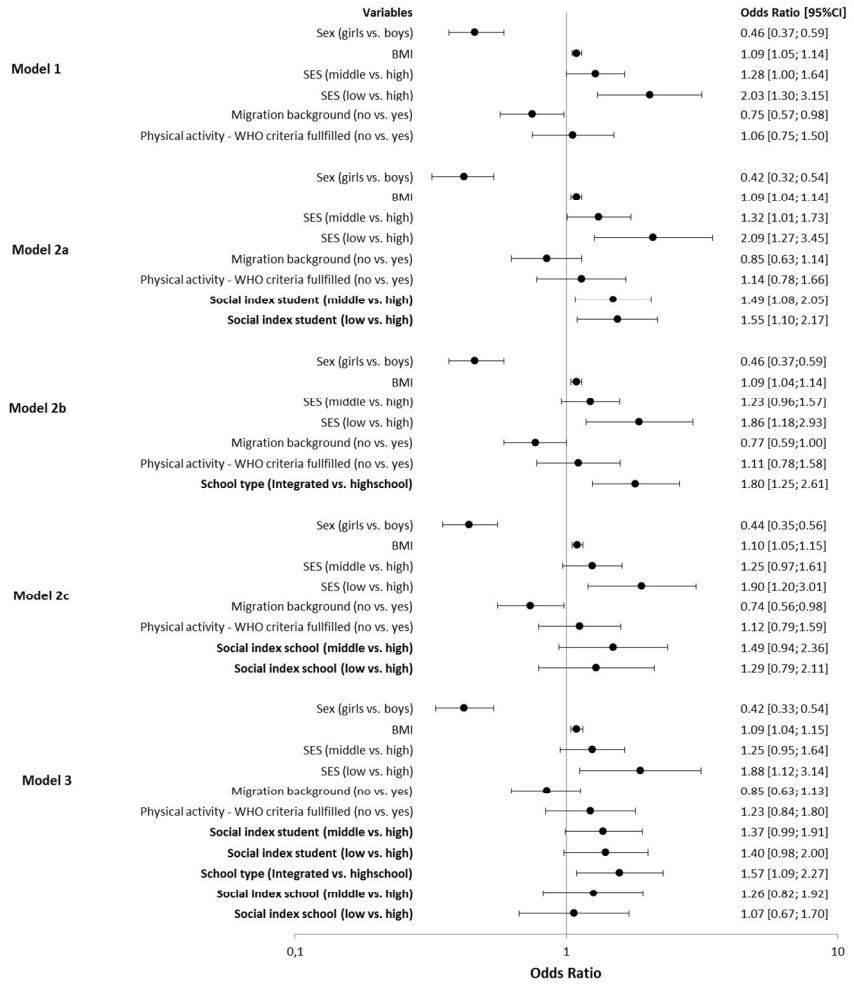

Figure 3. Multivariable analysis of influencing factors on sedentary behavior of 12 and 13 years old students

419x497mm (96 x 96 DPI)

Supplementary table 1: Multivariable analysis of influencing factors on physical activity of 12 and 13 year old students.

WHO criteria for physical activity (at least 60 minutes per day physically active) fulfilled:								
	Model 1* (n=1595)		**Model 2a** (n=1381)	**Model 2b** (n=1595)	**Model 2c**** (n=1527)		**Model 3***** (n=1364)	
	OR (95% CI)	**p-value**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Sex		**<0.001**				**<0.001 (2a,b,c)**		**<0.001**
Boys	1		1	1	1		1	
Girls	0.51 (0.38; 0.69)		0.48 (0.35; 0.67)	0.52 (0.38;0.72)	0.50(0.37;0.69)		0.48 (0.34; 0.68)	
BMI	0.90 (0.85; 0.95)	**<.001**	0.92 (0.87; 0.98)	0.90 (0.85;0.95)	0.90 (0.85;0.95)	**0.006 (2a); <0.001 (2b,c)**	0.91 (0.86; 0.97)	**0.003**
Individual socioeconomic status (FAS)		0.940	-			0.763 (2a); 0.684 (2b); 0.959 (2c)		0.476
High	1		1	1	1		1	
Middle	0.95 (0.69; 1.31)		0.89 (0.62; 1.26)	0.87 (0.62;1.22)	0.95 (0.68;1.33)		0.83 (0.58; 1.20)	
Low	1.01 (0.60; 1.69)		0.87 (0.50; 1.54)	0.86 (0.51;1.46)	0.97 (0.57;1.66)		0.74 (0.41; 1.33)	
Migration background		0.844				0.588 (2a); 0.981 (2b); 0.798 (2c)		0.761
yes	1		1	1	1		1	
no	0.97 (0.69; 1.36)		0.91 (0.63; 1.30)	1.00 (0.71;1.4)	0.96 (0.68;1.35)		0.94 (0.65; 1.37)	
Sedentary behaviour		0.734	-			0.425 (2a); 0.540 (2b); 0.494 (2c)		0.233
≥2 hours	1		1	1	1		1	
<2 hours	1.06 (0.76; 1.49)		1.16 (0.81; 1.67)	1.12 (0.78;1.60	1.13 (0.80;1.60)		1.26 (0.86; 1.86)	
Student's neighborhood SES	-	**-**		-	-	0.079		0.253
High (rank 1-2)	-	**-**	1	-	-		1	
Middle (rank 3-4)	-	**-**	1.27 (0.85; 1.88)	-	-		1.19 (0.78; 1.82)	
Low (rank 5-7)	-	**-**	1.65 (1.07; 2.56)	-	-		1.51 (0.93; 2.46)	
School type	-	**-**	**-**		**-**	**<0.001**		**0.002**
High School	-	**-**	**-**	1	**-**	**-**	1	
Integrated Secondary School	-	**-**	**-**	2.12 (1.39; 3.23)	**-**	**-**	2.15 (1.34; 3.47)	
Schools' neighborhood SES	-	**-**	**-**	-		0.546		0.723
High (rank 1-2)	-	**-**	**-**	**-**	1	**-**	1	
Middle (rank 3-4)	-	**-**	**-**	**-**	1.26 (0.75; 2.11)	**-**	1.15 (0.69; 1.92)	
Low (rank 5-7)	-	**-**	**-**	**-**	1.33 (0.76; 2.32)	**-**	0.92 (0.52; 1.62)	

***Model 1:** Sex, BMI, individual socioeconomic status (FAS), migration background, sedentary behavior; ****Model 2a:** Model 1+ student's neighborhood SES (3 categories); **Model 2b:** Model 1+ school type; **Model 2c:** Model 1 + schools' neighborhood SES (3 categories); *****Model 3:** Model 1+2a,b,c

Supplementary table 2: Multivariable analysis of influencing factors on sedentary behavior of 12 and 13 year old students

High sedentary behaviour (≥2 hours /day)								
	Model 1* (n=1595)		**Model 2a**** (n=1381)	**Model 2b**** (n=1595)	**Model 2c**** (n=1527)		**Model 3***** (**n**=1364)	
	OR (95% CI)	**p-value**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Sex		**<0.001**				**<0.001 (2a,b,c)**		**<0.001**
Boys	1		1	1	1		1	
Girls	0.46 (0.37; 0.59)		0.42 (0.32; 0.54)	0.46 (0.37;0.59)	0.44 (0.35;0.56)		0.42 (0.33; 0.54)	
BMI	1.09 (1.05; 1.14)	**<0.001**	1.09 (1.04; 1.14)	1.09 (1.04;1.14)	1.10 (1.05;1.15)	**<0.001 (2a,b,c)**	1.09 (1.04; 1.15)	**<0.001**
Individual socioeconomic status (FAS)		**0.004**				**0.007 (2a); 0,018 (2b); 0.014 (2c)**		**0.036**
High	1		1	1	1	1	1	
Middle	1.28 (1.00; 1.64)		1.32 (1.01; 1.73)	1.23 (0.96;1.57)	1.25 (0.97;1.61)		1.25 (0.95; 1.64)	
Low	2.03 (1.30; 3.15)		2.09 (1.27; 3.45)	1.86 (1.18;2.93)	1.90 (1.20;3.01)		1.88 (1.12; 3.14)	
Migration background		**0.035**				0.267 (2a); 0.052 (2b); **0.032 (2c)**		0.262
yes	1		1	1	1		1	
no	0.75 (0.57; 0.98)		0.85 (0.63; 1.14)	0.77 (0.59;1.00)	0.74 (0.56;0.98)		0.85 (0.63; 1.13)	
Physical activity (WHO criteria fulfilled)		0.738				0.510 (2a); 0.558 (2b); 0.533 (2c)		0.297
Yes	1		1	1	1		1	
No	1.06 (0.75; 1.50)		1.14 (0.78; 1.66)	1.11 (0.78;1.58)	1.12 (0.79;1.59)		1.23 (0.84; 1.80)	
Student's neighborhood SES	-	-	**Model 2a**	-	-	**0.019**		0.109
High (rank 1-2)	-	-	1	-	-		**1**	
Middle (rank 3-4)	-	-	1.49 (1.08; 2.05)	-	-		1.37 (0.99; 1.91)	
Low (rank 5-7)	-	-	1.55 (1.10; 2.17)	-	-		1.40 (0.98; 2.00)	
School type	-	-	-	**Model 2b**	-	**0.002**		**0.016**
High School	-	-	-	**1**	-	-	**1**	
Integrated Secondary School	-	-	-	1.80 (1.25; 2.61)	-	-	1.57 (1.09; 2.27)	
Schools' neighborhood SES	-	-	-	-	**Model 2c**	0.233		0.535
High (rank 1-2)	-	-	-	-	**1**	-	**1**	
Middle (rank 3-4)	-	-	-	-	1.49 (0.94; 2.36)	-	1.26 (0.82; 1.92)	
Low (rank 5-7)	-	-	-	-	1.29 (0.79; 2.11)	-	1.07 (0.67; 1.70)	

***Model 1**: Sex, BMI, individual socioeconomic status (FAS), migration background, physical activity; ****Model 2a:** Model 1+ student's neighborhood SES (3 categories); **Model 2b:** Model 1+ school type; **Model 2c**: Model 1 + schools' neighborhood SES (3 categories); *****Model 3:** Model 1+2a,b,c

STROBE (Strengthening The Reporting of OBservational Studies in Epidemiology) Checklist

A checklist of items that should be included in reports of observational studies. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Section and Item	Item No.	Recommendation	Reported on Page No.
Title and Abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/Rationale	2	Explain the scientific background and rationale for the investigation being reported	1
Objectives	3	State specific objectives, including any prespecified hypotheses	2
Methods			
Study Design	4	Present key elements of study design early in the paper	2
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2-3
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	2-3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3-5

Section and Item	Item No.	Recommendation	Reported on Page No.
Data Sources/ Measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3-5
Bias	9	Describe any efforts to address potential sources of bias	15
Study Size	10	Explain how the study size was arrived at	2
Quantitative Variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical Methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5-6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	7
Descriptive Data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-10
		(b) Indicate number of participants with missing data for each variable of interest	7-10
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome Data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	7-10

Section and Item	Item No.	Recommendation	Reported on Page No.
Main Results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other Analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	5-6
Discussion			
Key Results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Once you have completed this checklist, please save a copy and upload it as part of your submission. DO NOT include this checklist as part of the main manuscript document. It must be uploaded as a separate file.

BMJ Open

Association of individual and neighbourhood socioeconomic status with physical activity and screen time in 7th graders in Berlin, Germany

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Association of individual and neighbourhood socioeconomic status with physical activity and screen time in 7th graders in Berlin, Germany

Lilian Krist[1], Christin Bürger[1], Nanette Ströbele-Benschop[2], Stephanie Roll[1], Fabian Lotz[1], Nina Rieckmann[2], Jacqueline Müller-Nordhorn[2], Stefan N. Willich[1], Falk Müller-Riemenschneider[1,3]

1. *Institute for Social Medicine, Epidemiology and Health Economics, Charité - Universitätsmedizin Berlin, Germany*
2. *Institute of Nutritional Medicine, University of Hohenheim, Germany*
3. *Institute of Public Health, Charité-Universitätsmedizin Berlin, Germany*
4. *Saw Swee Hock School of Public Health, National University of Singapore*

Corresponding author:

Dr. Lilian Krist
Institute for Social Medicine, Epidemiology and Health Economics
Charité - Universitätsmedizin Berlin
Luisenstr. 57
10117 Berlin, Germany
E-Mail: lilian.krist@charite.de
Tel: +49 30 450 529 109

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ABSTRACT

Objectives Few studies have explored the impact of neighbourhood socioeconomic status (SES) on health behaviour in youths. Our aim was to investigate the association of individual and neighbourhood socioeconomic status with physical activity (PA) and screen time (ST) in 12-13 years old students in Berlin, Germany.

Design Cross-sectional study.

Setting Secondary schools (high schools and integrated secondary schools) in Berlin, Germany.

Participants A total of 2586 students aged 12-13 years (7^{th} grade).

Main outcome measures Sociodemographics, anthropometric data and health behaviour were assessed by self-report during classes. Primary outcome was the association of individual and neighbourhood SES with daily PA and daily ST. Students' characteristics were described with means or percentages. Comparisons were performed with Generalized Linear Mixed Model yielding odds ratios with 95% confidence intervals.

Results Mean (±SD) age was 12.5±0.5 years, 50.5% were girls, and 34.1% had a migrant background.Individual SES was only associated with screen time. The odds ratio of engaging in more than two hours of ST per day was 1.28 [1.00;1.64] and 2.03 [1.30;3.15] for students with middle and low SES, respectively, compared to students with high SES. Neighbourhood SES was associated with both, PA and ST. The odds ratios of spending more than 60 minutes per day in PA and of engaging in more than two hours of ST per day in screen time were 1.67 [1.14;2.44] and 1.68 [1.22;2.29], respectively, each for students with low compared to high neighbourhood SES.

Conclusions Both, individual and neighbourhood SES as well as school type are important factors that have to be considered, when developing prevention programs for school students. Future research should include measurement of the built environment in Berlin to provide further insights into the associations with PA.

Strengths and limitations of the study

- This study provides important new insights into the association of individual and neighbourhood socioeconomic status with physical activity and screen time in school students in Berlin, Germany.
- The study sample was very large with students recruited from all 12 districts of Berlin. It comprised a variety of neighbourhoods with different levels of socioeconomic status. Also, the amount of students with migration background reflected the proportion of the student population of Berlin.
- Anthropometric data and physical activity were not assessed objectively but via self-report.
- Only screen time was assessed, while other kinds of sedentary behaviours were not taken into account.

INTRODUCTION

Physical activity as well as sedentary beaviour have an important impact on health and wellbeing(1). Low levels of physical activity are associated with higher health risks already among children and adolescents(2) and an increasing number of studies have identified sedentary behaviour as an independent risk factor for diseases such as diabetes and obesity in children and adolescents(3).

In the last decades however, sedentary behaviour among children and adolescents is increasing while the rates of children being active appears to be decreasing over time(4,5). Screen time (time spent watching TV or playing games on the computer or playing video games) is one important aspect of sedentary behaviour, even though it does not represent the overall sedentary time (6).

In most developed countries, including Germany, a decline in physical activity among children and adolescents can be found with higher age(7). The percentage of boys and girls in the German Health Interview and Examination Survey for children and adolescents (KiGGS) fulfilling the WHO recommendations for physical activity was 51.5% for the age group 3-6 years (boys 52.2%, girls 50.7%) and 11.5% in the age group 14-17 (boys 15.0%, girls 8.0%). Over half of the girls and nearly three quarters of the boys spent more than two hours per day sitting while using computer, TV or video games(5).

While there is evidence of anassociation of age and sex with physical activity(8), studies exploring the influence of socioeconomic status and built and social environment of children show heterogeneous results(9–11).

A low SES is often associated with a higher BMI and more sedentary time, but not always with low physical activity(12–14). Studies investigating the social environment of children found evidence of an association with physical activity and diet(15–17).

Another aspect of the social environment is the neighbourhood socioeconomic status. Studies investigating the influence of neighbourhood SES on health showed an association of disadvantaged neighbourhoods with worse health status(18) or a higher risk for cardiovascular diseases(19). Mechanisms through which a lower neighbourhood socioeconomic status may influence physical activity and sedentary behaviour could be reduced municipal services such as recreational facilities and playgrounds, financial stress or less possibilities to own a gym membership(17). Regarding physical activity or sedentary behaviour, study results are heterogenous ranging from no association to a clear association

with neighbourhood SES (20–22). Other studies in turn found that the neighbourhood SES was a positive modifier for the association of environmental factors with physical activity and sedentary behaviour(23,24). Knowing more about the influence of SES would make it possible to develop more targeted prevention strategies for vulnerable groups.

Our aim was therefore to investigate the influence of individual and neighbourhood socioeconomic status with physical activity and screen time as one important form of sedentary behaviour in a population based sample of 12 to 13 year old secondary school students in Berlin, Germany.

METHODS

Study design and setting

The present cross-sectional analysis is part of the BEST-prevention study, a three armed cluster randomized controlled trial that was conducted from 2010 to 2014 (baseline assessment was conducted from 2010 to 2011) with the aim to evaluate a parent involving smoking prevention program for 7th grade students in Berlin(25). Here, we report cross-sectional data regarding physical activity and screen time among the students at baseline including associations with individual and neighbourhood socioeconomic status.

Participants and Recruitment

Details of the recruitment are described elsewhere(26). Briefly, prior to recruitment, permission of the Berlin senate of education, youth and research (Senatsverwaltung für Bildung, Jugend und Wissenschaft) was obtained, and school principals and contact teachers from all 12 districts of Berlin were informed about the project. Students were eligible for the study if they: i) were in the 7th grade, ii) attended one of the participating schools, and iii) showed intellectual and physical ability to make an informed decision about study participation. Separate signed written informed consent was required from participating students as well as from at least one parent/caregiver. The study was approved by the ethical review committee of the Charité-Universitätsmedizin Berlin, Germany.

Measurements

The study questionnaire is based on existing and validated questionnaires investigating adolescent health behaviour (e.g. Health Behaviour in School Aged Children, HBSC(27); German Children and Youths Survey, KIGGS(28)). It includes questions related to socio-demographics, smoking and other health behaviours, such as alcohol consumption, nutrition, physical activity and screen time, as well as height and weight. It took about 30-40 minutes to complete the questionnaire. Our study group has the status of an associated project of the HBSC.

During a first visit to schools, the BEST study was presented to the students by trained research personnel and consent forms were distributed for students and parents/caregivers. During the second visit, which took place a few weeks later, baseline data were assessed with the questionnaire in the classroom among children, who had provided both consent forms..

Outcome measures

Physical activity

Physical activity (PA) was assessed using three adapted items of the HBSC questionnaire. The first question was assessed by asking: 'On how many days in the past week were you physically active for at least 60 minutes?' According to the WHO guidelines, for our primary outcome we defined a student as meeting current guidelines if he or she was active at least 60 minutes on each of the last seven days (yes/no)(29). The other questions asked for the number of days and hours of moderate intensity physical activity per week.

Screen time

Screen time (ST) was assessed with two questions (as well of the HBSC questionnaire) asking for the time spent each day watching TV or playing with the Computer. TV time was assessed by asking 'How many hours/day do you usually watch television in your free time?' for weekdays and weekend days separately. Computer time (minutes/day) was assessed by asking 'How many hours/day do you usually play games on a computer, or use a game console in your leisure time?'. Total screen time was computed by adding up TV and computer time. Using a smartphone or tablet was not assessed. Ac-

cording to the AAP(30) recommendations we defined more than 2 hours of screen time per day as high screen time.

