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Between school and school class variation for objectively assessed physical activity, aerobic fitness and organized sports participation among 9- and 15-year-olds. The European Youth Heart Study.

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Introduction

The benefits of regular physical activity in preventing chronic disease are well established. Maintaining an active lifestyle reduces the risk of conditions such as cardiovascular disease, certain types of cancer, diabetes mellitus and osteoporosis {1999 4021 /id}. Less is known about what causes individual differences in physical activity and how to effectively intervene against physical inactivity. This has led to an increasing interest in knowledge within this field – not at least from health care professionals involved in prevention of physical inactivity. To develop effective intervention strategies there is a need for an improved understanding of the mechanisms underlying physical activity behavior. In particular, childhood physical activity behavior might be important, due to a potential tracking effect of physical activity from childhood to adulthood. It has often been argued that physical activity preferences and habits established in childhood could persist into adulthood – and existing studies of tracking provide some support of this hypothesis {Kristensen, 2008 3923 /id}.

A large proportion of a child's day is spent at school interacting with certain physical surroundings, teachers and school friends. In addition, school friends normally reside within the same school district, which means that they, to a certain extent, also share physical surroundings and social networks in their free time. As such, the school is a powerful socialization agent in children's lives and could have an important impact on establishing physical activity habits.

Only few earlier studies have studied the effect of schools on physical activity and aerobic fitness. These studies have primarily focused on sixth and eighth grade girls, and to the best of our knowledge no study has estimated both school and school class cluster effects for physical activity and aerobic fitness.

Previous studies of health behaviors other than physical activity have shown, that school-level cluster effects can vary by school grade, time of year, and other factors {Murray, 1994 4020 /id}{Murray, 2006 4012 /id}. Thus, in order to fully address the impact of schools on physical activity and aerobic fitness, there is a need to study between school variations for different subgroups and under varying conditions. Such research will be important for two key reasons: First, insight into the influence of schools on establishing physical activity habits can give us an indirect indication as to what extent children's physical activity are modifiable by external factors. A large school-level cluster effect will indicate that schoolchildren, to a large extent, adjust their physical activity according to the social and environmental circumstances they share. In turn, this may set the scene for important intervention initiatives to the extent that the underlying mechanisms can be identified and influenced. Secondly, the results could be very useful in the planning of future school-based randomized trials addressing physical activity – especially for appropriate sample size estimation.

The aim of the present study was to quantify between school and school class variation for physical activity, aerobic fitness and organized sports participation among third and ninth grade students using data from 34 different schools and 229 school classes. The large number of clusters (i.e. schools and school classes) are rarely available in studies that rely on objective methods of measurement, and as such, the present study provides a unique opportunity for examining school-level cluster effects for physical activity and aerobic fitness.

Methods

Data came from the Danish part of The European Youth Heart Study (EYHS), an international multicenter study addressing cardiovascular disease risk factors in children and adolescents (Riddoch et al. 2005).

Sampling

The sampling frame was a complete list of public schools in the municipality of Odense - the fourth largest municipality in Denmark. Schools were stratified according to location and the socioeconomic character of its uptake area. From each stratum, a proportional, two-stage cluster sample of children was selected. The primary units were the schools. Schools were selected using probability proportional to school size. Each school on the sampling list was allocated a weighting equivalent to the number of children in the school who were eligible to be selected for the study. The secondary units were the children in the schools. Equal numbers of children were sampled from each school. Children in the appropriate age band were allocated code numbers and randomly selected using random number tables. A more detailed description of the study has been given elsewhere (Riddoch et al. 2005).

Subjects and schools

Two measurement series have been conducted within the framework of EYHS in Denmark (see Fig. 1). In 1997 a sample of 590 nine-year-old children (third grade) and 429 fifteen-year-old adolescents (ninth grade) participated in EYHS-I. Six years later in EYHS-II the younger of the two EYHS-I-cohorts were re-examined and in addition, a new cohort of 9-year-olds was included, thus extending the design into a mixed longitudinal design. The overall participation rate was 61 % and 71 % for the 15–year-olds and 9–year-olds, respectively. In total, 34 out of a total population of 37 public schools in the municipality of Odense were represented in the dataset.