Covariates

Individual level

Sex, age and anthropometric data (height and weight) of the students were assessed via self-report. The BMI was calculated using the self-reported data. BMI categories are presented using cut-offs defined by the specific percentiles which at age 18 years correspond to the adult cut-off points for underweight (<18.5kg/m^2), overweight (25kg/m^2) and obesity (30kg/m^2). According to that definition, underweight is defined as a BMI <10^{th} percentile, normal weight as a BMI between the 10^{th} and the 90^{th} percentile, overweight as a BMI between the 90^{th} and the 97^{th} percentile and obesity as a BMI ≥97^{th} percentile(31,32).

Migration background

A student was defined as having a migration background if he or she was not born in Germany or if at least one parent was not born in Germany but moved to Germany after 1949(33).

Individual socioeconomic status

To assess the individual socioeconomic status (SES) of the student, we used the family affluence scale (FAS), a validated instrument to assess the material affluence of the family asking for the number of cars and computers in the family, for holidays during the past 12 months, and whether the child has its own room(34). The FAS consists of values from zero to seven, with higher values indicating higher affluence, and can be categorized into three categories (low (0-3), moderate (4-5), and high affluence (6-7)). The FAS was completely assessed only at the 24 months follow-up, we therefore used the 24 months follow-up FAS to describe family SES at baseline.

Neighbourhood socioeconomic status

For the SES of the students' neighbourhood, we used the social index defined and implemented by the 'Atlas of Social Structure' (Sozialstukturatlas). It is an instrument used in Berlin to describe the social

situation of Berlin by classifying 447 sub-areas (with on average 7500 habitants) of the 12 districts of Berlin accordingly(35,36). This social index reflects the distribution of social and health burden in Berlin. Social and health indicators are e.g. unemployment, welfare reception rate, average per capita income and also premature mortality and avoidable deaths. The index ranges from 1 reflecting the best to 7 reflecting the worst social situation of a district.

School types

In Berlin, two types of schools exist: high schools with the possibility to achieve a high-school diploma after 12 years, as well as integrated secondary schools (an integration of different school types) with the possibility to achieve a high-school diploma after 13 years. More often than high schools, integrated secondary schools are left by the students after the 10th grade with a secondary school leaving certificate. The academic requirements are higher in high schools than in integrated secondary schools(37).

Schools' neighbourhood socioeconomic status

.Since the neighbourhood of the school can be different to that of students, we assessed this information (analogous to the individual neighbourhood SES) as well in order to take an additional influencing factor of the students behavor into account.

Statistical analysis

All statistical analyses were performed for the 12 and 13 years old students due to the small number of students younger than 12 and older than 13 years (8.1%). We used all data available for the respective analysis; missing data were not imputed.

Characteristics of schools and students were analysed by descriptive statistical methods (e.g. mean and standard deviation (SD), frequencies and percentages; p-values are derived from t-tests and chi-square-tests).

Because of the nested structure of the data with both fixed and random effects, a generalized linear mixed model (GLMM) was used for the analysis when comparing groups (models with random intercept). In general, the random factors 'school' and 'class within school' (as nested factor) were includ-

ed into the models. For binary outcomes a logit link function was used, for continuous outcomes an identity link function was used (distribution family 'normal'). Results of logistic models are presented as odds ratios (OR) and 95%-confidence intervals (CI), results of linear models as Least-Square Means and 95%- CI. As sensitivity analyses, to assess if associations are modified by gender, interaction effects on gender were included into the models.

The same framework was used to determine the association of factors within a set of many factors in multivariable analyses. Here, we included sex, socioeconomic status (FAS-score), and migration background as categorical variables and BMI as continuous variable in our first model to investigate individual influencing factors. In addition we included the respective outcome as covariate (screen time as covariate for physical activity and vice versa). The same procedure was performed for neighbourhood SES. Afterwards we added in two steps the environmental factors 'school type' and 'schools' neighbourhood SES'. All p-values are considered exploratory (with no adjustment for multiple testing). Analyses were performed using the software package SAS release 9.3 and 9.4 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Characteristics of the study population

Out of 214 contacted schools, 49 schools (23%; 4291 students) showed interest and were eligible for study participation. Before baseline assessment, 1268 out of these 4291 students dropped out including two entire schools. 2801 students participated at the baseline assessment. Out of those, we included 2586 students aged 12 and 13 years in our analysis. Figure 1 shows the recruitment process of the schools, classes and students.

Sociodemographic baseline characteristics of all participating students are presented in Table 1a, the characteristics of the schools are presented in Table 1b. The mean (±SD) age of participants was 12.5 ± 0.5 years and the distribution between girls and boys was similar (50.5% vs. 49.5%). Of the entire sample, 34.1% were defined as having a migrant background.

Of the total sample, 12.8% fulfilled the WHO criteria being active for at least 60 minutes per day. The proportion of boys fulfilling the criteria was higher than in girls (15.9% of the boys vs. 9.8% of the

girls, OR 1.7 [1.4;2.2]; p<0.001) and boys were more active outside school than girls (0.9±0.8 versus 0.6±0.6 hours per day, mean difference 0.3 hours [0.2;0.3], p<0.001). More than 80% of the boys and almost two thirds of the girls reported more than 2 hours ST per day, OR 2.2 [1.8;2.6]; p<0.001. Screen time on weekend days was higher than on week days among all students (5.7±3.6 versus 3.5±2.7) (Table 1c).

Table 1a: Characteristics of the study sample

Individual level	Boys	Girls	Total	p-value
	Mean ± Standard Deviation (SD) or n (%)			
Number of students, n (%)	1279 (49.5)	1307 (50.5)	2586	
Age (years, mean ± SD) (n=2586)	12.5 ± 0.5	12.4 ± 0.5	12.4 ± 0.5	<0.001
12 years, n (%)	651 (50.9)	775 (59.3)	1426 (55.1)	<0.001
13 years, n (%)	628 (49.1)	532 (40.7)	1160 (44.9)	
Height (cm, mean ± SD) (n=2440)	161.1±9.5	160.1±7.3	160.6 ± 8.4	0.003
Weight (kg, mean ± SD) (n=2360)	49.5 ± 10.9	47.0 ± 8.9	48.3 ± 10.0	<0.001
BMI* (kg/m^2, mean ± SD) (n=2296)	18.9 ± 3.1	18.3 ± 2.7	18.6 ± 2.9	<0.001
BMI range	11.8 – 30.9	11.7 – 33.8	11.7 – 33.8	
Underweight (BMI <10^{th} percentile)**	126 (11.1)	218 (18.8)	344 (15.0)	<0.001
Normal weight (BMI 10^{th} - <90^{th} percentile)**	822 (72.2)	843 (72.6)	1665 (72.4)	
Overweight (BMI 90^{th} - <97^{th} percentile)**	166 (14.6)	90 (7.8)	256 (11.1)	
Obesity (BMI ≥97^{th} percentile)**	24 (2.1)	10 (0.9)	34 (1.5)	
Migrant background (n=2423)	396 (33.1)	429 (35.0)	825 (34.0)	0.307
Individual SES*** (family affluence scale; FAS) (n=2139)				
high (FAS 6-7)	569 (53.7)	500 (46.3)	1069 (50.0)	0.003
moderate (FAS 4-5)	371 (35.0)	441 (40.9)	812 (38.0)	
low (FAS 0-3)	120 (11.3)	138 (12.8)	258 (12.1)	
Student's neighbourhood SES (n=2240)	1114	1126	2240	
Mean±SD	4.0 ± 1.9	4.1 ± 1.9	4.0 ± 1.9	0.526
1 (best)	127 (11.4)	123 (10.9)	250 (11.2)	
2	182 (16.3)	194 (17.2)	376 (16.8)	
3	143 (12.8)	119 (10.6)	262 (11.7)	
4	215 (19.3)	229 (20.3)	444 (19.8)	
5	162 (14.5)	160 (14.2)	322 (14.4)	
6	134 (12.0)	134 (11.9)	268 (12.0)	
7 (worst)	151 (13.6)	167 (14.8)	318 (14.2)	
School type (n=2586)				

High School[a] students *(15 schools)*	507 (39.6)	624 (47.7)	1131 (43.7)	<0.001
Integrated Secondary School[b] students *(32 schools)*	772 (60.4)	683 (52.3)	1455 (56.3)	

(descriptive statistical methods)
*Body Mass Index (kg/m^2)
** BMI percentiles according to Cole et al. (38,39)
*** Socioeconomic Status
[a] High schools (5th or 7th grade to 12th grade, graduation with high school diploma after 12th grade)
[b] Integrated secondary schools (integration of different school types, 7th grade to 13th grade, graduation with secondary school leaving certificate after 10th grade or high school diploma after 13th grade)

Table 1b: Characteristics of schools

School level				
	High Schools[a]	Integrated Secondary Schools[b]	Total	
Schools' neighbourhood SES, Mean±SD (n=47)	3.5±1.4	3.2±1.6	4.0±1.8	<0.001
n (%)				
1 (best)	1 (6.7)	3 (9.4)	4 (8.5)	
2	4 (26.7)	3 (9.4)	7 (14.9)	
3	2 (13.3)	4 (12.5)	6 (12.8)	
4	4 (26.7)	7 (21.9)	11 (23.4)	
5	2 (13.3)	4 (12.5)	6 (12.8)	
6	2 (13.3)	5 (15.6)	6 (12.8)	
7 (worst)	0 (0.0)	6 (18.8)	6 (12.8)	
Student's neighbourhood SES*, Mean±SD (n=2240)	3.1±1.6	4.6±1.9		<0.001
Individual SES* (family affluence scale; FAS) (n=2139)				
n (%)				
High (FAS 6-7)	744 (65.8)	531 (36.5)		<0.001
Moderate (FAS 4-5)	338 (29.9)	652 (44.8)		
Low (FAS 0-3)	49 (4.3)	272 (18.7)		

(descriptive statistical methods)
SES: Socioeconomic Status, SD: Standard deviation
[a]High schools (5th or 7th grade to 12th grade, graduation with high school diploma after 12th grade)
[b]Integrated secondary schools (integration of different school types, 7th grade to 13th grade, graduation with secondary school leaving certificate after 10th grade or high school diploma after 13th grade)

Table 1c. Comparison of boys and girls aged 12-13 years

	Boys	Girls		p-value (boys vs. girls)	Total
	Proportion	Proportion	Odds ratio [95% CI]		Proportion
WHO recommendations fulfilled: 60min/day every day per week (%) (n=2517)	15.9	9.8	1.7 (1.4;2.2)	<0.001	12.8
Screen time of 2 hours or more per day (%) (n=2503)	81.5	66.9	2.2 (1.8;2.6)	<0.001	74.1
	Mean±SD	Mean±SD	Mean difference [95% CI]	p-value	Mean±SD
Time spent with physical activity per day (hours, mean±SD) (n=2517)	0.9±0.8	0.6±0.6	0.3 (0.2;0.3)	<0.001	0.8±0.7
behaviourScreen time (TV) (hours, mean±SD)					
school day (n=2555)	2.2 ± 1.8	1.9 ± 1.6	0.3 (0.2;0.4)	<0.001	2.0 ± 1.7
weekend day (n=2550)	3.4 ± 2.0	2.9 ± 2.0	0.4 (0.3;0.6)	<0.001	3.1 ± 2.0
behaviourScreen time (Computer) (hours, mean±SD)					
school day (n=2558)	1.8 ± 1.8	1.3 ± 1.6	0.5 (0.4;0.7)	<0.001	1.5 ± 1.7
weekend day (n=2541)	3.1 ± 2.2	2.0 ± 2.0	1.1 (1.0;1.3)	<0.001	2.6 ± 2.2
Overall behaviourscreen time (hours, mean±SD) (n=)					
school day (n=2536)	3.9 ± 2.7	3.1 ± 2.5	0.8 (0.6;0.97)	<0.001	3.5 ± 2.7
weekend day (n=2518)	6.5 ± 3.6	4.9 ± 3.4	1.6 (1.3;1.8)	<0.001	5.7 ± 3.6

(descriptive statistical methods)

SD: Standard deviation, CI: Confidence interval

Association of individual and neighbourhood SES with PA and ST

In model 1 of the multivariable analysis we included the individual SES with and without adjustment for sex, BMI, migration background and the respective outcome.

In model 2, we performed an analogous analysis for the student's neighbourhood SES. In model 3a we included individual and neighbourhood SES and the adjustment variables mentioned above. We then included stepwise "school type" (model 3b) and schools' neighbourhood SES (model 3c).

Physical activity was not associated with the individual SES, however, students with a low neighbourhood SES had a higher Odds (1.67 [1.14;2.44]; p=0.028) of spending at least 60 minutes per day being physically activie compared to students with a high neighbourhood SES.

If both types of SES were included in the model (model 3), this association was no longer statistically significant. Adding school type and schools' neighbourhood SES did not change that. Sex, BMI and school type were statistically significantly associated with physical activity (Figure 2; suppl. table 1).

Screen time, was associated with individual SES in all models. The lower the students' SES the higher the Odds to spent more than two hours of ST per day (1.25 [0.95; 1.64] and

1.88 [1.12; 3.14]; p=0.036 for middle and low individual SES, respectively, compared to high SES).The association with the neighbourhood SES showed the same trend. Students with lower neighbourhood SES were more likely to spend more than two hours of ST per day than students with a high neighbourhood SES. Again, after including school type and schools' neigbourhood SES (model 3b and 3c) the association was not statistically significant any more (Figure 3; suppl table 2).

Boys had a higher odds to be active but at the same time they were also more likely to engage in higher ST compared to girls. Higher BMI was associated with less activity and more screen time. We saw no association of screen time with physical activity (and vice versa). There was no interaction effect between gender and screen time regarding physical activity, nor between gender and physical activity regarding screen time (data not shown).

Students of the integrated secondary schools were more active but reported also more screen time than high school students. Schools' neighbourhood SES had no effect on physical activity nor on screen time.

DISCUSSION

In this study we investigated the association of individual and neighbourhood SES with physical activity and screen time among school students. The individual SES of the students in our study sample, measured with the family affluence scale, was significantly associated with screen time. Students with lower SES were more likely to spend more than 2 hours per day viewing screen devices. Low SES was stronger associated with screen time than middle SES, compared to high SES. Physical activity, however, was not associated with the individual SES. This is in line with other studies which showed that the individual SES is not a strong predictor of high PA among youths(40–42). A possible explanation for these results is that PA consists not only of organised sports or activities that require a club membership. A large part of PA among youths are daily life activities and are based on activities in the neighbourhood and in parks which is independent from the individual SES(43).Another aspect of our study was the investigation of the neighbourhood SES as an influencing factor of physical activity and screen time. In contrast to the individual SES, an association was found for physical and screen time. After including school type, the association remained statistically significant only for screen time. Probably there was some interaction between the student's neighbourhood SES and the school type, which is quite probable since there are more integrated secondary schools in neighbourhoods with lower SES than high schools. Also, it is known, that the neighbourhood SES as well as the SES of the students is often correlated with the school type (44).In one previous study also using the social index for Berlin, an association of a lower neighbourhood SES with a higher BMI in 5-6 years old children living in Berlin was observed. However, the authors did not include health behaviours like physical activity or sedentary time in their analyses(45).

It is possible that other factors like the built environment play a more important role than individual or neighbourhood SES as factors influencing physical activity. Sallis et al. have shown in a study among adults, that the number of public transport stops, residential density, intersection density and the number of parks were independently and positively associated with the time spent in physical activity(46). Other authors also found associations of the built environment and physical activity(24). In another study associations appeared to differ between population groups (persons with low neighbourhood SES had a bigger benefit of a good walkability than those with a high neighbourhood SES)(23). Future

research should include measurement of the built environment in Berlin to provide new insights into the associations with physical activity.

In another previous study unemployment rate and overcrowding were used as indicators of neighbourhood SES. The authors found a correlation between the unemployment rate and low physical activity in different urban districts in Germany and the Czech republic defining low physical activity as being active less than once a week which is a very broad definition(20).

A study from Switzerland reported different settings while engaging in physical activity and sedentary behaviour among children of low and high neighbourhood SES, whereas the overall time spent active or sedentary did not differ substantially between the two groups(21).

In the present study, the association of individual and neighbourhood SES with screen time is more consistent than the association with physical activity. For future health promotion programs different school types may need to be taken into account in addition to differences in SES. In this study, students of integrated secondary schools spent more time viewing screen devices, but were also more active than high school students. This is in contrast to another study from Germany, where high school students were more likely to achieve a healthier lifestyle, including regular physical activity than students from other school types(13). According to our study results, integrated secondary school students could benefit by interventions which promotes alternatives to screen time, whereas high school students seem to need physical activity promotion.

In contrast to the study by Lampert et al., there was no association of students' migration background and physical activity in our study(47).

Strengths and limitations

Strengths of our study include the size of our sample, as well as the proportion of students with migration background, socioeconomic status and gender distribution, which appear to be very similar to the student population of Berlin(48). However, the results are only valid for regions with similar characteristics as Berlin: an urban region with high walkability and good infrastructure for transportation and cycling.

Some limitations have to be considered as well. First, FAS was only assessed at the 24 month follow up. However, we assessed one item of the FAS (holiday) both at baseline and at the 12 month follow-up. The answers were quite similar over the two years. We thus think the period of two years implicates only minimal changes in the FAS level. Anthropometric data and physical activity were not measured objectively. Self-report may lead to distorted results through misreporting(49). However, children and adolescents seem to be reliable in providing accurate and valid information as long as the questionnaires are developed for the respective age group, which was the case(50). Another limitation is that as screen time measures, only the use of TV, Computer and video games was assessed by the applied HBSC questionnaire. Other kinds of divices (smartphones, tablets) and other kinds of sedentary behaviours like sitting during homework, talking on the phone and sitting at school were not taken into account, which may have led to an underestimation of the screen time.

CONCLUSION

Lower individual and neighbourhood SES were independently associated with higher screen time in students. Physical activity was not associated with the individual SES, but with neighborhood SES. Both, individual and neighbourhood SES as well as school type are important factors that have to be considered, when developing prevention programs for school students. Future research should include measurement of the built environment in Berlin to provide new insights into associations with physical activity.

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CONTRIBUTORS

LK and FMR drafted the manuscript with intellectual input from SR, NR, JMN, and NSB. FMR supervised the study and LK carried out the data collection and parts of the data analysis. FL and SR

were responsible for data assessment and statistical analyses, FMR, CB, NR, JMN and NSB were responsible for the design of the recruitment methods and the assessment tools, FMR, NR, JMN, and SW conceptualized the study. All authors read and approved the final manuscript.

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COMPETING INTERESTS

None declared.

ETHICS APPROVEL

The study was approved by the ethical review committee of the Charité-Universitätsmedizin Berlin, Germany.

DATA SHARING STATEMENT

No additional data available.

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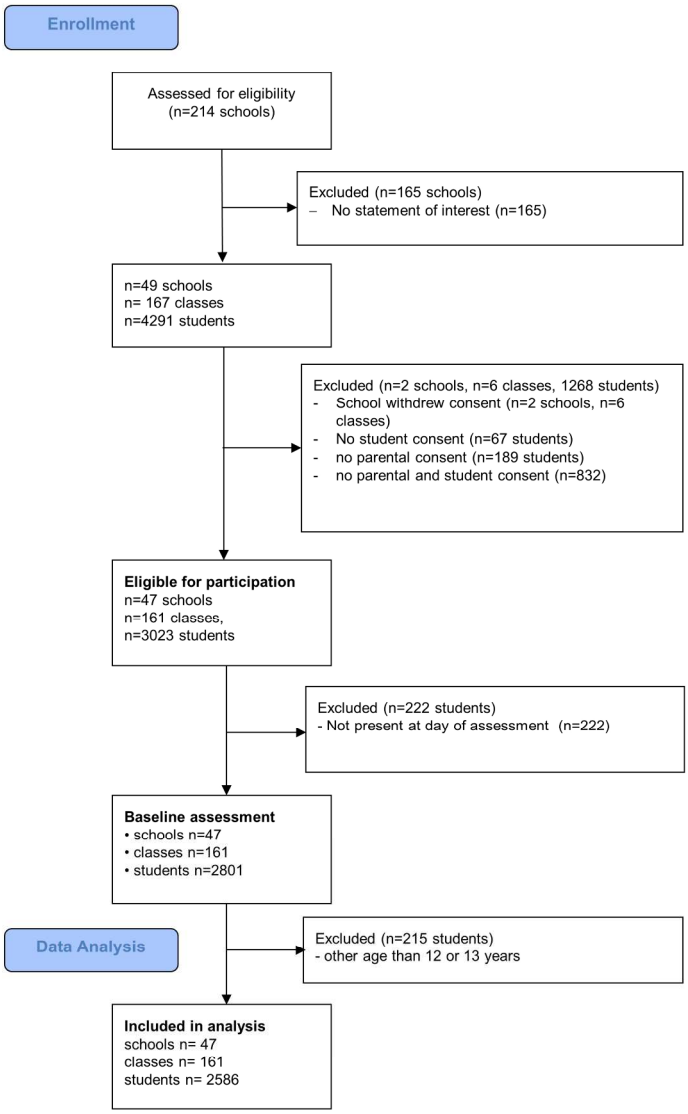
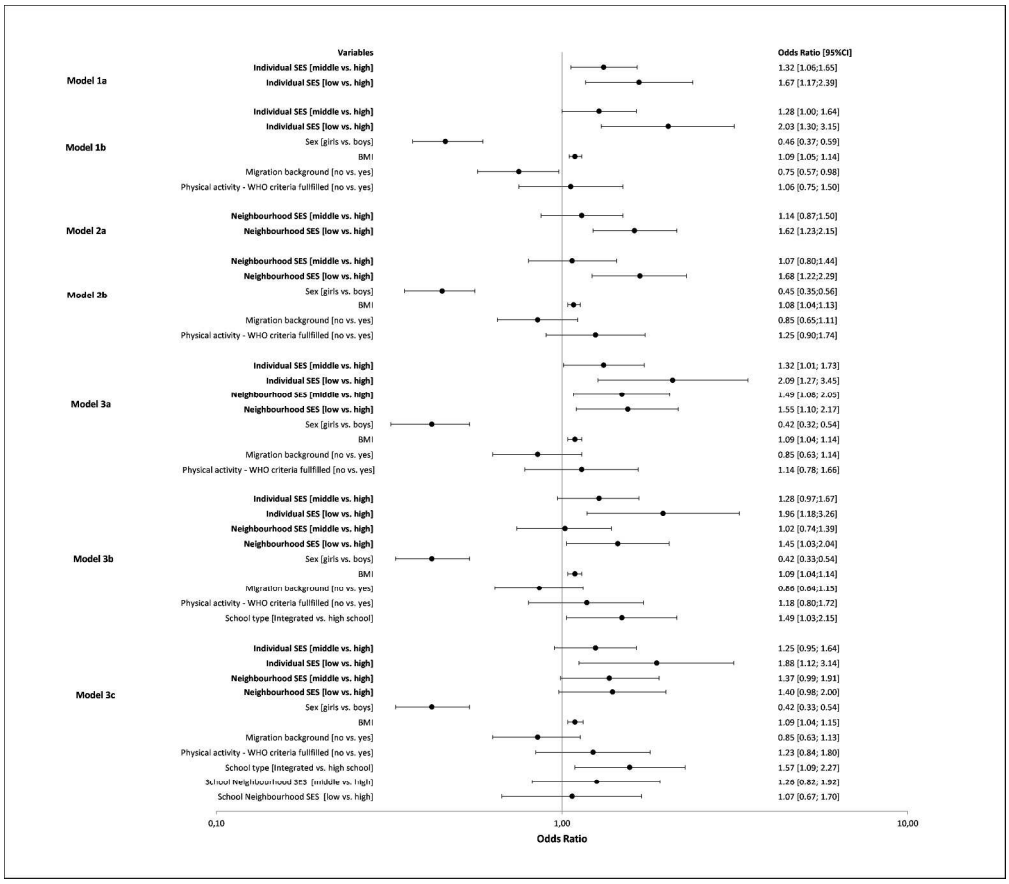
Figures

Supplementary files



Flowchart of the recruitment process

254x338mm (300 x 300 DPI)



Multivariable analysis of screen time associated factors among 12 and 13 years old students

380x331mm (300 x 300 DPI)

Supplementary table 1: Multivariable analysis of physical activity associated factors among 12 and 13 years old students

	WHO criteria for physical activity (at least 60 minutes per day physically active) fulfilled:													
	Model 1*				**Model 2****				**Model 3*****					
	Model 1a (n=1926)		**Model 1b** (n=1595)		**Model 2a** (n=2027)		**Model 2b** (n=1652)		**Model 3a** (n=1381)		**Model 3b** (n=1381)		**Model 3c (n=**1364)	
	OR (95% CI)	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Individual socioeconomic status (FAS)		0.640		0.940	-	-	-	-		0.763		0.520		0.476
High	1		1		-	-	-	-	1		1		1	
Middle	0.90 (0.67; 1.19)		0.95 (0.69; 1.31)		-	-	-	-	0.89 (0.62; 1.26)		0.83 (0.58;1.19)		0.83 (0.58; 1.20)	
Low	0.84 (0.53; 1.31)		1.01 (0.60; 1.69)		-	-	-	-	0.87 (0.50; 1.54)		0.78 (0.44;1.38)		0.74 (0.41; 1.33)	
Student's neighbourhood SES	-	-	-	-		0.064	-	**0.028**		0.079		0.301		0.253
High (rank 1-2)	-	-	-	-	1		1		1		1		1	
Middle (rank 3-4)	-	-	-	-	1.19 (0.83;1.71)		1.24 (0.84;1.84)		1.27 (0.85; 1.88)		1.20 (0.77;1.88)		1.19 (0.78; 1.82)	
Low (rank 5-7)	-	-	-	-	1.49 (1.06;2.11)		1.67 (1.14;2.44)		1.65 (1.07; 2.56)		1.43 (0.91;2.24)		1.51 (0.93; 2.46)	
Sex	-	-		**<0.001**	-	-		**<0.001**		**<0.001**		**<0.001**		**<0.001**
Boys	-	-	1		-	-	1		1		1		1	
Girls	-	-	0.51 (0.38; 0.69)		-	-	0.48 (0.36;0.65)		0.48 (0.35; 0.67)		0.49 (0.35;0.69)		0.48 (0.34; 0.68)	
BMI	-	-	0.90 (0.85; 0.95)	**<0.001**	-	-	0.92 (0.87;0.97)	**0.002**	0.92 (0.87; 0.98)	**0.006**	0.92 (0.86;0.97)	**0.003**	0.91 (0.86; 0.97)	**0.003**
Migration background	-	-		0.844	-	-		0.957		0.588		0.621		0.761
yes	-	-	1		-	-	1		1		1		1	
no	-	-	0.97 (0.69; 1.36)		-	-	0.99 (0.72;1.36)		0.91 (0.63; 1.30)		0.91 (0.63;1.31)		0.94 (0.65; 1.37)	
Screen time	-	-		0.734	-	-		0.165	-	0.425		0.352		0.233
≥2 hours	-	-	1		-	-	1		1		1		1	
<2 hours	-	-	1.06 (0.76; 1.49)		-	-	1.26 (0.91;1.74)		1.16 (0.81; 1.67)		1.20 (0.82;1.75)		1.26 (0.86; 1.86)	
School type	-	-	-	-	-	-	-	-	-			**0.006**		**0.002**
High School	-	-	-	-	-	-	-	-	-		1		1	
Integrated Secondary School	-	-	-	-	-	-	-	-	-		1.93 (1.21;3.07)		2.15 (1.34; 3.47)	
Schools' neighbourhood SES	-	-	-	-	-	-	-	-	-		-			0.723
High (rank 1-2)	-	-	-	-	-	-	-	-	-		-		1	
Middle (rank 3-4)	-	-	-	-	-	-	-	-	-		-		1.15 (0.69; 1.92)	
Low (rank 5-7)	-	-	-	-	-	-	-	-	-		-		0.92 (0.52; 1.62)	

*__Model 1__ (__Model 1a:__ individual socioeconomic status (FAS), __Model 1b:__ individual socioeconomic status (FAS) adjusted for Sex, BMI, migration background, screen time)

**__Model 2 (Model 2a:__ student's neighbourhood SES (3 categories); __Model 2b:__ student's neighbourhood SES (3 categories) adjusted for Sex, BMI, migration background, screen time)

***__Model 3 (Model 3a:__ Model 1+2, __Model 3b:__ Model 1+2+School type, __Model 3b:__ Model 1+2+School type+School neighbourhood SES

Supplementary table 2: Multivariable analysis of screen time associated factors among 12 and 13 years old students

	Model 1*				Model 2**				Model 3***					
	Model 1a (n=1925)		**Model 1b** (n=1595)		**Model 2a** (n=2014)		**Model 2b** (n=1652)		**Model 3a** (n=1381)		**Model 3b** (n=1381)		**Model 3c (n=**1364)	
	OR (95% CI)	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Individual SES (FAS)		**0.005**		**0.004**	-	-	-	-		**0.007**		**0.019**		**0.036**
High	1		1		-	-	-	-	1		1		1	
Middle	1.32 (1.06;1.65)		1.28 (1.00; 1.64)		-	-	-	-	1.32 (1.01; 1.73)		1.28 (0.97;1.67)		1.25 (0.95; 1.64)	
Low	1.67 (1.17;2.39)		2.03 (1.30; 3.15)		-	-	-	-	2.09 (1.27; 3.45)		1.96 (1.18;3.26)		1.88 (1.12; 3.14)	
Student's neighbourhood SES	-	-	-	-		**0.005**		**0.002**		**0.019**		0.057		0.109
High (rank 1-2)	-	-	-	-	1		1		1		1		**1**	
Middle (rank 3-4)	-	-	-	-	1.14 (0.87;1.50)		1.07 (0.80;1.44)		1.49 (1.08; 2.05)		1.02 (0.74;1.39)		1.37 (0.99; 1.91)	
Low (rank 5-7)	-	-	-	-	1.62 (1.23;2.15)		1.68 (1.22;2.29)		1.55 (1.10; 2.17)		1.45 (1.03;2.04)		1.40 (0.98; 2.00)	
Sex	-	-		**<0.001**	-	-				**<0.001**		**<0.001**		**<0.001**
Boys	-	-	1		-	-	1	**<0.001**	1		1		1	
Girls	-	-	0.46 (0.37; 0.59)		-	-	0.45 (0.35;0.56)		0.42 (0.32; 0.54)		0.42 (0.33;0.54)		0.42 (0.33; 0.54)	
BMI	-	-	1.09 (1.05; 1.14)	**<0.001**	-	-	1.08 (1.04;1.13)	**<0.001**	1.09 (1.04; 1.14)	**<0.001**	1.09 (1.04;1.14)	**<0.001**	1.09 (1.04; 1.15)	**<0.001**
Migration background	-	-		**0.035**	-	-		0.223		0.267		0.293		0.262
yes	-	-	1		-	-	1		1		1		1	
no	-	-	0.75 (0.57; 0.98)		-	-	0.85 (0.65;1.11)		0.85 (0.63; 1.14)		0.86 (0.64;1.15)		0.85 (0.63; 1.13)	
Physical activity (PA) (WHO criteria fulfilled)	-	-		0.738	-	-		0.189		0.510		0.404		0.297
Yes	-	-	1		-	-	1		1		1		1	
No	-	-	1.06 (0.75; 1.50)		-	-	1.25 (0.90;1.74)		1.14 (0.78; 1.66)		1.18 (0.80;1.72)		1.23 (0.84; 1.80)	
School type	-	-			-	-	-	-	-	-		**0.036**		**0.016**
High School	-	-			-	-	-	-	-	-	1		**1**	
Integrated Secondary School	-	-			-	-	-	-	-	-	1.49 (1.03;2.15)		1.57 (1.09; 2.27)	
Schools' neighbourhood SES	-	-			-	-	-	-	-	-	-	-		0.535
High (rank 1-2)	-	-			-	-	-	-	-	-	-	-	**1**	
Middle (rank 3-4)	-	-			-	-	-	-	-	-	-	-	1.26 (0.82; 1.92)	
Low (rank 5-7)	-	-			-	-	-	-	-	-	-	-	1.07 (0.67; 1.70)	

*__Model 1__ (**Model 1a:** individual socioeconomic status (SES) (FAS), **Model 1b:** individual socioeconomic status (FAS) adjusted for Sex, BMI, migration background, PA)

__Model 2 (Model 2a:__ student's neighbourhood SES (3 categories); **Model 2b: neighbourhood SES (3 categories) adjusted for Sex, BMI, migration background, PA)

***__Model 3 (Model 3a:__ Model 1+2, **Model 3b:** Model 1+2+School type, **Model 3b:** Model 1+2+School type+School neighbourhood SES)

STROBE (Strengthening The Reporting of OBservational Studies in Epidemiology) Checklist

A checklist of items that should be included in reports of observational studies. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Section and Item	Item No.	Recommendation	Reported on Page No.
Title and Abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/Rationale	2	Explain the scientific background and rationale for the investigation being reported	1
Objectives	3	State specific objectives, including any prespecified hypotheses	2
Methods			
Study Design	4	Present key elements of study design early in the paper	2
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2-3
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	2-3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3-5

Section and Item	Item No.	Recommendation	Reported on Page No.
Data Sources/ Measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3-5
Bias	9	Describe any efforts to address potential sources of bias	15
Study Size	10	Explain how the study size was arrived at	2
Quantitative Variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical Methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5-6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	7
Descriptive Data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-10
		(b) Indicate number of participants with missing data for each variable of interest	7-10
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome Data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	7-10

Section and Item	Item No.	Recommendation	Reported on Page No.
Main Results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other Analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	5-6
Discussion			
Key Results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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BMJ Open

Association of individual and neighbourhood socioeconomic status with physical activity and screen time in 7th grade boys and girls in Berlin, Germany – a cross sectional study.

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Association of individual and neighbourhood socioeconomic status with physical activity and screen time in 7th grade boys and girls in Berlin, Germany – a cross sectional study.

Lilian Krist[1], Christin Bürger[1], Nanette Ströbele-Benschop[2], Stephanie Roll[1], Fabian Lotz[1], Nina Rieckmann[3], Jacqueline Müller-Nordhorn[3], Stefan N. Willich[1], Falk Müller-Riemenschneider[1,4]

1. *Institute for Social Medicine, Epidemiology and Health Economics, Charité - Universitätsmedizin Berlin, Germany*
2. *Institute of Nutritional Medicine, University of Hohenheim, Germany*
3. *Institute of Public Health, Charité-Universitätsmedizin Berlin, Germany*
4. *Saw Swee Hock School of Public Health, National University of Singapore*

Corresponding author:

Dr. Lilian Krist
Institute for Social Medicine, Epidemiology and Health Economics
Charité - Universitätsmedizin Berlin
Luisenstr. 57
10117 Berlin, Germany
E-Mail: lilian.krist@charite.de
Tel: +49 30 450 529 109

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ABSTRACT

Objectives Few studies have explored the impact of neighbourhood socioeconomic status (SES) on health behaviours in youths in Germany. Our aim was to investigate the association of individual and neighbourhood SES with physical activity (PA) and screen time (ST) in 12-13 year old students in Berlin.

Design Cross-sectional study.

Setting Secondary schools (high schools and integrated secondary schools) in Berlin, Germany.

Participants A total of 2586 students aged 12-13 years (7th grade).

Main outcome measures Sociodemographics, anthropometric data and health behaviours were assessed by self-report during classes. Primary outcome was the association of individual and neighbourhood SES with daily PA and ST. Students' characteristics were described with means or percentages. Comparisons were performed using Generalized Linear Mixed Model yielding odds ratios (OR) with 95% confidence intervals.

Results Mean (±SD) age was 12.5±0.5 years, 50.5% were girls, and 34.1% had a migrant background. Individual SES was only associated with ST. The OR of engaging in more than two hours of ST per day was 1.88 [1.12;3.14] for students with low compared to high SES. Neighbourhood SES was associated with both PA (OR 1.51 [0.93; 2.46]) and ST (OR 1.40 [0.98; 2.00]), for students with low compared to high neighbourhood SES, when adjusting for individual covariates. Additional adjustment for school type and schools neighbourhood SES attenuated the associations somewhat.

Conclusions Lower individual SES was only associated with higher ST but not with PA, whereas lower neighbourhood SES was associated with higher PA and higher ST. After consideration of the school environment (school type and schools' neighbourhood SES) the effect of neighbourhood SES on PA and ST was attenuated somewhat, suggesting an important role in the complex relationship between individual SES, neighbourhood SES and school environment. Further research is warranted to unravel these relationships and to develop more targeted health promotion strategies in the future.

Strengths and limitations of the study

- This study provides important new insights into the association of individual and neighbourhood socioeconomic status with PA and ST among 7th grade boys and girls attending secondary schools in Berlin, Germany.
- The study comprises a large sample with students recruited from all 12 districts of Berlin, including a variety of neighbourhoods with different levels of socioeconomic status.
- Anthropometric data and PA were not assessed objectively but via self-report.
- Only ST was assessed, while other kinds of sedentary behaviours were not taken into account.

INTRODUCTION

Physical activity as well as sedentary behaviour have an important impact on health and wellbeing(1). Low levels of PA are associated with higher health risks already among children and adolescents(2) and an increasing number of studies have identified sedentary behaviour as an independent risk factor for diseases such as diabetes and obesity in children and adolescents(3).

In the last decades however, sedentary behaviour among children and adolescents is increasing while the rates of children being active appear to be decreasing over time(4–7). In addition, longitudinal studies have shown a decline in PA and at the same time an increase in sedentary behaviour among children and adolescents with increasing age(8–10). ST (time spent watching TV or playing games on the computer or playing video games) is one important aspect of sedentary behaviour, even though it does not encompass the total time spent being sedentary(11).

While there is evidence of an association of age and sex with PA(12), studies exploring the influence of socioeconomic status and built and social environment of children show heterogeneous results(13–16).

A low individual SES is often associated with a higher BMI and more sedentary time, but not always with low PA(17–19). In addition to individual SES, studies investigating the social environment (i.e. social support and social networks, socioeconomic position and income inequality, racial discrimination, social cohesion and social capital) of children found evidence of an association with PA and diet(20–22). The built environment has also been shown to be associated with PA among children and youth(23).

Another aspect of the social environment is the neighbourhood socioeconomic status. Studies investigating the influence of neighbourhood SES on health showed an association of disadvantaged neighbourhoods with worse health status(24) or a higher risk for cardiovascular diseases(25). Mechanisms through which a lower neighbourhood socioeconomic status may influence PA and sedentary behaviour could be reduced municipal services such as recreational facilities and playgrounds, financial stress or less possibilities to own a gym membership(22). Also a higher crime rate may lead to less activities outside(26). With regard to these associations between PA, sedentary behaviour and the neighbourhood SES, study results are heterogeneous ranging from no association to a clear association

(27–30). Other studies in turn found that the neighbourhood SES was only a positive modifier for the association of environmental factors with PA and sedentary behaviour(31,32). Knowing more about independent associations of individual and neighbourhood SES could help to address groups of adolescents in a more targeted way when implementing prevention strategies (e.g. adapting the content of health promotion strategies to different neighbourhoods).

Our aim was therefore to investigate the association of individual and neighbourhood socioeconomic status with PA and ST as one important form of sedentary behaviour in a population based sample of 12 to 13 year old boys and girls attending secondary schools in Berlin, Germany.

METHODS

Study design and setting

The present cross-sectional analysis is part of the BEST-prevention study, a three armed cluster randomized controlled trial that was conducted from 2010 to 2014 (baseline assessment was conducted from 2010 to 2011) with the aim to evaluate a parent involving smoking prevention program for 7th grade students in Berlin(33). Here, we report cross-sectional data regarding PA and ST among the students at baseline including associations with individual and neighbourhood socioeconomic status.