Ethics

All procedures and methods in this study conformed to the ethical guidelines laid down in the World Medical Association's Declaration of Helsinki and its subsequent revisions. The study was approved by the ethics committee of Vejle and Funen.

Physical activity

Daily physical activity was assessed objectively by the use of the uniaxial MTI Actigraph (Manufacturing Technology Inc, Fort Walton Beach, Florida, USA). Participants were asked to wear the Actigraph for at least five consecutive days. Subjects who did not manage to record $\geq$600 min/d of activity for $\geq$3 d were excluded from further analyses. In order to distinguish between true intervals of inactivity and "inactivity" recorded when the monitor had been taken off, all MTI files were screened for periods of zero activity. Zero activity periods of 20 min or longer were interpreted as "MTI not worn," and these periods were removed from the summation of activity by the data reduction program. In both EYHS-I and EYHS-II data was collected through most of a school year.

Physical activity dimensions

Mean daily physical activity (MDPA) was defined as total accelerometer counts per valid minute of monitoring. Percentage of recorded time spent above 3 MET´s was defined as moderate to vigorous physical activity (MVPA) (Freedson et al. 1998). The age-specific count range corresponding to the vigorous intensity level were derived from the energy expenditure prediction equation developed by Freedson and coworkers (1998).

Time periods

Data collected on physical activity were analyzed over three different time periods, in order to estimate separate effects for time spent in school, leisure time and total time. The time in school was defined as the period from 8 am to

15 pm for both the nine - and fifteen-year-olds. Leisure was defined as the remaining time period, including weekends.

Individual estimates of physical activity was not based on precisely the same combination of recording days. In Kristensen et al. (2008a), the association between physical activity and the type of measurement day was examined and the results showed two clusters of days. Both 9-year-old children and 15-year-old adolescents are less active on weekends than on the remaining days of the week. In order to control for day type variation in physical activity, weekend activity was weighted by 2/7 and weekday activity by 5/7 for variables representing total time and leisure time.

Aerobic fitness

Aerobic fitness was determined by an indirect maximal cycle ergometer test – the watt-max test. The protocol has been described in detail elsewhere (Riddoch et al. 2005).

Criteria for exhaustion were:

1) A heart rate above or equal to 185 beats per minute
2) Failure to keep a pedaling frequency of at least 30 revolutions per minute
3) Subjective valuation by the test personnel

The test has been validated in both children and adolescents with a correlation coefficient of r=0.89 and r=0.90, respectively, to directly measured Vo2 max (unpublished data).

Scaling of maximal power output

The maximal power output was scaled to body mass using empirically derived scaling exponents, in accordance to the principles described by Vanderburgh {Vanderburgh, 1998 3855 /id}. The calculations showed that the mass exponent was independent of gender and year of measurement, but varied significantly across age groups. For the 9-year-olds the mass exponent was estimated to be -0.45 and for the 15-year-olds the mass exponent was -0.55.

Self-report data

Organized sport participation was assessed as follows: “How often do you take part in exercise at sport clubs?” Response options were *Hardly ever or never, Once or twice a week, Most days, Every day*. Parental exercise habits were assessed by a parental questionnaire: “Do you regularly exercise or do any sports (2 or more times per week)?” Response options were *yes/no.*

Socioeconomic status

Socioeconomic status was classified according to the economic profile of the catchment areas of the individual schools. A list of the average gross income per inhabitant within the individual school catchment areas was obtained from the local authorities. This information was acquired for the years 1997 and 2003, respectively, in order to account for both the data from EYHS-I and EYHS-II, and formed the basis for a classification of schools into three distinct subgroups. By consulting both the 1997 and the 2003 list of average gross incomes, three types of school catchment areas were recognized – low, middle and high income areas. The three subgroups contained approximately the same number of schools. The boundary between low and middle income areas was set at an average gross income of 187.000 Danish kroner per year and the boundary between middle and high income areas was set at 198.500 Danish kroner per year. The stated values are average values of the 1997 and the 2003 gross income data.

Statistics

Data from the two measurement series in EYHS were pooled to maximize power. To ensure that the physical activity data were sufficient in quantity and distributed appropriately over gender, SES groups, year and season of measurement, a series of cross tabulations examining two-by-two combinations of the variables were produced.