Participants and Recruitment

Details of the recruitment are described elsewhere(34). Briefly, prior to recruitment, permission of the Berlin senate of education, youth and research (Senatsverwaltung für Bildung, Jugend und Wissenschaft) was obtained, and school principals and contact teachers from all 12 districts of Berlin were informed about the project. Students were eligible for the study if they: i) were in the 7th grade, ii) attended one of the participating schools, and iii) showed intellectual and physical ability to make an informed decision about study participation. Separate signed written informed consent was required from participating students as well as from at least one parent/caregiver. The study was approved by the ethical review committee of the Charité-Universitätsmedizin Berlin, Germany.

Measurements

The study questionnaire is based on existing and validated questionnaires investigating adolescent health behaviour (e.g. Health Behaviour in School Aged Children, HBSC(35); German Children and Youths Survey, KIGGS(36)). It includes questions related to socio-demographics, smoking and other health behaviours, such as alcohol consumption, nutrition, PA and ST, as well as height and weight. It took about 30-40 minutes to complete the questionnaire. Our study group has the status of an associated project of the HBSC.

During a first visit to schools, the BEST study was presented to the students by trained research personnel and consent forms were distributed for students and parents/caregivers. During the second visit, which took place a few weeks later, baseline data were assessed with the questionnaire in the classroom among children, who had provided both consent forms.

Outcome measures

Physical activity (PA)

PA was assessed using three adapted items of the HBSC questionnaire. The first question read: 'On how many days in the past week were you physically active for at least 60 minutes?' According to the WHO guidelines, for our primary outcome we defined a student as meeting current guidelines if he or she was active at least 60 minutes on each of the last seven days (yes/no)(37). The other questions asked for the number of days and hours of moderate intensity PA per week.

Screen time (ST)

ST was assessed with two questions (also part of the HBSC questionnaire) asking for the time spent each day watching TV or playing with the Computer. TV time was assessed by asking 'How many hours/day do you usually watch television in your free time?' for weekdays and weekend days separately. Computer time (minutes/day) was assessed by asking 'How many hours/day do you usually play games on a computer, or use a game console in your leisure time?'. Total ST was computed by adding up TV and computer time. Using a smartphone or tablet was not assessed. According to the AAP(38) recommendations we defined more than 2 hours of ST per day as high ST.

Covariates

Individual level

Sex, age and anthropometric data (height and weight) of the students were assessed via self-report. The BMI was calculated using the self-reported data. BMI categories are presented using cut-offs defined by the specific percentiles which at age 18 years correspond to the adult cut-off points for underweight (<18.5kg/m^2), overweight (25kg/m^2) and obesity (30kg/m^2). According to that definition, underweight is defined as a BMI <10th percentile, normal weight as a BMI between the 10th and the 90th percentile, overweight as a BMI between the 90th and the 97th percentile and obesity as a BMI ≥97th percentile(39,40). According to official definitions a student was defined as having a migration background if he or she was not born in Germany or if at least one parent was not born in Germany but moved to Germany after 1949(41).

Individual socioeconomic status

To assess the individual socioeconomic status (SES) of the student, we used the family affluence scale (FAS), a validated instrument to assess the material affluence of the family asking for the number of cars and computers in the family, for holidays during the past 12 months, and whether the child has its own room(42). The FAS consists of values from zero to seven, with higher values indicating higher affluence, and can be categorized into three categories (low (0-3), moderate (4-5), and high affluence (6-7)). The FAS was completely assessed only at the 24 months follow-up, we therefore used the 24 months follow-up FAS to describe family SES at baseline.

Neighbourhood socioeconomic status

For the SES of the students' neighbourhood, we used the social index defined and implemented by the 'Atlas of Social Structure' (Sozialstukturatlas). It is an instrument used in Berlin to describe the social situation of Berlin by classifying 447 sub-areas (with on average 7500 habitants) of the 12 districts of Berlin accordingly(43,44). This social index reflects the distribution of social and health burden in Berlin. Social and health indicators are e.g. unemployment, welfare reception rate, average per capita

income and also premature mortality and avoidable deaths. The index ranges from 1 reflecting the best to 7 reflecting the worst social situation of a district.

School types

In Berlin, two types of secondary schools exist: high schools with the possibility to achieve a high-school diploma after 12 years, as well as integrated secondary schools (an integration of different school types) with the possibility to achieve a high-school diploma after 13 years. More often than high schools, integrated secondary schools are left by the students after the 10th grade with a secondary school leaving certificate. The academic requirements are higher in high schools than in integrated secondary schools(45).

Schools' neighbourhood socioeconomic status

Since the neighbourhood of the school can be different to that of students, we assessed this information (analogous to the individual neighbourhood SES) in order to take an additional influencing factor of the students' behaviour into account.

Statistical analysis

All statistical analyses were performed for the 12 and 13 years old students due to the small number of students younger than 12 and older than 13 years (8.1%). We used all data available for the respective analysis; missing data were not imputed.

Characteristics of schools and students were analysed by descriptive statistical methods (e.g. mean and standard deviation (SD), frequencies and percentages; p-values are derived from t-tests and chi-square-tests).

Because of the nested structure of the data with both fixed and random effects, a generalized linear mixed model (GLMM) with a logit link function was used for the analysis when comparing groups (models with random intercept). In general, the random factors 'school' and 'class within school' (as nested factor) were included into the models, with either PA or ST as the dependent variable. Results are presented as odds ratios (OR) and 95%-confidence intervals (CI).

These models were used to determine the association of several factors. For PA as the dependent variable, sex, migration background, BMI and ST were included into all models, in addition with individual socioeconomic status (FAS-score) (Model 1) or students' neighbourhood SES (Model 2) or both (Model 3a). A final model included the aforementioned plus the two school level variables school type and schools' neighbourhood (Model 3b). The same procedure was performed for ST as the dependent variable, respectively. To be able to compare different models, the analyses were restricted to the number of students with non-missing data for the model with the largest number of variables included. As sensitivity analyses, to assess if associations are modified by gender, interaction effects on gender were included into the models. Additional sensitivity analyses were performed based on the maximum number of students with non-missing data for the respective model. All p-values are considered exploratory (with no adjustment for multiple testing). Analyses were performed using the software package SAS release 9.3 and 9.4 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Characteristics of the study population

Out of 214 contacted schools, 49 schools (23%; 4291 students) showed interest and were eligible for study participation. Before baseline assessment, 1268 out of these 4291 students dropped out including two entire schools. 2801 students participated at the baseline assessment. Out of those, we included 2586 students aged 12 and 13 years in our analysis. Figure 1 shows the recruitment process of the schools, classes and students.

Sociodemographic baseline characteristics of all participating students are presented in Table 1a. The mean (±SD) age of participants was 12.4 ± 0.5 years (12.5 ± 0.5 for boys and 12.4 ± 0.5 for girls) and the distribution between girls and boys was similar (50.5% vs. 49.5%). Of the entire sample, 34.1% were defined as having a migrant background. Boys reported more often a high individual SES than girls (53.7% vs. 46.3%). School characteristics of are presented in Table 1b. An association between the students' neighbourhood SES and the school type could be observed, indicating that the mean students' neighbourhood SES was higher among high school students than integrated secondary school students.

Of the total sample, 12.8% fulfilled the WHO criteria being active for at least 60 minutes per day. The proportion of boys fulfilling the criteria was higher than in girls (15.9% of the boys vs. 9.8% of the girls, OR 1.7 [1.4;2.2]; p<0.001) and boys were more active than girls (0.9±0.8 versus 0.6±0.6 hours per day, mean difference 0.3 hours [0.2;0.3], p<0.001). More than 80% of the boys and almost two thirds of the girls reported more than 2 hours ST per day, OR 2.2 [1.8;2.6]; p<0.001. ST on weekend days was higher than on week days among all students (5.7±3.6 versus 3.5±2.7) (Table 1c).

Table 1a: Characteristics of the study sample

Individual level	Boys	Girls	Total	p-value
	Mean ± Standard Deviation (SD) or n (%)			
Number of students, n (%)	1279 (49.5)	1307 (50.5)	2586	
Age (years, mean ± SD) (n=2586)	12.5 ± 0.5	12.4 ± 0.5	12.4 ± 0.5	<0.001
12 years, n (%)	651 (50.9)	775 (59.3)	1426 (55.1)	<0.001
13 years, n (%)	628 (49.1)	532 (40.7)	1160 (44.9)	
Height (cm, mean ± SD) (n=2440)	161.1±9.5	160.1±7.3	160.6 ± 8.4	0.003
Weight (kg, mean ± SD) (n=2360)	49.5 ± 10.9	47.0 ± 8.9	48.3 ± 10.0	<0.001
BMI* (kg/m^2, mean ± SD) (n=2296)	18.9 ± 3.1	18.3 ± 2.7	18.6 ± 2.9	<0.001
BMI range	11.8 – 30.9	11.7 – 33.8	11.7 – 33.8	
Underweight (BMI <10^{th} percentile)**	126 (11.1)	218 (18.8)	344 (15.0)	<0.001
Normal weight (BMI 10^{th} - <90^{th} percentile)**	822 (72.2)	843 (72.6)	1665 (72.4)	
Overweight (BMI 90^{th} - <97^{th} percentile)**	166 (14.6)	90 (7.8)	256 (11.1)	
Obesity (BMI ≥97^{th} percentile)**	24 (2.1)	10 (0.9)	34 (1.5)	
Migrant background (n=2423)	396 (33.1)	429 (35.0)	825 (34.0)	0.307
Individual SES*** (family affluence scale; FAS) (n=2139)				
high (FAS 6-7)	569 (53.7)	500 (46.3)	1069 (50.0)	0.003
moderate (FAS 4-5)	371 (35.0)	441 (40.9)	812 (38.0)	
low (FAS 0-3)	120 (11.3)	138 (12.8)	258 (12.1)	
Students' neighbourhood SES (n=2240)	1114	1126	2240	
Mean±SD	4.0 ± 1.9	4.1 ± 1.9	4.0 ± 1.9	0.526
1 (best)	127 (11.4)	123 (10.9)	250 (11.2)	
2	182 (16.3)	194 (17.2)	376 (16.8)	
3	143 (12.8)	119 (10.6)	262 (11.7)	
4	215 (19.3)	229 (20.3)	444 (19.8)	
5	162 (14.5)	160 (14.2)	322 (14.4)	

6	134 (12.0)	134 (11.9)	268 (12.0)	
7 (worst)	151 (13.6)	167 (14.8)	318 (14.2)	
School type (n=2586)				
High School[a] students *(15 schools)*	507 (39.6)	624 (47.7)	1131 (43.7)	<0.001
Integrated Secondary School[b] students *(32 schools)*	772 (60.4)	683 (52.3)	1455 (56.3)	

(descriptive statistical methods)

*Body Mass Index (kg/m^2)

** BMI percentiles according to Cole et al. (46,47)

*** Socioeconomic Status

[a] High schools (5th or 7th grade to 12th grade, graduation with high school diploma after 12th grade)

[b] Integrated secondary schools (integration of different school types, 7th grade to 13th grade, graduation with secondary school leaving certificate after 10th grade or high school diploma after 13th grade)

Table 1b: Characteristics of schools

School level				
	High Schools[a]	Integrated Secondary Schools[b]	Total	
Schools' neighbourhood SES, Mean±SD (n=47)	3.5±1.4	4.4±1.9	4.0±1.8	<0.001
n (%)				
1 (best)	1 (6.7)	3 (9.4)	4 (8.5)	
2	4 (26.7)	3 (9.4)	7 (14.9)	
3	2 (13.3)	4 (12.5)	6 (12.8)	
4	4 (26.7)	7 (21.9)	11 (23.4)	
5	2 (13.3)	4 (12.5)	6 (12.8)	
6	2 (13.3)	5 (15.6)	6 (12.8)	
7 (worst)	0 (0.0)	6 (18.8)	6 (12.8)	
Students' neighbourhood SES*, Mean±SD (n=2240)	3.1±1.6	4.6±1.9		<0.001
Individual SES* (family affluence scale; FAS) (n=2139)				
n (%)				
High (FAS 6-7)	744 (65.8)	531 (36.5)		<0.001
Moderate (FAS 4-5)	338 (29.9)	652 (44.8)		
Low (FAS 0-3)	49 (4.3)	272 (18.7)		

(descriptive statistical methods)

SES: Socioeconomic Status, SD: Standard deviation

[a]High schools (5th or 7th grade to 12th grade, graduation with high school diploma after 12th grade)

[b]Integrated secondary schools (integration of different school types, 7th grade to 13th grade, graduation with secondary school leaving certificate after 10th grade or high school diploma after 13th grade)

Table 1c. Comparison of boys and girls aged 12-13 years

	Boys	Girls		p-value (boys vs. girls)	Total
	Proportion	Proportion	Odds ratio [95% CI]		Proportion
WHO recommendations fulfilled: 60min/day every day per week (%) (n=2517)	15.9	9.8	1.7 (1.4;2.2)	<0.001	12.8
Screen time of 2 hours or more per day (%) (n=2503)	81.5	66.9	2.2 (1.8;2.6)	<0.001	74.1
	Mean±SD	Mean±SD	Mean difference [95% CI]	p-value	Mean±SD

Time spent with physical activity per day (hours, mean±SD) (n=2517)	0.9±0.8	0.6±0.6	0.3 (0.2;0.3)	<0.001	0.8±0.7
Screen time (TV) (hours, mean±SD)					
school day (n=2555)	2.2 ± 1.8	1.9 ± 1.6	0.3 (0.2;0.4)	<0.001	2.0 ± 1.7
weekend day (n=2550)	3.4 ± 2.0	2.9 ± 2.0	0.4 (0.3;0.6)	<0.001	3.1 ± 2.0
Screen time (Computer) (hours, mean±SD)					
school day (n=2558)	1.8 ± 1.8	1.3 ± 1.6	0.5 (0.4;0.7)	<0.001	1.5 ± 1.7
weekend day (n=2541)	3.1 ± 2.2	2.0 ± 2.0	1.1 (1.0;1.3)	<0.001	2.6 ± 2.2
Overall screen time (hours, mean±SD) (n=)					
school day (n=2536)	3.9 ± 2.7	3.1 ± 2.5	0.8 (0.6;0.97)	<0.001	3.5 ± 2.7
weekend day (n=2518)	6.5 ± 3.6	4.9 ± 3.4	1.6 (1.3;1.8)	<0.001	5.7 ± 3.6

(descriptive statistical methods)

SD: Standard deviation, CI: Confidence interval

Association of individual and neighbourhood SES with PA and ST

Results of multivariable analyses are presented in figure 2 and figure 3. Results presented in figures 2 and 3 and supplemental tables 1 and 2 are based on an identical analysis population with complete information (n=1523). Results for the multivariable analysis not restricted to complete cases is presented in supplement tables 3 and 4. The results did not differ markedly between both approaches.

Individual SES was not associated with PA, but with ST. The lower the students' SES the higher the odds to spent more than two hours of ST per day (1.31 [1.00; 1.72] and 2.08 [1.26; 3.43]; p=0.008) for middle and low individual SES, respectively, compared to high SES). This association was attenuated slightly when additionally adjusting for school type and school neighbourhood SES (1.25 [0.95;1.64] and 1.88 [1.12;3.14]; p=0.036).

In contrast to individual SES, a lower neighbourhood SES was associated with a higher odds of engaging in 60 minutes per day in PA (1.34 [0.86;2.08] and 1.76 [1.12; 2.75]) for middle and low neighbourhood SES, respectively, compared to high neighbourhood SES; this association was attenuated somewhat when additionally adjusting for the school type and schools' neighbourhood SES.

Compared with high neighbourhood SES, students with lower neighbourhood SES were also more likely to spend more than two hours of ST per day. The effect was stronger for low than for middle neighbourhood SES (1.54 [1.10; 2.17] and 1.03 [0.75; 1.41]), and remained largely consistent when additionally adjusting for school type and school neighbourhood SES (1.40 [0.98; 2.00] and 1.37 [0.99; 1.91]).

There was no interaction effect between gender and ST regarding PA, nor between gender and PA regarding ST (data not shown).

DISCUSSION

In this study we investigated the association of individual and neighbourhood SES with PA and ST among 7th grade school students. The individual SES of the students in our study sample, measured with the family affluence scale, was significantly associated with ST. Students with lower SES were more likely to spend more than 2 hours per day viewing screen devices. Compared to high SES, low SES was more strongly associated with ST than middle SES. Similar results were found in other studies(16,48,49). Potential reasons for these findings are that parents with better education and higher statuses may be more aware of the health consequences of excessive ST and thus have stricter rules regarding ST behaviour(50). Children from families with lower socioeconomic status may also more often have a TV in their room, which has been shown to be associated with higher ST levels(51). Moreover, it is well known that parents have an important role-modelling function, which influences children's behaviours, such as screen viewing(52). Since children of families with lower SES may more often have parents that engage in higher ST and/or watch more often TV together with their parents, they may in turn engage in more ST(53).

PA on the other hand was not associated with individual SES in our study population. This finding is in part consistent with the results of the HBSC study for Germany and with a few other studies(8,54,55). A possible explanation for this finding is that PA consists not only of organised sports or activities that require a club membership or sports equipment. On the contrary, a large part of PA among youths may be daily life activities, such as active commuting, or sports and activities in the neighbourhood and in parks which is independent from the individual SES(56). However, in contrast to our findings and the other studies, a variety of studies do show an association between socioeconomic status and PA, which has been highlighted in reviews by Sallis et al or Hanson et al(57,58). It should be noted that most of these studies are from the US or Australia and the explications for the observed associations, such as the higher prevalence of unsafe neighbourhoods or of neighbourhoods with less green space may not be directly transferable to Germany and Berlin.

The other main aspect of our study was the investigation of the neighbourhood SES and its association with PA and ST. The neighbourhood SES represents the social and health indicators of a city or of its districts including unemployment rate, welfare reception rate, average per capita income and others. In our study, students living in low SES neighbourhood areas were more likely to be physically active than those with middle or high neighbourhood SES. To a certain extent this is surprising and in contrast to many earlier studies that have reported mostly no or inverse associations between neighbourhood SES and PA(28,59–62). However, as suggested in an earlier study the observed finding in our study may be related to higher active transportation among adolescents of families with lower SES because they may be less likely to own a car resulting in more students using the bicycle or public transportation to school(63). Similar to individual SES, another explication could be that the major part of PA among adolescents consists of leisure or unstructured activities rather than organised team sports(56). Thus, a membership in a sports club (which is less probable in neighbourhoods with lower SES) would not affect the overall amount of PA.

Low neighbourhood SES was also associated with higher ST compared to high neighbourhood SES. This result is in line with a study by Carson et al(64). Neighbourhood safety, as suggested by Carson et al, may be one possible explanation for this finding. In addition, the lack of suitable and well-maintained recreation facilities could lead to more ST as replacement of other leisure time activities. In contrast to our results, many studies investigating neighbourhood SES and its association with sedentary behaviour reported null results as shown in a recent review by Stierlin et al., suggesting that other factors may be more important than neighbourhood SES in the context of adolescents' sedentary behaviour(30). Possible reasons for these differences between findings may be related to different study populations across individual studies but also the fact that our study only focussed on ST instead of total sedentary behaviour. Screen viewing as a health behaviour has not been investigated widely in the context of individual and neighbourhood SES, but it appears that in Berlin it is more closely linked with these factors than PA. Hence, promoting alternative activity opportunities for adolescents living in lower SES neighbourhoods could be a worthwhile target for interventions. In the context of the existing literature it would be useful to also investigate total sedentary behaviour in future German studies.

In addition to individual and neighbourhood SES, school level factors play a role in the health behaviour of school children(65). Moore et al found that school level affluence was independently associated with health behaviours (except physical activity) of the school students after adjusting for the individual SES(66). When additionally including school type and school neighbourhood SES as covariates in our analysis, presented results for PA and ST were attenuated somewhat, indicating the potentially important role of school type and school neighbourhood SES on PA and ST. A possible explanation for this finding could be that adolescents living in areas with lower neighbourhood SES are more often attending an integrated secondary school. Since the academic standards of integrated secondary schools tend to be lower than those of high schools, it is possible that students of the first-mentioned have more leisure time than those of the latter(67,68).

Some studies found that the school socioeconomic environment i.e. social networks and peer influences had a greater effect on health behaviour among adolescents than the individual SES(66,69). This illustrates the complex interplay of individual SES, neighbourhood SES, and the school environment (school type and school neighbourhood SES), that may also be affected by parental choice of schools and other parental influences on school activities(70). A recent study from the UK has provided some further evidence for these complex relationships(66). Studies from Germany have also shown that the neighbourhood SES as well as the SES of the students tends to be correlated with the school type(71). Better educated parents tend to send their children to high schools rather than integrated secondary schools(72), which could imply that it is not only the school type itself influencing PA and ST, but the social environment of the student. But even if the choice of the school type is done by the parents and is influenced by their SES, targeting integrated secondary schools may be important and could be emphasized more in health promotion activities. It appears that this may help to address the issue of individual SES on the one hand (more children with low SES in secondary schools) but also neighbourhood SES on the other hand. Further research is needed to disentangle these complex relationships between individual and neighbourhood SES, as well as school environment. With additional research it could be investigated if some neighbourhoods might benefit more from screen time related activities, while others might benefit more from PA related activities. The aim should be the ability to target

the content of health promotion activities according to school type and neighbourhood to meet greatest needs.

In addition to individual and neighbourhood SES, other factors like the built environment (i.e. number of public transport stops, residential density, intersection density and the number of parks) could also play an important role in adolescents' health behaviours(73). These factors may be mediators of the observed associations but studies have also suggested that associations may be moderated by the built environment (studies have shown that individuals with low neighbourhood SES had a greater benefit of a good walkability than those with a high neighbourhood SES)(31,32). Future research should therefore also include measurements of the built environment in Berlin to provide new insights into the associations with PA.

Strengths and limitations

Strengths of our study include the size of our sample, as well as the proportion of students with migration background, socioeconomic status and gender distribution, which appear to be very similar to the student population of Berlin(74). However, the results are only valid for regions with similar characteristics as Berlin: an urban well-connected region with relatively safe neighbourhoods and good infrastructure for transportation and cycling.

Some limitations have to be considered as well. First, FAS was only assessed at the 24 month follow up. However, we assessed one item of the FAS (holiday) additionally at baseline and at the 12 month follow-up. The answers were quite similar over the two years. We thus think the period of two years implicates only minimal changes in the FAS level. We also found differences in the self-report FAS of boys and girls, which is somewhat surprising. It is possible that the structure of the questionnaire led to an overestimation among boys due to a higher interest in cars and computers (i.e. two key elements of the FAS). Second, anthropometric data and PA were not measured objectively. Self-report of children and adolescents, especially regarding PA, may lead to biased results through misreporting(75). Measurement errors associated with self-report may further be influenced by SES of adolescents(76). Future studies should use accelerometers or other means to objectively measure PA and sedentary behaviour(77). Another limitation of our study is that we did not assess total sedentary behaviour and

that ST was determined based on the use of TV, Computer and video games as assessed by the HBSC questionnaire(35,78). Other increasingly popular screen devices (e.g. smartphones, tablets) and other kinds of sedentary behaviours like sitting during homework, talking on the phone and sitting at school were not taken into account, which may have led to an underestimation of ST.

CONCLUSION

Lower individual SES was only associated with higher ST but not with PA, whereas lower neighbourhood SES was associated with higher PA and higher ST. After consideration of the school environment (school type and schools neighbourhood SES) the effect of neighbourhood SES on PA and ST was attenuated somewhat, suggesting an important role in the complex relationship between individual SES, neighbourhood SES and school environment. Further research is warranted to unravel these relationships and to develop more targeted health promotion strategies in the future.

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CONTRIBUTORS

LK and FMR drafted the manuscript with intellectual input from SR, NR, JMN, and NSB. FMR supervised the study and LK carried out the data collection and parts of the data analysis. FL and SR were responsible for data assessment and statistical analyses, FMR, CB, NR, JMN and NSB were responsible for the design of the recruitment methods and the assessment tools, FMR, NR, JMN, and SW conceptualized the study. All authors read and approved the final manuscript.

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COMPETING INTERESTS

None declared.

ETHICS APPROVEL

The study was approved by the ethical review committee of the Charité-Universitätsmedizin Berlin, Germany.

DATA SHARING STATEMENT

No additional data available.

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Figures

Figure 1. Flowchart of the recruitment process

Figure 2. Multivariable analysis of physical activity associated factors among 12 and 13 years old students (complete case analysis, n=1523)

Figure 3. Multivariable analysis of screen time associated factors among 12 and 13 years old students (complete case analysis, n=1523)

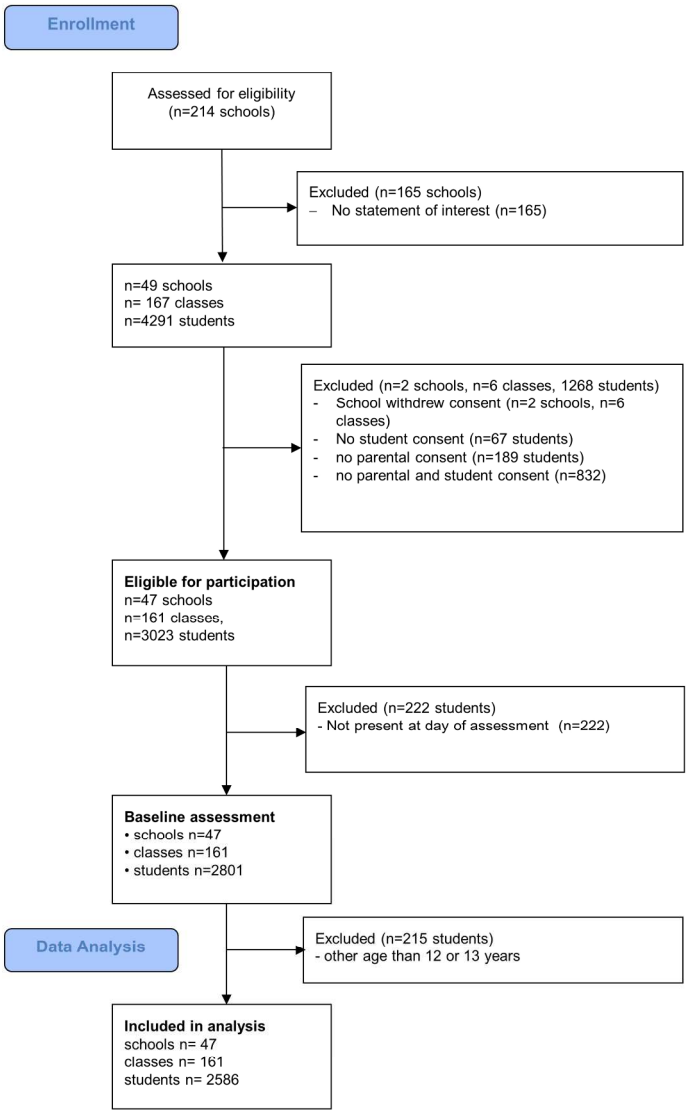
Supplementary files

Supplementary table 1. Multivariable analysis of physical activity associated factors among 12 and 13 years old students (complete case analysis, n=1523)

Supplementary table 2. Multivariable analysis of screen time associated factors among 12 and 13 years old students (complete case analysis, n=1523)

Supplementary table 3. Multivariable analysis of physical activity associated factors among 12 and 13 years old students (unequal sample sizes)

Supplementary table 4. Multivariable analysis of screen time associated factors among 12 and 13 years old students (unequal sample sizes)



Flowchart of the recruitment process

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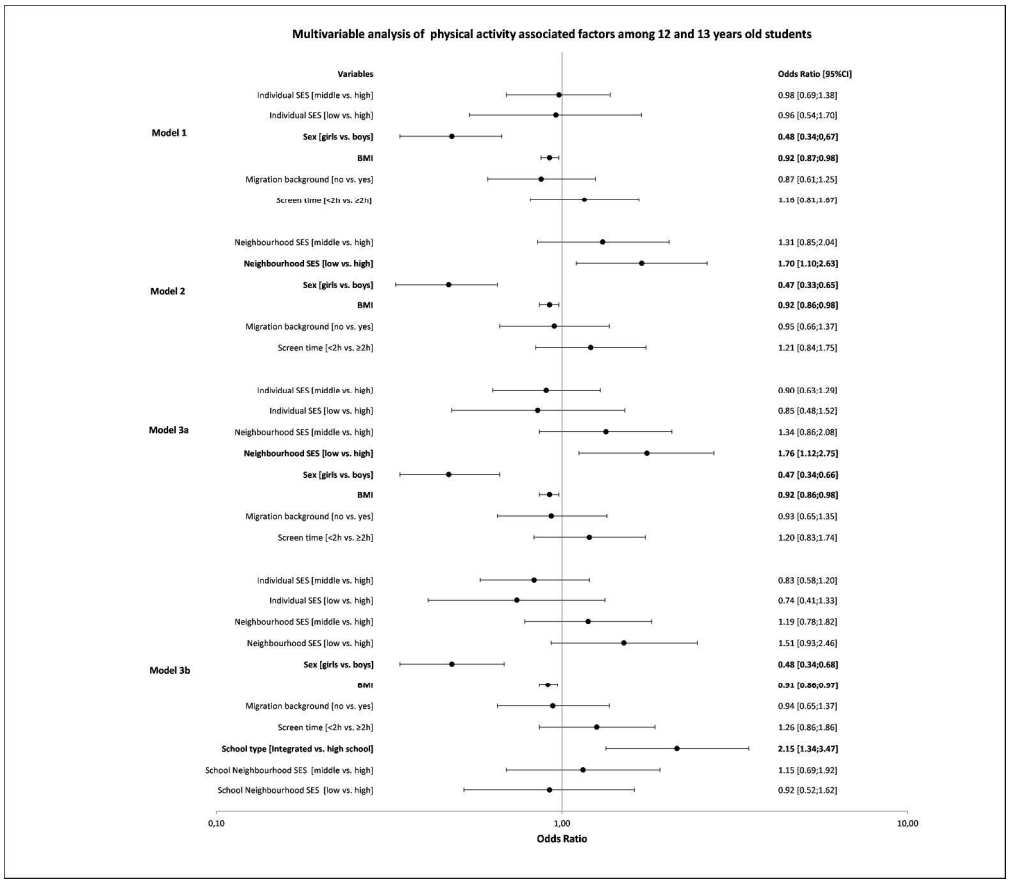
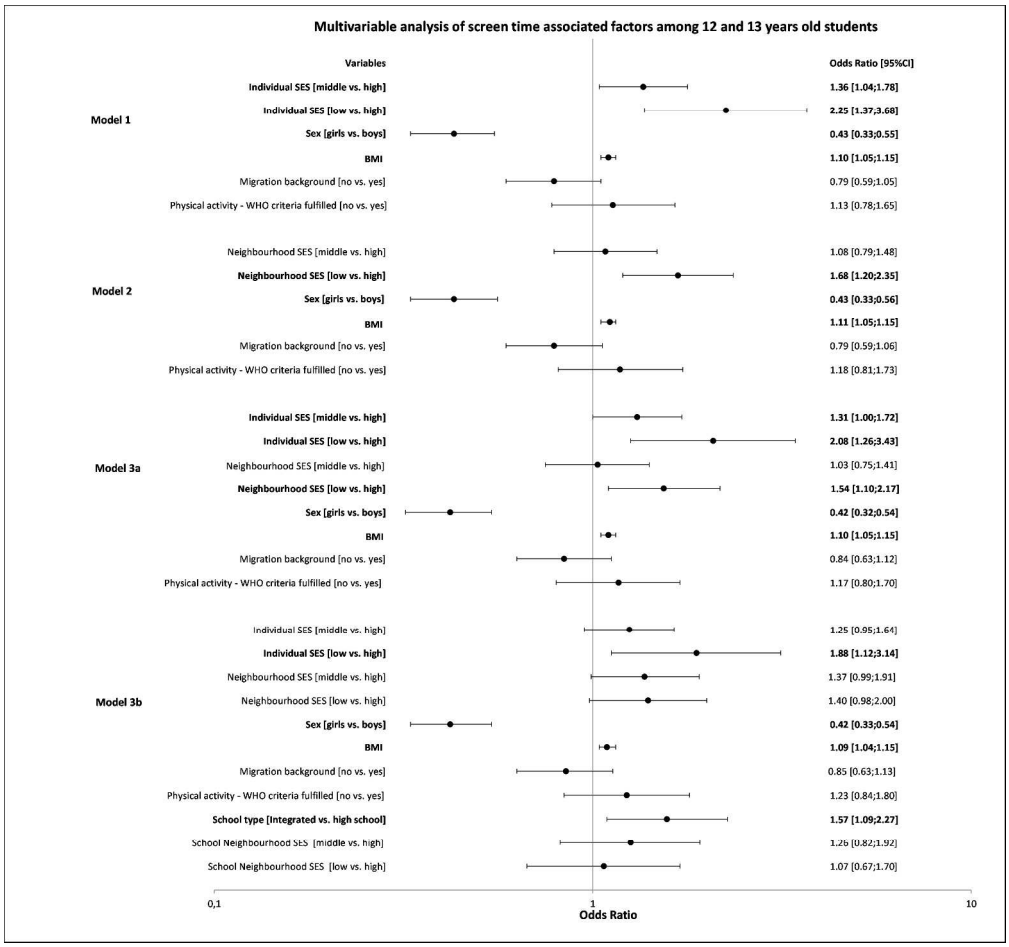


Multivariable analysis of physical activity associated factors among 12 and 13 years old students (complete case analysis, n=1523)

380x331mm (300 x 300 DPI)



Multivariable analysis of screen time associated factors among 12 and 13 years old stu-dents (complete case analysis, n=1523)

333x312mm (300 x 300 DPI)

Supplementary table 1: Multivariable analysis of physical activity associated factors among 12 and 13 years old students

WHO criteria for physical activity (at least 60 minutes per day physically active) fulfilled:								
	Model 1*		Model 2**		Model 3***			
					Model 3a		Model 3b	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Individual socioeconomic status (FAS)		0.984	-	-		0.792		0.476
High	1		-	-	1		1	
Middle	0.98 (0.69; 1.38)		-	-	0.90 (0.63;1.29)		0.83 (0.58; 1.20)	
Low	0.96 (0.54; 1.70)		-	-	0.85 (0.48; 1.52)		0.74 (0.41; 1.33)	
Students' neighbourhood SES	-	-	-	**0.058**		**0.047**		0.253
High (rank 1-2)	-	-	1		1		1	
Middle (rank 3-4)	-	-	1.31 (0.85;2.04)		1.34 (0.86; 2.08)		1.19 (0.78; 1.82)	
Low (rank 5-7)	-	-	1.70 (1.10;2.63)		1.76 (1.12; 2.75)		1.51 (0.93; 2.46)	
Sex		**<0.001**		**<0.001**		**<0.001**		**<0.001**
Boys	1		1		1		1	
Girls	0.48 (0.34; 0.67)		0.47 (0.33;0.65)		0.47 (0.34; 0.66)		0.48 (0.34; 0.68)	
BMI	0.92 (0.87; 0.98)	**0.007**	0.92 (0.86;0.98)	**0.005**	0.92 (0.86; 0.98)	**0.006**	0.91 (0.86; 0.97)	**0.003**
Migration background		0.457		0.786		0.716		0.761
yes	1		1		1		1	
no	0.87 (0.61; 1.25)		0.95 (0.66;1.37)		0.93 (0.65; 1.35)		0.94 (0.65; 1.37)	
Screen time		0.429		0.311	-	0.334		0.233
≥2 hours	1		1		1		1	
<2 hours	1.16 (0.81; 1.67)		1.21 (0.84;1.75)		1.20 (0.83; 1.74)		1.26 (0.86; 1.86)	
School type	-	-	-	-	-			**0.002**
High School	-	-	-	-	-		1	
Integrated Secondary School	-	-	-	-	-		2.15 (1.34; 3.47)	
Schools' neighbourhood SES	-	-	-	-	-			0.723
High (rank 1-2)	-	-	-	-	-		1	
Middle (rank 3-4)	-	-	-	-	-		1.15 (0.69; 1.92)	
Low (rank 5-7)	-	-	-	-	-		0.92 (0.52; 1.62)	

Complete case analysis (n=1523)

***Model 1:** individual socioeconomic status (FAS) adjusted for Sex, BMI, migration background, screen time

****Model 2:** students' neighbourhood SES (3 categories) adjusted for Sex, BMI, migration background, screen time

*****Model 3 (Model 3a:** Model 1+2, **Model 3b:** Model 1+2+School type+Schools' neighbourhood SES

Supplementary table 2: Multivariable analysis of screen time associated factors among 12 and 13 years old students

	High screen time (>2 hours per day)							
	Model 1*		Model 2**		Model 3***			
					Model 3a		Model 3b	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Individual SES (FAS)		**0.002**	**-**	**-**		**0.008**		**0.036**
High	1		-	-	1		1	
Middle	1.36 (1.04; 1.78)		-	-	1.31 (1.00; 1.72)		1.25 (0.95; 1.64)	
Low	2.25 (1.37; 3.68)		-	-	2.08 (1.26; 3.43)		1.88 (1.12; 3.14)	
Students' neighbourhood SES	-	**-**		**0.005**		**0.019**		0.109
High (rank 1-2)	-	**-**	1		1		**1**	
Middle (rank 3-4)	-	**-**	1.08 (0.79;1.48)		1.03 (0.75; 1.41)		1.37 (0.99; 1.91)	
Low (rank 5-7)	-	**-**	1.68 (1.20;2.35)		1.54 (1.10; 2.17)		1.40 (0.98; 2.00)	
Sex		**<0.001**				**<0.001**		**<0.001**
Boys	1		1	**<0.001**	1		1	
Girls	0.43 (0.33; 0.55)		0.43 (0.33;0.56)		0.42 (0.32; 0.54)		0.42 (0.33; 0.54)	
BMI	1.10 (1.05; 1.15)	**<0.001**	1.11 (1.05;1.15)	**<0.001**	1.10 (1.05; 1.15)	**<0.001**	1.09 (1.04; 1.15)	**<0.001**
Migration background		**0.102**		0.117		0.238		0.262
yes	1		1		1		1	
no	0.79 (0.59; 1.05)		0.79 (0.59;1.06)		0.84 (0.63; 1.12)		0.85 (0.63; 1.13)	
Physical activity (PA) (WHO criteria fulfilled)		0.523		0.389		0.430		0.297
Yes	1		1		1		1	
No	1.13 (0.78; 1.65)		1.18 (0.81;1.73)		1.17 (0.80; 1.70)		1.23 (0.84; 1.80)	
School type			-	-	-	**-**		**0.016**
High School			-	-	-	**-**	**1**	
Integrated Secondary School			-	-	-	-	1.57 (1.09; 2.27)	
Schools' neighbourhood SES			-	-	-	-		0.535
High (rank 1-2)			-	-	-	**-**	**1**	
Middle (rank 3-4)			-	-	-	**-**	1.26 (0.82; 1.92)	
Low (rank 5-7)			-	-	-	**-**	1.07 (0.67; 1.70)	

Complete case analysis (n=1523)