The between cluster variation for schools and school classes were estimated by three-level generalized linear mixed models in STATA, with a random effect for schools and school classes. All analyses were performed in Stata version 10. The program GLLAMM was used to fit models with an ordinary outcome variable, i.e. the modeling of the impact of schools and school classes on participation rates in organized sports. For accelerometer-assessed physical activity and aerobic fitness as outcome variables the program XTMIXED was used.
The magnitude of the between cluster variation was indexed by an intraclass correlation coefficient (ICC). The ICC provides a measure of how similar, or homogeneous, individuals are within clusters. The ICC is the proportion of variability in the outcome that is accounted for by the clusters or groups {McCoach, 2010 4026 /id}. To calculate the ICC the total variability were partitioned into two pieces: that which is within clusters (θ) and that which lies between clusters (ψ) {McCoach, 2010 4026 /id}. The following formula was used to calculate the ICC for continuous data:

$$ICC\ (\rho) = \frac{\psi}{\psi+\theta}$$

For binary/ordinal outcomes an equation based on a latent-variable formulation of generalized linear models was used:

$$ICC\ (\rho logit) = \frac{\psi}{\psi + \pi^2/3}$$

A large ICC indicates that there is a large degree of homogeneity within clusters and/or a large degree of heterogeneity across clusters {McCoach, 2010 4026 /id}.
The 95% confidence intervals of the ICC were computed using the delta method.

Potential confounding variables considered were: gender, SES, parental exercise habits, grade, year and season of measurement. The adjustment for season was particularly important since schools were studied over most of a school year and physical activity varies by season of measurement {Kristensen, 2008 3924 /id}.

Results

In all, 1326 children from 34 different schools and 229 school classes had complete data for all variables considered and were entered into the analyses. Descriptive statistics are provided in table I.
All analyses were adjusted for SES, parental exercise habits, gender, season, grade and year of measurement.
In Table 2 school-level ICCs for mean daily physical activity and moderate to vigorous physical activity are presented. The ICCs were calculated separately by setting (i.e. time spent in school, leisure time and total time). Consistently

higher ICC values were observed for time spent in school compared to leisure time. For instance, ICCs representing the between school and school class variation for MVPA were estimated to 0.18 and 0.06 for school time and leisure time, respectively. As to the relative impact of school and school class on physical activity, results pointed at the school class as the most influential factor. For school time physical activity the intra-class correlation between children from the same school but different classes was estimated to 0.04, whereas the corresponding ICCs for the same school and class was significantly higher i.e. 0.15 or 0.18 depending on the dimension of physical activity.

Table 2 presents ICCs for aerobic fitness and organized sports participation. No significant effects were observed for organized sports but highly significant cluster effects were found for aerobic fitness. Similar to the results for physical activity, school class seemed more influential on aerobic fitness than the school itself. The intra-class correlation between children from the same school but different classes was estimated to 0.02, while the ICC for the same school and class was 0.11.

Due to power concerns data for the 9- and 15-year-olds were pooled for the main analyses – this type of data analysis requires a large dataset. However, as described in the introduction, previous studies of health behaviors other than physical activity have shown, that school-level cluster effects can vary by school grade. Therefore as a post hoc analysis we calculated the total cluster effect of school and school class for the two age groups separately. Results are presented in figure2. As shown in the figure, the ICC values were estimated as slightly higher for the 9-year-olds compared to the 15-year-olds, except for the issue of organized sports participation.

Discussion

This study examined between school and school class variation for physical activity, aerobic fitness and organized sports participation among third and ninth grade students from 34 different schools and 229 school classes in Denmark. The magnitude of between cluster variation was indexed by an intraclass correlation coefficient. For physical activity ICCs were calculated separately by setting (i.e. time spent in school, leisure time and total time) and for schools and school classes, respectively. Looking at the combined effect of school and school class, ICC values ranged from 0.03-0.18 with the highest values observed for the time spent at school. This was indeed expected as students are very much subjected to the same environmental and behavioral conditions during school time, while this is not so much the case during leisure. Despite this, the results also showed a significant impact of school and school class on physical activity during leisure time. This means that children not only tend to be more alike within than across schools when it comes to physical activity during school time, but also in terms of physical activity during leisure time. A key question, of course, is what can explain these cluster effects? By nature, the explanatory factors must be sought in circumstances that are shared by students within their respective schools, school classes or school areas. Both physical and psychosocial factors could be relevant, such as the interaction between students, opportunities for active transport, health policies at the schools, teacher interaction, opportunities for physical activity during leisure etc. Most likely a complex interplay between several factors explains our results; but some factors might be more important than others. The present study is not designed to uncover these underlying factors; nevertheless it may still offer a small contribution to this work. The finding of consistently higher ICC estimates for the effect of school class rather than school on physical activity indicates that the most important explanatory factors should be found among psychosocial rather than physical conditions. The unique circumstances within a school class that are not necessarily shared with other students at the school are of a psychosocial nature, whereas physical conditions inside and outside the school, generally speaking, are accessible to all students regardless of school class relations. It should be noted, however, that all participating schools were located in the same municipality and thus may share some common characteristics - for instance, they are all administrated by the same local political authorities. Thus, it is possible, that the importance of the physical facilities or environment might not be fully reflected in the present data and one would find higher school-level ICCs if the study was conducted across several different municipalities or in countries where there is a high degree of variation between schools regarding physical facilities.

To the best of our knowledge only few earlier studies have been dedicated to exploring school-level cluster effects for physical activity {Murray, 2006 4012 /id}{Murray, 2004 4013 /id}{Ma, 2000 4037 /id}{Maes, 2003 4038 /id}, aerobic fitness {Zhu, 1997 4039 /id} and PE enrollment {Hobin, 2010 4025 /id}. In addition, a number of studies have reported school level cluster effects as a side note and not as a primary objective that is discussed in detail {Stevens, 2004 4023 /id}{Naylor, 2008 4014 /id}. For physical activity, earlier studies have reported school-level ICCs ranging from approximately 0 to 0.29. Due to the limited number of studies, it remains unclear if the relatively large range in ICCs were due to differences in methodology (questionnaire vs. accelerometer), sample population (age, female only vs. male and female combined, single grade vs. multiple grades), sample size (e.g. number of schools, number of students), country (Canada vs. USA vs. Belgium etc.) or adjustment for covariates, which often helps reduce the magnitude of the ICC {Murray, 2003 4016 /id} {Wong, 2007 4041 /id}. More studies are needed to help explain these differences. No previous study have reported ICCs for both schools and school-classes, despite the obvious two-level hierarchical clustering structure of school based data. Thus, there is no available information on whether the reported impact of school and school class, respectively, can be reproduced in other studies. Nor did earlier studies, to any significant extent, examine school characteristics that may account for the reported ICCs.

In interpreting the magnitude of the reported school-level ICCs, it may be fruitful to look to other disciplines. A recent review by Hedges and Hedberg indicates that when the school represents the cluster variable, the average ICC for student academic achievement (in either mathematics or reading) is 0.22. After controlling for pretest scores and/or demographic characteristics such as socioeconomic status, the average ICC is 0.11 {Hedges, 2007 4011 /id}{McCoach, 2010 4026 /id}. Thus, ICC values representing between school and school class variation for physical activity and aerobic fitness were estimated relatively close to school ICC values for academic achievement.

Knowledge of the relative impact of school and school class on health behavior is important as it gives us an indication as to what extent children's physical activity are influenced by the school environment. In turn, this may set the scene for important intervention initiatives to the extent that the underlying mechanisms can be identified and influenced. In addition, precise school-level ICCs provides valuable information for the calculation of sample size in future group randomized trials. Observations that are clustered, as for instance observations among students clustered within classes, tend to exhibit some degree of interdependence or correlation {McCoach, 2010 4026 /id}. This is because when people exhibit some level of homogeneity, there will be a certain degree of correlation in their responses or behavior. Because of this correlation, the “effective sample size” for the study is smaller than the actual sample size {McCoach, 2010 4026 /id}. This reduction in effective sample size must be taken into account when performing power calculations for group randomized trials. If precise school-level ICC estimates are available a corrected power calculation can easily be carried out using various statistical packages. An example of the impact of between school variation on required sample size is given by Murray et al. {Murray, 2004 4013 /id}.