***Model 1:** individual socioeconomic status (FAS) adjusted for Sex, BMI, migration background, PA

****Model 2:** students' neighbourhood SES (3 categories) adjusted for Sex, BMI, migration background, PA

*****Model 3 (Model 3a:** Model 1+2, **Model 3b:** Model 1+2+ School type + Schools' neighbourhood SES)

Supplementary table 3: Multivariable analysis of physical activity associated factors among 12 and 13 years old students

WHO criteria for physical activity (at least 60 minutes per day physically active) fulfilled:								
	Model 1*		**Model 2****		**Model 3*****			
	(n=1760)		(n=1818)		**Model 3a** (n=1547)		**Model 3b (n**=1523)	
	OR (95% CI)	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Individual socioeconomic status (FAS)		0.940	-	-		0.763		0.476
High	1		-	-	1		1	
Middle	0.95 (0.69; 1.31)		-	-	0.89 (0.62; 1.26)		0.83 (0.58; 1.20)	
Low	1.01 (0.60; 1.69)		-	-	0.87 (0.50; 1.54)		0.74 (0.41; 1.33)	
Students' neighbourhood SES	-	-	-	**0.028**		0.079		0.253
High (rank 1-2)	-	-	1		1		1	
Middle (rank 3-4)	-	-	1.24 (0.84;1.84)		1.27 (0.85; 1.88)		1.19 (0.78; 1.82)	
Low (rank 5-7)	-	-	1.67 (1.14;2.44)		1.65 (1.07; 2.56)		1.51 (0.93; 2.46)	
Sex		**<0.001**		**<0.001**		**<0.001**		**<0.001**
Boys	1		1		1		1	
Girls	0.51 (0.38; 0.69)		0.48 (0.36;0.65)		0.48 (0.35; 0.67)		0.48 (0.34; 0.68)	
BMI	0.90 (0.85; 0.95)	**<0.001**	0.92 (0.87;0.97)	**0.002**	0.92 (0.87; 0.98)	**0.006**	0.91 (0.86; 0.97)	**0.003**
Migration background		0.844		0.957		0.588		0.761
yes	1		1		1		1	
no	0.97 (0.69; 1.36)		0.99 (0.72;1.36)		0.91 (0.63; 1.30)		0.94 (0.65; 1.37)	
Screen time		0.734		0.165	-	0.425		0.233
≥2 hours	1		1		1		1	
<2 hours	1.06 (0.76; 1.49)		1.26 (0.91;1.74)		1.16 (0.81; 1.67)		1.26 (0.86; 1.86)	
School type	-	-	-	-	-			**0.002**
High School	-	-	-	-	-		1	
Integrated Secondary School	-	-	-	-	-		2.15 (1.34; 3.47)	
Schools' neighbourhood SES	-	-	-	-	-			0.723
High (rank 1-2)	-	-	-	-	-		1	
Middle (rank 3-4)	-	-	-	-	-		1.15 (0.69; 1.92)	
Low (rank 5-7)	-	-	-	-	-		0.92 (0.52; 1.62)	

***Model 1:** individual socioeconomic status (FAS) adjusted for Sex, BMI, migration background, screen time

****Model 2:** students' neighbourhood SES (3 categories) adjusted for Sex, BMI, migration background, screen time

*****Model 3 (Model 3a:** Model 1+2, **Model 3b:** Model 1+2+School type+Schools'neighbourhood SES

Supplementary table 4: Multivariable analysis of screen time associated factors among 12 and 13 years old students

	High screen time (>2 hours per day)							
	Model 1*		**Model 2****		**Model 3*****			
	(n=1760)		(n=1818)		**Model 3a** (n=1547)		**Model 3b** (n=1523)	
	OR (95% CI)	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Individual SES (FAS)		**0.004**	-	-		**0.007**		**0.036**
High	1		-	-	1		1	
Middle	1.28 (1.00; 1.64)		-	-	1.32 (1.01; 1.73)		1.25 (0.95; 1.64)	
Low	2.03 (1.30; 3.15)		-	-	2.09 (1.27; 3.45)		1.88 (1.12; 3.14)	
Students' neighbourhood SES	-	-		**0.002**		**0.019**		0.109
High (rank 1-2)	-	-	1		1		**1**	
Middle (rank 3-4)	-	-	1.07 (0.80;1.44)		1.49 (1.08; 2.05)		1.37 (0.99; 1.91)	
Low (rank 5-7)	-	-	1.68 (1.22;2.29)		1.55 (1.10; 2.17)		1.40 (0.98; 2.00)	
Sex		**<0.001**				**<0.001**		**<0.001**
Boys	1		1	**<0.001**	1		1	
Girls	0.46 (0.37; 0.59)		0.45 (0.35;0.56)		0.42 (0.32; 0.54)		0.42 (0.33; 0.54)	
BMI	1.09 (1.05; 1.14)	**<0.001**	1.08 (1.04;1.13)	**<0.001**	1.09 (1.04; 1.14)	**<0.001**	1.09 (1.04; 1.15)	**<0.001**
Migration background		**0.035**		0.223		0.267		0.262
yes	1		1		1		1	
no	0.75 (0.57; 0.98)		0.85 (0.65;1.11)		0.85 (0.63; 1.14)		0.85 (0.63; 1.13)	
Physical activity (PA) (WHO criteria fulfilled)		0.738		0.189		0.510		0.297
Yes	1		1		1		1	
No	1.06 (0.75; 1.50)		1.25 (0.90;1.74)		1.14 (0.78; 1.66)		1.23 (0.84; 1.80)	
School type			-	-	-	-		**0.016**
High School			-	-	-	-	**1**	
Integrated Secondary School			-	-	-	-	1.57 (1.09; 2.27)	
Schools' neighbourhood SES			-	-	-	-		0.535
High (rank 1-2)			-	-	-	-	**1**	
Middle (rank 3-4)			-	-	-	-	1.26 (0.82; 1.92)	
Low (rank 5-7)			-	-	-	-	1.07 (0.67; 1.70)	

***Model 1:** individual socioeconomic status (FAS) adjusted for Sex, BMI, migration background, PA
****Model 2:** students' neighbourhood SES (3 categories) adjusted for Sex, BMI, migration background, PA
*****Model 3 (Model 3a:** Model 1+2, **Model 3b:** Model 1+2+ School type + Schools' neighbourhood SES)

STROBE (Strengthening The Reporting of OBservational Studies in Epidemiology) Checklist

A checklist of items that should be included in reports of observational studies. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Section and Item	Item No.	Recommendation	Reported on Page No.
Title and Abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/Rationale	2	Explain the scientific background and rationale for the investigation being reported	1
Objectives	3	State specific objectives, including any prespecified hypotheses	2
Methods			
Study Design	4	Present key elements of study design early in the paper	2
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2-3
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	2-3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3-5

Section and Item	Item No.	Recommendation	Reported on Page No.
Data Sources/ Measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3-5
Bias	9	Describe any efforts to address potential sources of bias	15
Study Size	10	Explain how the study size was arrived at	2
Quantitative Variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical Methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5-6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	7
Descriptive Data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-10
		(b) Indicate number of participants with missing data for each variable of interest	7-10
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome Data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	7-10

Section and Item	Item No.	Recommendation	Reported on Page No.
Main Results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other Analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	5-6
Discussion			
Key Results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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BMJ Open

Association of individual and neighbourhood socioeconomic status with physical activity and screen time in 7th grade boys and girls in Berlin, Germany – a cross sectional study.

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Association of individual and neighbourhood socioeconomic status with physical activity and screen time in 7th grade boys and girls in Berlin, Germany – a cross sectional study.

Lilian Krist[1], Christin Bürger[1], Nanette Ströbele-Benschop[2], Stephanie Roll[1], Fabian Lotz[1], Nina Rieckmann[3], Jacqueline Müller-Nordhorn[3], Stefan N. Willich[1], Falk Müller-Riemenschneider[1,4]

1. *Institute for Social Medicine, Epidemiology and Health Economics, Charité - Universitätsmedizin Berlin, Germany*
2. *Institute of Nutritional Medicine, University of Hohenheim, Germany*
3. *Institute of Public Health, Charité-Universitätsmedizin Berlin, Germany*
4. *Saw Swee Hock School of Public Health, National University of Singapore*

Corresponding author:

Dr. Lilian Krist
Institute for Social Medicine, Epidemiology and Health Economics
Charité - Universitätsmedizin Berlin
Luisenstr. 57
10117 Berlin, Germany
E-Mail: lilian.krist@charite.de
Tel: +49 30 450 529 109

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ABSTRACT

Objectives Few studies have explored the impact of neighbourhood socioeconomic status (SES) on health behaviours in youths in Germany. Our aim was to investigate the association of individual and neighbourhood SES with physical activity (PA) and screen time (ST) in 12-13 year old students in Berlin.

Design Cross-sectional study.

Setting Secondary schools (high schools and integrated secondary schools) in Berlin, Germany.

Participants A total of 2586 students aged 12-13 years (7^{th} grade).

Main outcome measures Sociodemographics, anthropometric data and health behaviours were assessed by self-report during classes. Primary outcome was the association of individual and neighbourhood SES with meeting daily PA and exceeding daily ST recommendations. Students' characteristics were described with means or percentages. Comparisons were performed using Generalized Linear Mixed Model yielding odds ratios (OR) with 95% confidence intervals.

Results Mean(±SD) age was 12.5±0.5 years, 50.5% were girls, and 34.1% had a migrant background. When adjusting for individual covariates, associations of low versus high individual SES were 0.85 [0.48;1.52] for PA and 2.08 [1.26;3.43] for ST. Associations of low versus high neighbourhood SES were 1.76 [1.12;2.75] for PA and 1.54 [1.10;2.17] for ST. After additional adjustment for school type and school neighbourhood SES, associations comparing low versus high individual and neighbourhood SES were attenuated for PA (individual SES 0.74 [0.41;1.33] and neighbourhood SES 1.51 [0.93;2.46]) and ST (individual SES 1.88 [1.12;3.14] and neighbourhood SES 1.40 [0.98;2.00].

Conclusions

Lower individual and neighbourhood SES was associated with higher ST. Lower neighbourhood but not individual SES was associated with higher PA. After consideration of school type and school neighbourhood SES associations were attenuated and became insignificant for the relationship between neighbourhood SES, PA and ST. Further research is warranted to unravel the complex relationships between individual SES, neighbourhood SES and school environment to develop more targeted health promotion strategies in the future.

Strengths and limitations of the study

- This study provides important new insights into the association of individual and neighbourhood socioeconomic status with physical activity and screen time among 7th grade boys and girls attending secondary schools in Berlin, Germany.
- The study comprises a large sample with students recruited from all 12 districts of Berlin, including a variety of neighbourhoods with different levels of socioeconomic status.
- Physical activity was not assessed objectively but via self-report and only ST was assessed, while other types of sedentary behaviours were not taken into account.

INTRODUCTION

Physical activity as well as sedentary behaviour have an important impact on health and wellbeing(1). Low levels of PA are associated with higher health risks already among children and adolescents(2) and an increasing number of studies have identified sedentary behaviour as an independent risk factor for diseases such as diabetes and obesity in children and adolescents(3).

In the last decades however, sedentary behaviour among children and adolescents is increasing while the rates of children being active appear to be decreasing over time(4–7). In addition, longitudinal studies have shown a decline in PA and at the same time an increase in sedentary behaviour among children and adolescents with increasing age(8–10). ST (time spent watching TV or playing games on the computer or playing video games) is one important aspect of sedentary behaviour, even though it does not encompass the total time spent being sedentary(11).

While there is evidence of an association of age and sex with PA(12), studies exploring the influence of socioeconomic status and built and social environment of children show heterogeneous results(13–16).

A low individual SES is often associated with a higher BMI and more sedentary time, but not always with low PA(17–19). In addition to individual SES, studies investigating the social environment (i.e. social support and social networks, socioeconomic position and income inequality, racial discrimination, social cohesion and social capital) of children found evidence of an association with PA and diet(20–22). The built environment has also been shown to be associated with PA among children and youth(23).

Another aspect of the social environment is the neighbourhood socioeconomic status. Studies investigating the influence of neighbourhood SES on health showed an association of disadvantaged neighbourhoods with worse health status(24) or a higher risk for cardiovascular diseases(25). Mechanisms through which a lower neighbourhood socioeconomic status may influence PA and sedentary behaviour could be reduced municipal services such as recreational facilities and playgrounds, financial stress or less possibilities to own a gym membership(22). Also a higher crime rate may lead to less activities outside(26). With regard to these associations between PA, sedentary behaviour and the neighbourhood SES, study results are heterogeneous ranging from no association to a clear association

(27–30). Other studies in turn found that the neighbourhood SES was only a positive modifier for the association of environmental factors with PA and sedentary behaviour(31,32). Knowing more about independent associations of individual and neighbourhood SES could help to address groups of adolescents in a more targeted way when implementing prevention strategies (e.g. adapting the content of health promotion strategies to different neighbourhoods).

Our aim was therefore to investigate the association of individual and neighbourhood socioeconomic status with PA and ST as one important form of sedentary behaviour in a population based sample of 12 to 13 year old boys and girls attending secondary schools in Berlin, Germany.

METHODS

Study design and setting

The present cross-sectional analysis is part of the BEST-prevention study, a three armed cluster randomized controlled trial that was conducted from 2010 to 2014 (baseline assessment was conducted from 2010 to 2011) with the aim to evaluate a parent involving smoking prevention program for 7th grade students in Berlin(33). Here, we report cross-sectional data regarding PA and ST among the students at baseline including associations with individual and neighbourhood socioeconomic status.

Participants and Recruitment

Details of the recruitment are described elsewhere(34). Briefly, prior to recruitment, permission of the Berlin senate of education, youth and research (Senatsverwaltung für Bildung, Jugend und Wissenschaft) was obtained, and school principals and contact teachers from all 12 districts of Berlin were informed about the project. Students were eligible for the study if they: i) were in the 7th grade, ii) attended one of the participating schools, and iii) showed intellectual and physical ability to make an informed decision about study participation. Separate signed written informed consent was required from participating students as well as from at least one parent/caregiver. The study was approved by the ethical review committee of the Charité-Universitätsmedizin Berlin, Germany.

Measurements

The study questionnaire is based on existing and validated questionnaires investigating adolescent health behaviour (e.g. Health Behaviour in School Aged Children, HBSC(35); German Children and Youths Survey, KIGGS(36)). It includes questions related to socio-demographics, smoking and other health behaviours, such as alcohol consumption, nutrition, PA and ST, as well as height and weight. It took about 30-40 minutes to complete the questionnaire. Our study group has the status of an associated project of the HBSC.

During a first visit to schools, the BEST study was presented to the students by trained research personnel and consent forms were distributed for students and parents/caregivers. During the second visit, which took place a few weeks later, baseline data were assessed with the questionnaire in the classroom among children, who had provided both consent forms.

Outcome measures

Physical activity (PA)

PA was assessed using two adapted items of the HBSC questionnaire. The first question read: 'On how many days in the past week were you physically active for at least 60 minutes?' According to the WHO guidelines, for our primary outcome we defined a student as meeting current guidelines if he or she was active at least 60 minutes on each of the last seven days (yes/no)(37). The other question asked for the number of hours of moderate intensity PA per week ('How many hours per week are you physically active (any activity that increases your heart rate and makes you get out of breath)?') with examples of such activities. This number was divided by seven to obtain the number of hours of PA per day.

Screen time (ST)

ST was assessed with two questions (also part of the HBSC questionnaire) asking for the time spent each day watching TV or playing with the Computer. TV time was assessed by asking 'How many hours/day do you usually watch television in your free time?' for weekdays and weekend days separately. Computer time (minutes/day) was assessed by asking 'How many hours/day do you usually

play games on a computer, or use a game console in your leisure time?'. Total ST was computed by adding up TV and computer time. Using a smartphone or tablet was not assessed. According to the AAP(38) recommendations we defined more than 2 hours of ST per day as high ST.

Covariates

Individual level

Sex, age and anthropometric data (height and weight) of the students were assessed via self-report. The BMI was calculated using the self-reported data. BMI categories are presented using cut-offs defined by the specific percentiles which at age 18 years correspond to the adult cut-off points for underweight (<18.5kg/m^2), overweight (25kg/m^2) and obesity (30kg/m^2). According to that definition, underweight is defined as a BMI <10^{th} percentile, normal weight as a BMI between the 10^{th} and the 90^{th} percentile, overweight as a BMI between the 90^{th} and the 97^{th} percentile and obesity as a BMI ≥97^{th} percentile(39,40).

According to official definitions a student was defined as having a migration background if he or she was not born in Germany or if at least one parent was not born in Germany but moved to Germany after 1949(41).

Individual socioeconomic status

To assess the individual socioeconomic status (SES) of the student, we used the family affluence scale (FAS), a validated instrument to assess the material affluence of the family asking for the number of cars and computers in the family, for holidays during the past 12 months, and whether the child has its own room(42). The FAS consists of values from zero to seven, with higher values indicating higher affluence, and can be categorized into three categories (low (0-3), moderate (4-5), and high affluence (6-7)). The FAS was completely assessed only at the 24 months follow-up, we therefore used the 24 months follow-up FAS to describe family SES at baseline.

Neighbourhood socioeconomic status

For the SES of the students' neighbourhood, we used the social index defined and implemented by the 'Atlas of Social Structure' (Sozialstukturatlas). It is an instrument used in Berlin to describe the social situation of Berlin by classifying 447 sub-areas (with on average 7500 habitants) of the 12 districts of Berlin accordingly(43,44). This social index reflects the distribution of social and health burden in Berlin. Social and health indicators are e.g. unemployment, welfare reception rate, average per capita income and also premature mortality and avoidable deaths. The index ranges from 1 reflecting the best to 7 reflecting the worst social situation of a district.

School types

In Berlin, two types of secondary schools exist: high schools with the possibility to achieve a high-school diploma after 12 years, as well as integrated secondary schools (an integration of different school types) with the possibility to achieve a high-school diploma after 13 years. More often than high schools, integrated secondary schools are left by the students after the 10^{th} grade with a secondary school leaving certificate. The academic requirements are higher in high schools than in integrated secondary schools(45).

School neighbourhood socioeconomic status

Since the neighbourhood of the school can be different to that of students, we assessed this information (analogous to the individual neighbourhood SES) in order to take an additional influencing factor of the students' behaviour into account.

Statistical analysis

All statistical analyses were performed for the 12 and 13 year old students due to the small number of students younger than 12 and older than 13 years (8.1%). We used all data available for the respective analysis; missing data were not imputed.

Characteristics of schools and students were analysed by descriptive statistical methods (e.g. mean and standard deviation (SD), frequencies and percentages; p-values are derived from t-tests and chi-square-tests).

Because of the nested structure of the data with both fixed and random effects, a generalized linear mixed model (GLMM) with a logit link function was used for the analysis when comparing groups (models with random intercept). In general, the random factors 'school' and 'class within school' (as nested factor) were included into the models, with either PA or ST as the dependent variable. Results are presented as odds ratios (OR) and 95%-confidence intervals (CI).

These models were used to determine the association of several factors. For PA as the dependent variable, sex, migration background, BMI and ST were included into all models, in addition with individual socioeconomic status (FAS-score) (Model 1) or students' neighbourhood SES (Model 2) or both (Model 3a). A final model included the aforementioned plus the two school level variables school type and school neighbourhood (Model 3b). The same procedure was performed for ST as the dependent variable, respectively. To be able to compare different models, the analyses were restricted to the number of students with non-missing data for the model with the largest number of variables included. As sensitivity analyses, to assess if associations are modified by gender, interaction effects on gender were included into the models. Additional sensitivity analyses were performed based on the maximum number of students with non-missing data for the respective model. All p-values are considered exploratory (with no adjustment for multiple testing). Analyses were performed using the software package SAS release 9.3 and 9.4 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Characteristics of the study population

Out of 214 contacted schools, 49 schools (23%; 4291 students) showed interest and were eligible for study participation. Before baseline assessment, 1268 out of these 4291 students dropped out including two entire schools. 2801 students participated at the baseline assessment. Out of those, we included 2586 students aged 12 and 13 years in our descriptive analyses and 1523 in our complete case analyses. Figure 1 shows the recruitment process of the schools, classes and students.