In conclusion, the present study quantified the between school and school class variation for physical activity, aerobic fitness and organized sports participation among third and ninth grade students from 34 different schools and 229 school classes. Although most variation in physical activity and aerobic fitness lies within schools and school classes this study shows, that there is sufficient between-school and school class variation to draw interest from both a scientific and practical political perspective. Understanding the mechanisms behind school and school class cluster effects could prove vital for the planning of future effective intervention strategies aimed at preventing physical inactivity and low aerobic fitness.

Table 2

	N	Setting	School			Class			Difference[a]		School & Class		
			ICC	CI	P	ICC	CI	P	ΔICC	P	ICC	CI	P
MDPA	1210	Total	0.02	-0.01-0.05	0.21	0.09	0.04-0.13	<0.001	0.07	0.047	0.11	0.05-0.16	<0.001
	1326	School	0.04	-0.01-0.09	0.08	0.10	0.05-0.15	<0.001	0.06	0.134	0.15	0.09-0.20	<0.001
	1210	Leisure	0.00	-0.02-0.02	0.86	0.07	0.03-0.12	0.002	0.07	0.012	0.08	0.03-0.12	0.001
MVPA	1210	Total	0.02	-0.01-0.05	0.24	0.08	0.04-0.13	0.001	0.06	0.068	0.10	0.05-0.16	<0.001
	1326	School	0.04	-0.01-0.09	0.15	0.14	0.09-0.20	<0.001	0.11	0.019	0.18	0.12-0.24	<0.001
	1210	Leisure	0.00	-0.02-0.03	0.70	0.06	0.01-0.10	0.01	0.05	0.061	0.06	0.02-0.11	0.004

Abbreviations: MDPA, mean daily physical activity; MVPA, Moderate to vigorous physical activity

[a] The difference between the ICC values estimated for class and school, respectively.

Table 3

	N	School			Class			Difference[a]		School & Class		
		ICC	CI	P	ICC	CI	P	ΔICC	P	ICC	CI	P
Organized sport	707	0.02	-0.05-0.09	0.524	0.00	-0.03-0.03	0.842	0.02	0.673	0.03	-0.03-0.08	0.381
Aerobic fitness	1253	0.02	-0.01-0.06	0.163	0.08	0.03-0.13	0.001	0.06	0.0812	0.11	0.05-0.16	<0.001

[a] The difference between the ICC values estimated for class and school, respectively.

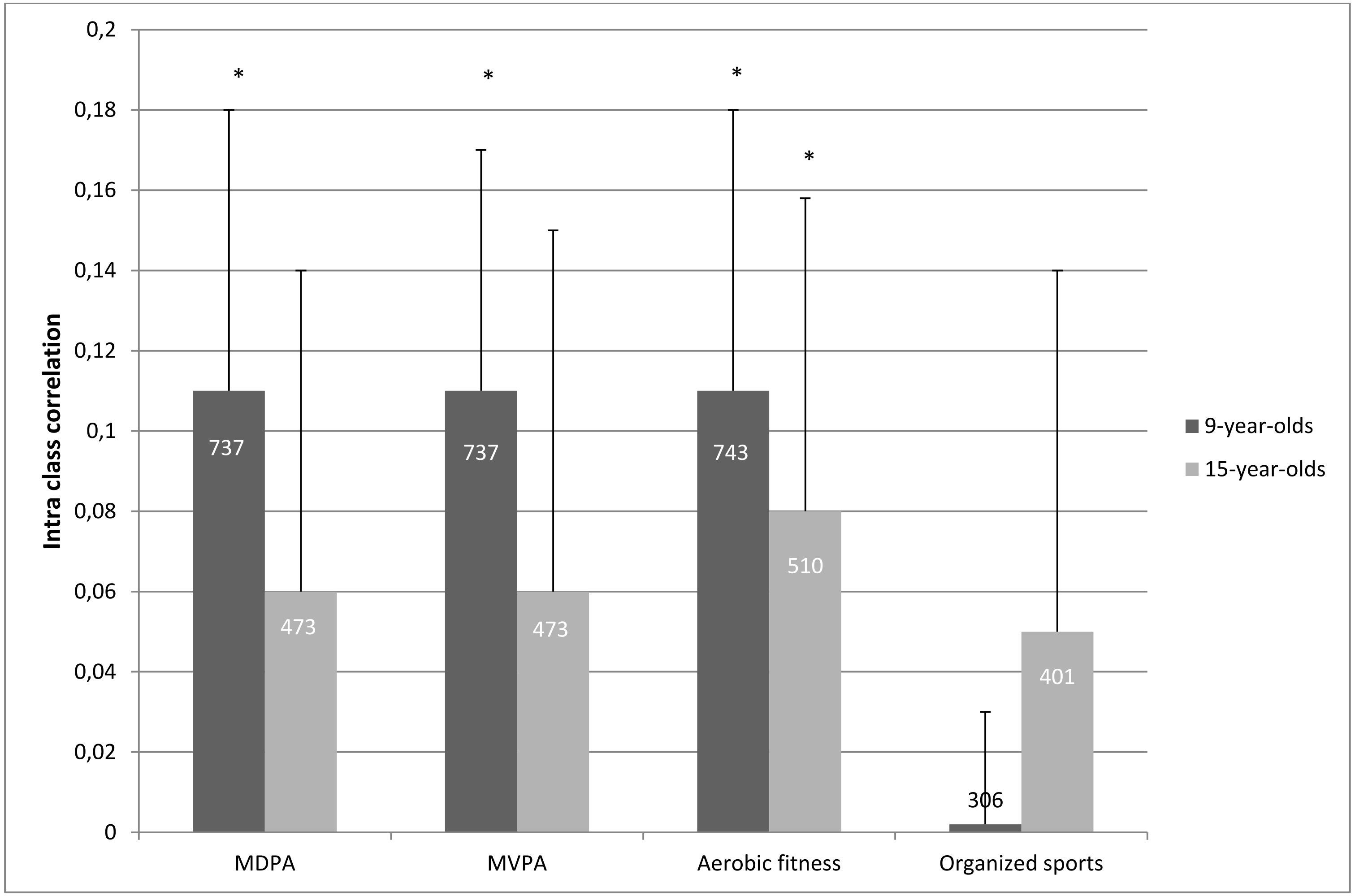
Table 1 Basic Subject Characteristics[a] across Study Year, Age Group, and Gender, The European Youth Heart Study, Denmark, 1997-2003

	EYHS-I						**EYHS-II**					
	9-year-olds			**15-year-olds**			**9-year-olds**			**15-year-olds**		
	N	Boys	Girls	N	Boys	Girls	N	Boys	Girls	N	Boys	Girls
Age Years	590	9.7 (0.4)	9.6 (0.4)	429	15.5 (0.4)	15.5 (0.5)	458	9.9 (0.4)	9.8 (0.4)	444	15.8 (0.3)	15.7 (0.4)
Weight Kg	590	34.0 (6.4)	33.2 (6.3)	429	63.5 (10.0)	57.0 (8.8)	458	34.5 (6.8)	34.2 (7.0)	444	65.2 (10.8)	58.0 (9.4)
MDPA Counts/min	383	719 (238)	599 (209)	226	452 (168)	413 (146)	419	715 (204)	596 (173)	346	503 (180)	409 (144)
Reg Days n	383	4 (3 – 5)	4 (3 – 5)	226	4 (3 – 5)	4 (3 – 5)	419	5 (3 – 5)	5 (3 – 5)	346	4 (3 – 5)	4 (3 – 5)
Schools n	590	25	25	429	23	23	458	22	22	444	29	29
School classes n	590	62	62	429	51	51	458	64	64	444	70	70
Active commuting %	578	65	63	418	88	86	457	66	65	443	80	85

Abbreviations: Active commuting, frequency of children who bicycle or walk to school on a daily basis; MDPA, mean daily physical activity estimated by accelrometry; Reg Days, median number of physical activity registration days.

[a] Shown are means (SD), except for the variables School, School classes and Active commuting, where frequencies and numbers are reported. Furthermore, non-normally distributed variables (i.e. Reg Days) are expressed as median (10th-90th percentile).

Figure 2 ICCs representing cluster effects for both school and school class by age group



Abbreviations: MDPA, mean daily physical activity; MVPA, Moderate to vigorous physical activity
* denotes that the estimated ICC is significantly different from zero.
Numbers within bars denotes the number of children included in the analysis.

Figure 1

Schematic diagram showing the design of the Danish part of the European Youth Heart Study.