Sociodemographic characteristics of all participating students are presented in Table 1a. The mean (±SD) age of participants was 12.4 ± 0.5 years (12.5 ± 0.5 for boys and 12.4 ± 0.5 for girls) and the distribution between girls and boys was similar (50.5% vs. 49.5%). Of the entire sample, 34.1% were

defined as having a migrant background. Boys reported more often a high individual SES than girls (53.7% vs. 46.3%). Mean neighbourhood SES was similar among boys and girls (4.0±1.9 and 4.1± 1.9). Individual and neighbourhood SES were moderately correlated (spearman's rank correlation coefficient =0.36; p<0.001). School characteristics are presented in Table 1b. An association between the students' neighbourhood SES and the school type could be observed, indicating that the mean students' neighbourhood SES was higher among high school students than integrated secondary school students.

Of the total sample, 12.8% fulfilled the WHO criteria of being active for at least 60 minutes per day. The proportion of boys fulfilling the criteria was higher than in girls (15.9% of the boys vs. 9.8% of the girls, OR 1.7 [1.4;2.2]; p<0.001) and boys also spent more time being active than girls (0.9±0.8 versus 0.6±0.6 hours per day, mean difference 0.3 hours [0.2;0.3], p<0.001). 81.5% of the boys and 66.9% of the girls reported more than 2 hours ST per day, OR 2.2 [1.8;2.6]; p<0.001. Average ST was also higher among boys than among girls (3.9±2.7 hours vs. 3.1±2.5 hours; p<0.001 on week days and 6.5±3.6 hours vs. 4.9±3.4 hours on weekend days.

Table 1a: Characteristics of the study sample

Individual level	Boys	Girls	Total	p-value
	Mean ± Standard Deviation (SD) or n (%)			
Number of students, n (%)	1279 (49.5)	1307 (50.5)	2586	
Age (years, mean ± SD) (n=2586)	12.5 ± 0.5	12.4 ± 0.5	12.4 ± 0.5	<0.001
12 years, n (%)	651 (50.9)	775 (59.3)	1426 (55.1)	<0.001
13 years, n (%)	628 (49.1)	532 (40.7)	1160 (44.9)	
Height (cm, mean ± SD) (n=2440)	161.1±9.5	160.1±7.3	160.6 ± 8.4	0.003
Weight (kg, mean ± SD) (n=2360)	49.5 ± 10.9	47.0 ± 8.9	48.3 ± 10.0	<0.001
BMI* (kg/m^2, mean ± SD) (n=2296)	18.9 ± 3.1	18.3 ± 2.7	18.6 ± 2.9	<0.001
BMI range	11.8 – 30.9	11.7 – 33.8	11.7 – 33.8	
Underweight (BMI <10^{th} percentile)**	126 (11.1)	218 (18.8)	344 (15.0)	<0.001
Normal weight (BMI 10^{th} - <90^{th} percentile)**	822 (72.2)	843 (72.6)	1665 (72.4)	
Overweight (BMI 90^{th} - <97^{th} percentile)**	166 (14.6)	90 (7.8)	256 (11.1)	
Obesity (BMI ≥97^{th} percentile)**	24 (2.1)	10 (0.9)	34 (1.5)	
Migrant background (n=2423)	396 (33.1)	429 (35.0)	825 (34.0)	0.307
Individual SES*** (family affluence scale; FAS) (n=2139)				
high (FAS 6-7)	569 (53.7)	500 (46.3)	1069 (50.0)	0.003
moderate (FAS 4-5)	371 (35.0)	441 (40.9)	812 (38.0)	
low (FAS 0-3)	120 (11.3)	138 (12.8)	258 (12.1)	
Students' neighbourhood SES (n=2240)	1114	1126	2240	
Mean±SD	4.0 ± 1.9	4.1 ± 1.9	4.0 ± 1.9	0.526
1 (best)	127 (11.4)	123 (10.9)	250 (11.2)	
2	182 (16.3)	194 (17.2)	376 (16.8)	
3	143 (12.8)	119 (10.6)	262 (11.7)	
4	215 (19.3)	229 (20.3)	444 (19.8)	
5	162 (14.5)	160 (14.2)	322 (14.4)	
6	134 (12.0)	134 (11.9)	268 (12.0)	
7 (worst)	151 (13.6)	167 (14.8)	318 (14.2)	
School type (n=2586)				
High School[a] students *(15 schools)*	507 (39.6)	624 (47.7)	1131 (43.7)	<0.001
Integrated Secondary School[b] students *(32 schools)*	772 (60.4)	683 (52.3)	1455 (56.3)	

(descriptive statistical methods)

*Body Mass Index (kg/m^2)

** BMI percentiles according to Cole et al. (46,47)

*** Socioeconomic Status

[a] High schools (5^{th} or 7^{th} grade to 12^{th} grade, graduation with high school diploma after 12^{th} grade)

[b] Integrated secondary schools (integration of different school types, 7^{th} grade to 13^{th} grade, graduation with secondary school leaving certificate after 10^{th} grade or high school diploma after 13^{th} grade)

Table 1b: Characteristics of schools

School level				
	High Schools[a]	Integrated Secondary Schools[b]	Total	
School neighbourhood SES, Mean±SD (n=47)	3.5±1.4	4.4±1.9	4.0±1.8	<0.001
n (%)				
1 (best)	1 (6.7)	3 (9.4)	4 (8.5)	
2	4 (26.7)	3 (9.4)	7 (14.9)	
3	2 (13.3)	4 (12.5)	6 (12.8)	
4	4 (26.7)	7 (21.9)	11 (23.4)	
5	2 (13.3)	4 (12.5)	6 (12.8)	
6	2 (13.3)	5 (15.6)	6 (12.8)	
7 (worst)	0 (0.0)	6 (18.8)	6 (12.8)	
Students' neighbourhood SES*, Mean±SD (n=2240)	3.1±1.6	4.6±1.9		<0.001
Individual SES* (family affluence scale; FAS) (n=2139)				
n (%)				
High (FAS 6-7)	744 (65.8)	531 (36.5)		<0.001
Moderate (FAS 4-5)	338 (29.9)	652 (44.8)		
Low (FAS 0-3)	49 (4.3)	272 (18.7)		

(descriptive statistical methods)

SES: Socioeconomic Status, SD: Standard deviation

[a]High schools (5th or 7th grade to 12th grade, graduation with high school diploma after 12th grade)

[b]Integrated secondary schools (integration of different school types, 7th grade to 13th grade, graduation with secondary school leaving certificate after 10th grade or high school diploma after 13th grade)

Association of individual and neighbourhood SES with PA and ST

Results of multivariable analyses are presented in figure 2 and figure 3. These results presented in figures 2 and 3 and in supplement table1 and supplement table 2 are based on an identical analysis population with complete information (n=1523). Results for the multivariable analysis not restricted to complete cases is additionally presented in supplement table 3 and supplement table 4. The results did not differ markedly between both approaches.

In multivariable analyses individual SES was not associated with PA. The ORs after adjustment for individual factors were 0.90 [0.63;1.29] and 0.85 [0.48;1.52]; p=0.792 for middle and low SES, respectively, compared to high SES. Additional adjustment for school type and school neighbourhood SES did not change the results notably (0.83 [0.58;1.20] and 0.74 [0.41;1.33]; p=0.476). ST in contrast was associated with individual SES. The lower the students' SES the higher the odds to spent more than two hours of ST per day (1.31 [1.00;1.72] and 2.08 [1.26;3.43]; p=0.008) for middle and low individual SES, respectively, compared to high SES. This association was attenuated slightly when additionally adjusting for school variables (1.25 [0.95;1.64] and 1.88 [1.12;3.14]; p=0.036).

In contrast to individual SES, a lower neighbourhood SES was associated with a higher odds of engaging in 60 minutes per day in PA (1.34 [0.86;2.08] and 1.76 [1.12;2.75]; p=0.047) for middle and low neighbourhood SES, respectively, compared to high neighbourhood SES after adjustment for individual factors; after adjustment for school variables, the association of neighbourhood SES with PA was attenuated somewhat and no longer independently associated (OR 1.19 [0.78;1.82] and 1.51 [0.93;2.46]; p=0.253).

Compared with high neighbourhood SES, students with low neighbourhood SES were more likely to spend more than two hours of ST per day (OR 1.54 [1.10;2.17]), while there was no association for students with middle neighbourhood SES (1.03 [0.75;1.41]; p=0.019). When additionally adjusting for school variables, neighbourhood SES was no longer independently associated with ST and the OR of middle and low neighbourhood SES, compared to high neighbourhood SES, became almost equal (1.37 [0.99;1.91] and 1.40 [0.98;2.00]; p=0.109). There was no interaction effect between gender and ST regarding PA, nor between gender and PA regarding ST (data not shown).

DISCUSSION

In this study we investigated the association of individual and neighbourhood SES with PA and ST among 7th grade school students. The individual SES of the students in our study sample, measured with the family affluence scale, was significantly associated with ST. Students with lower SES were more likely to spend more than 2 hours per day viewing screen devices. Compared to high SES, low SES was more strongly associated with ST than middle SES. Similar results were found in other stud-

ies(16,48,49). Potential reasons for these findings are that parents with better education and higher statuses may be more aware of the health consequences of excessive ST and thus have stricter rules regarding ST behaviour(50). Children from families with lower socioeconomic status may also more often have a TV in their room, which has been shown to be associated with higher ST levels(51). Moreover, it is well known that parents have an important role-modelling function, which influences children's behaviours, such as screen viewing(52). Since children of families with lower SES may more often have parents that engage in higher ST and/or watch more often TV together with their parents, they may in turn engage in more ST(53).

PA on the other hand was not associated with individual SES in our study population. This finding is in part consistent with the results of the HBSC study for Germany and with a few other studies(8,54,55). A possible explanation for this finding is that PA consists not only of organised sports or activities that require a club membership or sports equipment. On the contrary, a large part of PA among youths may be daily life activities, such as active commuting, or sports and activities in the neighbourhood and in parks which is independent from the individual SES(56). However, in contrast to our findings and the other studies, a variety of studies do show an association between socioeconomic status and PA, which has been highlighted in reviews by Sallis et al or Hanson et al(57,58). It should be noted that most of these studies are from the US or Australia and the explanations for the observed associations, such as the higher prevalence of unsafe neighbourhoods or of neighbourhoods with less green space may not be directly transferable to Germany and Berlin.

The other main aspect of our study was the investigation of the neighbourhood SES and its association with PA and ST. The neighbourhood SES represents the social and health indicators of a city or of its districts including unemployment rate, welfare reception rate, average per capita income and others. In our study, students living in low SES neighbourhood areas were more likely to be physically active than those with middle or high neighbourhood SES. To a certain extent this is surprising and in contrast to many earlier studies that have reported mostly no or inverse associations between neighbourhood SES and PA(28,59–62). However, as suggested in an earlier study the observed finding in our study may be related to higher active transportation among adolescents of families with lower SES because they may be less likely to own a car resulting in more students using the bicycle or public

transportation to school(63). Similar to individual SES, another explication could be that the major part of PA among adolescents consists of unstructured activities rather than organised team sports(56). Thus, a membership in a sports club (which is less probable in neighbourhoods with lower SES) would not affect the overall amount of PA.

Low and middle neighbourhood SES were also associated with higher ST compared to high neighbourhood SES. This result is in line with a study by Carson et al(64). Neighbourhood safety, as suggested by Carson et al, may be one possible explanation for this finding. In addition, the lack of suitable and well-maintained recreation facilities could lead to more ST as replacement of other leisure time activities. In contrast to our results, many studies investigating neighbourhood SES and its association with sedentary behaviour reported null results as shown in a recent review by Stierlin et al., suggesting that other factors may be more important than neighbourhood SES in the context of adolescents' sedentary behaviour(30). Possible reasons for these differences between findings may be related to different study populations across individual studies but also the fact that our study only focussed on ST instead of total sedentary behaviour. Screen viewing as a health behaviour has not been investigated widely in the context of individual and neighbourhood SES, but it appears that in Berlin it is more closely linked with these factors than PA. Hence, promoting alternative activity opportunities for adolescents living in lower SES neighbourhoods could be a worthwhile target for interventions. In the context of the existing literature, it would be useful to also investigate total sedentary behaviour in future German studies.

In addition to individual and neighbourhood SES, school level factors play a role in the health behaviour of school children(65). Moore et al found that school level affluence was independently associated with health behaviours (except physical activity) of the school students after adjusting for the individual SES(66). When additionally including school type and school neighbourhood SES as covariates in our analysis, presented results for PA and ST were attenuated somewhat and neighbourhood SES was no longer independently associated with PA and ST, indicating the potentially important role of school type and school neighbourhood SES on PA and ST.

A possible explanation for this finding could be that adolescents living in areas with lower neighbourhood SES are more often attending an integrated secondary school which has been shown in table 1b.

Since the academic standards of integrated secondary schools tend to be lower than those of high schools, it is possible that students of the first-mentioned have more leisure time than those of the latter(67,68).

Some studies found that the school socioeconomic environment i.e. social networks and peer influences had a greater effect on health behaviour among adolescents than the individual SES(66,69). This illustrates the complex interplay of individual SES, neighbourhood SES, and the school environment (school type and school neighbourhood SES), that may also be affected by parental choice of schools and other parental influences on school activities(70). A recent study from the UK has provided some further evidence for these complex relationships(66). Studies from Germany have also shown that the neighbourhood SES as well as the SES of the students tends to be correlated with the school type(71). Better educated parents tend to send their children to high schools rather than integrated secondary schools(72), which could imply that it is not only the school type itself influencing PA and ST, but the social environment of the student. But even if the choice of the school type is done by the parents and is influenced by their SES, targeting integrated secondary schools may be important and could be emphasized more in health promotion activities. It appears that this may help to address the issue of individual SES on the one hand (more children with low SES in secondary schools) but also neighbourhood SES on the other hand. Further research is needed to disentangle these complex relationships between individual and neighbourhood SES, as well as school environment. With additional research it could be investigated if some neighbourhoods might benefit more from screen time related activities, while others might benefit more from PA related activities. The aim should be the ability to target the content of health promotion activities according to school type and neighbourhood to meet greatest needs.

In addition to individual and neighbourhood SES, other factors like the built environment (i.e. number of public transport stops, residential density, intersection density and the number of parks) could also play an important role in adolescents' health behaviours(73). These factors may be mediators of the observed associations but studies have also suggested that associations may be moderated by the built environment (studies have shown that individuals with low neighbourhood SES had a greater benefit of good walkability than those with a high neighbourhood SES)(31,32). Future research should there-

fore also include measurements of the built environment in Berlin to provide new insights into the associations with PA.

Strengths and limitations

Strengths of our study include the size of our sample, as well as the proportion of students with migration background, socioeconomic status and gender distribution, which appear to be very similar to the student population of Berlin(74). However, the results are only valid for regions with similar characteristics as Berlin: an urban well-connected region with relatively safe neighbourhoods and good infrastructure for transportation and cycling.

Some limitations have to be considered as well. First, FAS was only assessed at the 24 month follow up. However, we assessed one item of the FAS (holiday) additionally at baseline and at the 12 month follow-up. The answers were quite similar over the two years. We thus think that the period of two years was not associated with major changes in the FAS level. We also found differences in the self-report FAS of boys and girls, which is somewhat surprising. It is possible that the structure of the questionnaire led to an overestimation among boys due to a higher interest in cars and computers (i.e. two key elements of the FAS). Second, PA was not measured objectively. Self-report of children and adolescents, especially regarding PA, may lead to biased results through misreporting(75). Measurement errors associated with self-report may further be influenced by SES of adolescents(76). Future studies should use accelerometers or other means to objectively measure PA and sedentary behaviour(77). Another limitation of our study is that we did not assess total sedentary behaviour and that ST was determined based on the use of TV, Computer and video games as assessed by the HBSC questionnaire(35,78). Other increasingly popular screen devices (e.g. smartphones, tablets) and other kinds of sedentary behaviours like sitting during homework, talking on the phone and sitting at school were not taken into account, which may have led to an underestimation of ST.

CONCLUSION

Lower individual and neighbourhood SES was associated with higher ST. Lower neighbourhood but not individual SES was associated with higher PA. After consideration of school type and school

neighbourhood SES associations were attenuated and became insignificant for the relationship between neighbourhood SES, PA and ST. Further research is warranted to unravel the complex relationships between individual SES, neighbourhood SES and school environment to develop more targeted health promotion strategies in the future.

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CONTRIBUTORS

LK and FMR drafted the manuscript with intellectual input from SR, NR, JMN, and NSB. FMR supervised the study and LK carried out the data collection and parts of the data analysis. FL and SR were responsible for data assessment and statistical analyses, FMR, CB, NR, JMN and NSB were responsible for the design of the recruitment methods and the assessment tools, FMR, NR, JMN, and SW conceptualized the study. All authors read and approved the final manuscript.

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COMPETING INTERESTS

None declared.

ETHICS APPROVEL

The study was approved by the ethical review committee of the Charité-Universitätsmedizin Berlin, Germany.

DATA SHARING STATEMENT

No additional data available.

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Figures

Figure 1. Flowchart of the recruitment process

Figure 2. Multivariable analysis of physical activity associated factors among 12 and 13 years old students (complete case analysis, n=1523)

Figure 3. Multivariable analysis of screen time associated factors among 12 and 13 years old students (complete case analysis, n=1523)

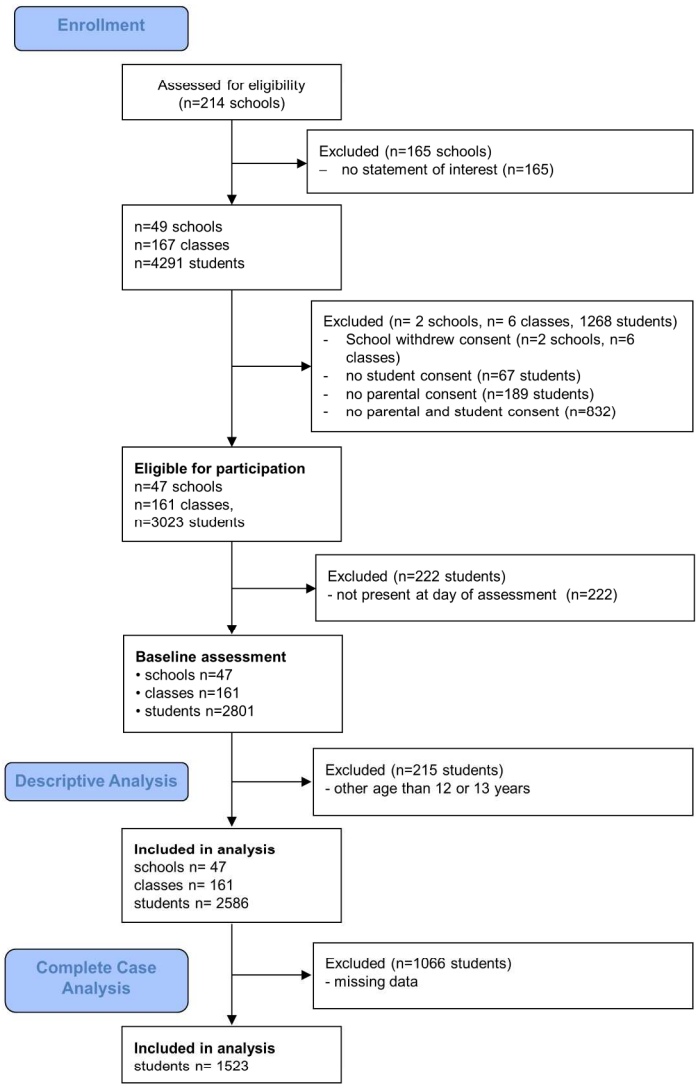
Supplementary files

Supplementary table 1. Multivariable analysis of physical activity associated factors among 12 and 13 years old students (complete case analysis, n=1523)

Supplementary table 2. Multivariable analysis of screen time associated factors among 12 and 13 years old students (complete case analysis, n=1523)

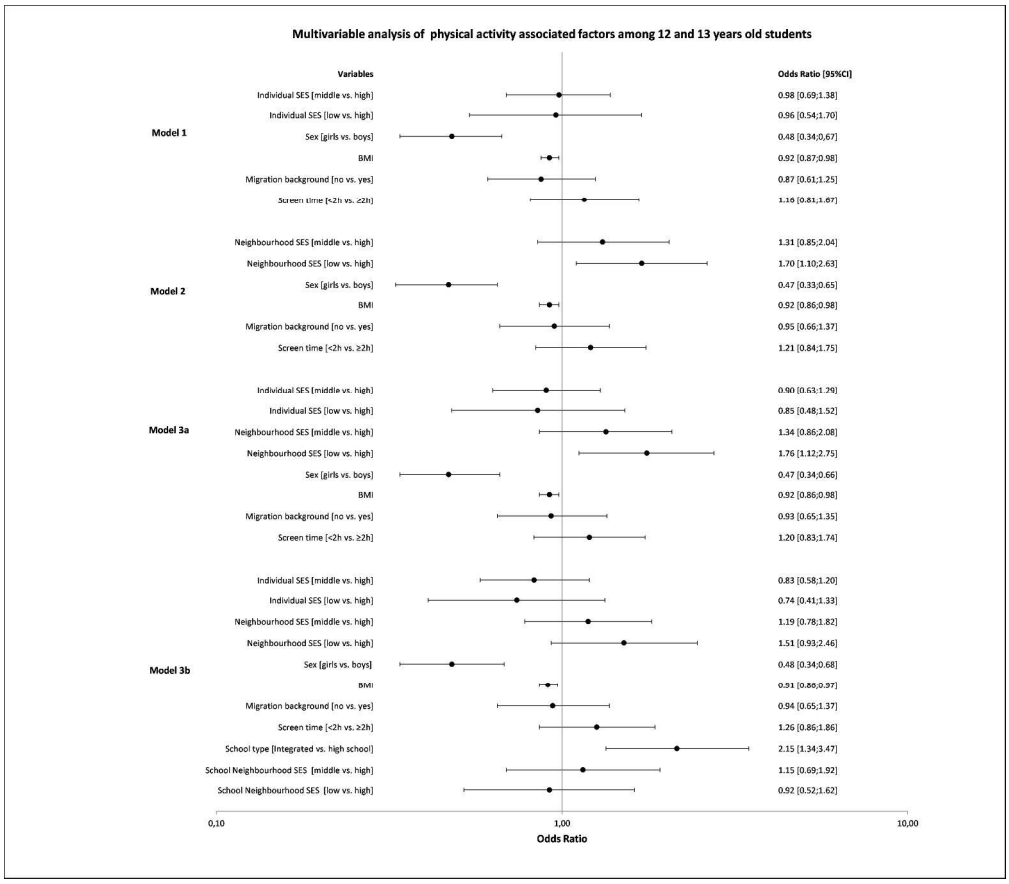
Supplementary table 3. Multivariable analysis of physical activity associated factors among 12 and 13 years old students (unequal sample sizes)

Supplementary table 4. Multivariable analysis of screen time associated factors among 12 and 13 years old students (unequal sample sizes)



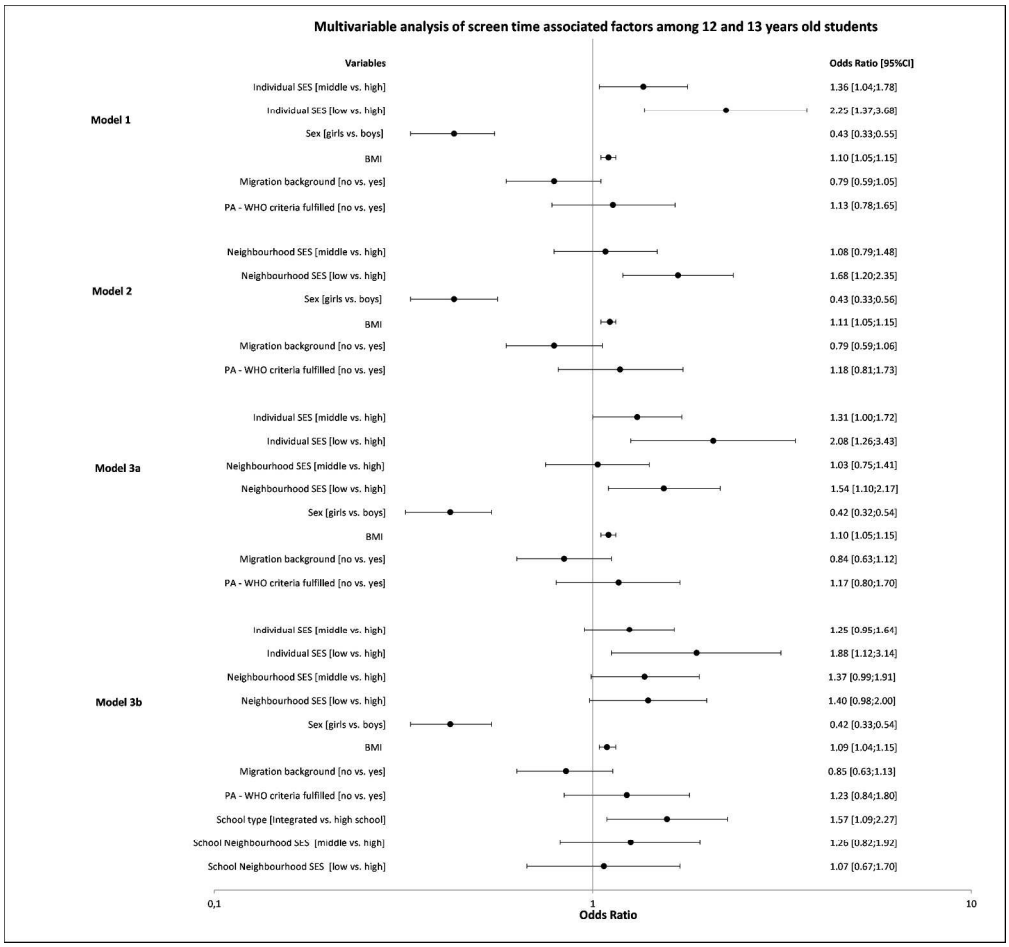
Flowchart of the recruitment process

254x338mm (300 x 300 DPI)



Multivariable analysis of physical activity associated factors among 12 and 13 years old students (complete case analysis, n=1523)

380x331mm (300 x 300 DPI)



Multivariable analysis of screen time associated factors among 12 and 13 years old stu-dents (complete case analysis, n=1523)

333x312mm (300 x 300 DPI)

Supplementary table 1: Multivariable analysis of physical activity associated factors among 12 and 13 years old students

WHO criteria for physical activity (at least 60 minutes per day physically active) fulfilled:								
	Model 1*		Model 2**		Model 3***			
					Model 3a		Model 3b	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Individual socioeconomic status (FAS)		0.984	-	-		0.792		0.476
High	1		-	-	1		1	
Middle	0.98 (0.69; 1.38)		-	-	0.90 (0.63;1.29)		0.83 (0.58; 1.20)	
Low	0.96 (0.54; 1.70)		-	-	0.85 (0.48; 1.52)		0.74 (0.41; 1.33)	
Students' neighbourhood SES	-	-	-	**0.058**		**0.047**		0.253
High (rank 1-2)	-	-	1		1		1	
Middle (rank 3-4)	-	-	1.31 (0.85;2.04)		1.34 (0.86; 2.08)		1.19 (0.78; 1.82)	
Low (rank 5-7)	-	-	1.70 (1.10;2.63)		1.76 (1.12; 2.75)		1.51 (0.93; 2.46)	
Sex		**<0.001**		**<0.001**		**<0.001**		**<0.001**
Boys	1		1		1		1	
Girls	0.48 (0.34; 0.67)		0.47 (0.33;0.65)		0.47 (0.34; 0.66)		0.48 (0.34; 0.68)	
BMI	0.92 (0.87; 0.98)	**0.007**	0.92 (0.86;0.98)	**0.005**	0.92 (0.86; 0.98)	**0.006**	0.91 (0.86; 0.97)	**0.003**
Migration background		0.457		0.786		0.716		0.761
yes	1		1		1		1	
no	0.87 (0.61; 1.25)		0.95 (0.66;1.37)		0.93 (0.65; 1.35)		0.94 (0.65; 1.37)	
Screen time		0.429		0.311	-	0.334		0.233
≥2 hours	1		1		1		1	
<2 hours	1.16 (0.81; 1.67)		1.21 (0.84;1.75)		1.20 (0.83; 1.74)		1.26 (0.86; 1.86)	
School type	-	-	-	-	-			**0.002**
High School	-	-	-	-	-		1	
Integrated Secondary School	-	-	-	-	-		2.15 (1.34; 3.47)	
School neighbourhood SES	-	-	-	-	-			0.723
High (rank 1-2)	-	-	-	-	-		1	
Middle (rank 3-4)	-	-	-	-	-		1.15 (0.69; 1.92)	
Low (rank 5-7)	-	-	-	-	-		0.92 (0.52; 1.62)	

Complete case analysis (n=1523)

*__Model 1:__ individual socioeconomic status (FAS) adjusted for Sex, BMI, migration background, screen time

**__Model 2:__ students' neighbourhood SES (3 categories) adjusted for Sex, BMI, migration background, screen time

***__Model 3 (Model 3a:__ Model 1+2, __Model 3b:__ Model 1+2+school type+school neighbourhood SES

Supplementary table 2: Multivariable analysis of screen time associated factors among 12 and 13 years old students

	High screen time (>2 hours per day)							
	Model 1*		Model 2**		Model 3***			
					Model 3a		Model 3b	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Individual SES (FAS)		**0.002**	-	-		**0.008**		**0.036**
High	1		-	-	1		1	
Middle	1.36 (1.04; 1.78)		-	-	1.31 (1.00; 1.72)		1.25 (0.95; 1.64)	
Low	2.25 (1.37; 3.68)		-	-	2.08 (1.26; 3.43)		1.88 (1.12; 3.14)	
Students' neighbourhood SES	-	-		**0.005**		**0.019**		0.109
High (rank 1-2)	-	-	1		1		**1**	
Middle (rank 3-4)	-	-	1.08 (0.79;1.48)		1.03 (0.75; 1.41)		1.37 (0.99; 1.91)	
Low (rank 5-7)	-	-	1.68 (1.20;2.35)		1.54 (1.10; 2.17)		1.40 (0.98; 2.00)	
Sex		**<0.001**				**<0.001**		**<0.001**
Boys	1		1	**<0.001**	1		1	
Girls	0.43 (0.33; 0.55)		0.43 (0.33;0.56)		0.42 (0.32; 0.54)		0.42 (0.33; 0.54)	
BMI	1.10 (1.05; 1.15)	**<0.001**	1.11 (1.05;1.15)	**<0.001**	1.10 (1.05; 1.15)	**<0.001**	1.09 (1.04; 1.15)	**<0.001**
Migration background		**0.102**		0.117		0.238		0.262
yes	1		1		1		1	
no	0.79 (0.59; 1.05)		0.79 (0.59;1.06)		0.84 (0.63; 1.12)		0.85 (0.63; 1.13)	
Physical activity (PA) (WHO criteria fulfilled)		0.523		0.389		0.430		0.297
Yes	1		1		1		1	
No	1.13 (0.78; 1.65)		1.18 (0.81;1.73)		1.17 (0.80; 1.70)		1.23 (0.84; 1.80)	
School type			-	-	-	-		**0.016**
High School			-	-	-	-	**1**	
Integrated Secondary School			-	-	-	-	1.57 (1.09; 2.27)	
School neighbourhood SES			-	-	-	-		0.535
High (rank 1-2)			-	-	-	-	**1**	
Middle (rank 3-4)			-	-	-	-	1.26 (0.82; 1.92)	
Low (rank 5-7)			-	-	-	-	1.07 (0.67; 1.70)	

Complete case analysis (n=1523)

*__Model 1:__ individual socioeconomic status (FAS) adjusted for Sex, BMI, migration background, PA

**__Model 2:__ students' neighbourhood SES (3 categories) adjusted for Sex, BMI, migration background, PA

***__Model 3 (Model 3a:__ Model 1+2, __Model 3b:__ Model 1+2+ school type + school neighbourhood SES)

Supplementary table 3: Multivariable analysis of physical activity associated factors among 12 and 13 years old students

WHO criteria for physical activity (at least 60 minutes per day physically active) fulfilled:								
	Model 1*		**Model 2****		**Model 3*****			
	(n=1760)		(n=1818)		**Model 3a** (n=1547)		**Model 3b (n**=1523)	
	OR (95% CI)	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Individual socioeconomic status (FAS)		0.940	-	-		0.763		0.476
High	1		-	-	1		1	
Middle	0.95 (0.69; 1.31)		-	-	0.89 (0.62; 1.26)		0.83 (0.58; 1.20)	
Low	1.01 (0.60; 1.69)		-	-	0.87 (0.50; 1.54)		0.74 (0.41; 1.33)	
Students' neighbourhood SES	-	-	-	**0.028**		0.079		0.253
High (rank 1-2)	-	-	1		1		1	
Middle (rank 3-4)	-	-	1.24 (0.84;1.84)		1.27 (0.85; 1.88)		1.19 (0.78; 1.82)	
Low (rank 5-7)	-	-	1.67 (1.14;2.44)		1.65 (1.07; 2.56)		1.51 (0.93; 2.46)	
Sex		**<0.001**		**<0.001**		**<0.001**		**<0.001**
Boys	1		1		1		1	
Girls	0.51 (0.38; 0.69)		0.48 (0.36;0.65)		0.48 (0.35; 0.67)		0.48 (0.34; 0.68)	
BMI	0.90 (0.85; 0.95)	**<0.001**	0.92 (0.87;0.97)	**0.002**	0.92 (0.87; 0.98)	**0.006**	0.91 (0.86; 0.97)	**0.003**
Migration background		0.844		0.957		0.588		0.761
yes	1		1		1		1	
no	0.97 (0.69; 1.36)		0.99 (0.72;1.36)		0.91 (0.63; 1.30)		0.94 (0.65; 1.37)	
Screen time		0.734		0.165	-	0.425		0.233
≥2 hours	1		1		1		1	
<2 hours	1.06 (0.76; 1.49)		1.26 (0.91;1.74)		1.16 (0.81; 1.67)		1.26 (0.86; 1.86)	
School type	-	-	-	-	-			**0.002**
High School	-	-	-	-	-		1	
Integrated Secondary School	-	-	-	-	-		2.15 (1.34; 3.47)	
School neighbourhood SES	-	-	-	-	-			0.723
High (rank 1-2)	-	-	-	-	-		1	
Middle (rank 3-4)	-	-	-	-	-		1.15 (0.69; 1.92)	
Low (rank 5-7)	-	-	-	-	-		0.92 (0.52; 1.62)	

*__Model 1:__ individual socioeconomic status (FAS) adjusted for Sex, BMI, migration background, screen time

**__Model 2:__ students' neighbourhood SES (3 categories) adjusted for Sex, BMI, migration background, screen time

***__Model 3 (Model 3a:__ Model 1+2, __Model 3b:__ Model 1+2+ school type + school neighbourhood SES

Supplementary table 4: Multivariable analysis of screen time associated factors among 12 and 13 years old students

	High screen time (>2 hours per day)							
	Model 1*		**Model 2****		**Model 3*****			
	(n=1760)		(n=1818)		**Model 3a** (n=1547)		**Model 3b** (n=1523)	
	OR (95% CI)	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Individual SES (FAS)		**0.004**	-	-		**0.007**		**0.036**
High	1		-	-	1		1	
Middle	1.28 (1.00; 1.64)		-	-	1.32 (1.01; 1.73)		1.25 (0.95; 1.64)	
Low	2.03 (1.30; 3.15)		-	-	2.09 (1.27; 3.45)		1.88 (1.12; 3.14)	
Students' neighbourhood SES	-	-		**0.002**		**0.019**		0.109
High (rank 1-2)	-	-	1		1		**1**	
Middle (rank 3-4)	-	-	1.07 (0.80;1.44)		1.49 (1.08; 2.05)		1.37 (0.99; 1.91)	
Low (rank 5-7)	-	-	1.68 (1.22;2.29)		1.55 (1.10; 2.17)		1.40 (0.98; 2.00)	
Sex		**<0.001**				**<0.001**		**<0.001**
Boys	1		1	**<0.001**	1		1	
Girls	0.46 (0.37; 0.59)		0.45 (0.35;0.56)		0.42 (0.32; 0.54)		0.42 (0.33; 0.54)	
BMI	1.09 (1.05; 1.14)	**<0.001**	1.08 (1.04;1.13)	**<0.001**	1.09 (1.04; 1.14)	**<0.001**	1.09 (1.04; 1.15)	**<0.001**
Migration background		**0.035**		0.223		0.267		0.262
yes	1		1		1		1	
no	0.75 (0.57; 0.98)		0.85 (0.65;1.11)		0.85 (0.63; 1.14)		0.85 (0.63; 1.13)	
Physical activity (PA) (WHO criteria fulfilled)		0.738		0.189		0.510		0.297
Yes	1		1		1		1	
No	1.06 (0.75; 1.50)		1.25 (0.90;1.74)		1.14 (0.78; 1.66)		1.23 (0.84; 1.80)	
School type			-	-	-	-		**0.016**
High School			-	-	-	-	**1**	
Integrated Secondary School			-	-	-	-	1.57 (1.09; 2.27)	
School neighbourhood SES			-	-	-	-		0.535
High (rank 1-2)			-	-	-	-	**1**	
Middle (rank 3-4)			-	-	-	-	1.26 (0.82; 1.92)	
Low (rank 5-7)			-	-	-	-	1.07 (0.67; 1.70)	

*__Model 1:__ individual socioeconomic status (FAS) adjusted for Sex, BMI, migration background, PA
**__Model 2:__ students' neighbourhood SES (3 categories) adjusted for Sex, BMI, migration background, PA
***__Model 3 (Model 3a:__ Model 1+2, __Model 3b:__ Model 1+2+ school type + school neighbourhood SES)

STROBE (Strengthening The Reporting of OBservational Studies in Epidemiology) Checklist

A checklist of items that should be included in reports of observational studies. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Section and Item	Item No.	Recommendation	Reported on Page No.
Title and Abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/Rationale	2	Explain the scientific background and rationale for the investigation being reported	1
Objectives	3	State specific objectives, including any prespecified hypotheses	2
Methods			
Study Design	4	Present key elements of study design early in the paper	2
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2-3
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	2-3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3-5

Section and Item	Item No.	Recommendation	Reported on Page No.
Data Sources/ Measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3-5
Bias	9	Describe any efforts to address potential sources of bias	15
Study Size	10	Explain how the study size was arrived at	2
Quantitative Variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical Methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5-6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	7
Descriptive Data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-10
		(b) Indicate number of participants with missing data for each variable of interest	7-10
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome Data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	7-10

Section and Item	Item No.	Recommendation	Reported on Page No.
Main Results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other Analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	5-6
Discussion			
Key Results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Once you have completed this checklist, please save a copy and upload it as part of your submission. DO NOT include this checklist as part of the main manuscript document. It must be uploaded as a separate file.