

**Objectively measured habitual physical activity in 1997/98 vs.
2003/04 in Danish children:**

The European Youth Heart Study

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Abstract

Based on two cross sectional studies conducted in 8-10-year-old third grade children living in the municipality of Odense, potential differences were examined in the level of habitual physical activity (HPA) in Danish children between 1997/98 and 2003/04. HPA was assessed objectively by accelerometry. Primarily, overall differences were analysed as gender and day type specific (i.e. Mon-Thu vs. Fri-Sun) levels in HPA. Secondly, differences were analysed across socio-economic gradients defined according to parents' occupation. Data were expressed as total counts per registered time. During the period 1997/98 to 2003/04, no significant differences were observed in the level of HPA during Mon-Thu or Fri-Sun or across socio-economic gradients. Post hoc analyses indicated a slightly more favourable ratio between the percentages of time spent in light and moderate intensity levels during Mon-Thu in 2003/04 when compared to 1997/98. Gender differences in the level of HPA were found to be more distinct during Mon-Thu than during Fri-Sun. This study does not support the idea that Danish children are becoming less physically active. However, a limited statistical power should be considered when interpreting differences across socio-economic gradients. Boys were found to be more physically active compared to girls, especially during the weekdays (Friday not included).

Keywords: Activity behaviour, trends, accelerometer, child, socio-economic status, epidemiology

Introduction

Increased physical activity (PA) is an important contributor to health status and prevention of several chronic diseases and premature mortality in adults (NIH Consensus Development Panel on Physical Activity and Cardiovascular Health, 1996; Leon et al., 1997). However, the clinical manifestations of chronic diseases such as coronary heart diseases and type II diabetes mellitus are typically absent until adulthood. Therefore, when investigating the health benefits of PA in children and young people it is usually performed by focusing on risk factors known to be linked with disease end points in adults. Habitual physical activity (HPA) has previously been found to be inversely related to the risk factors related to the metabolic syndrome in Danish children (Brage et al., 2004), and recently a graded negative association has been observed between clustering of cardiovascular risk factors and HPA in children from three different European countries (Andersen et al., 2006).

Even though it is generally believed that recent generations of children and young people in the Western society have experienced a decline in their PA level, the standardized data investigating such a trend are rather limited. Therefore, suspicions that children are getting more physically inactive are often build on indirect evidence suggesting that children are getting fatter (Lobstein & Frelut, 2003). However, the aetiology of obesity does not include PA alone but is multidimensional in its nature. Thus, examining the differences in, and current levels of, HPA in children and young people, using a reliable objective assessment technique, might hold valuable information in the attempt trying to increase and improve the current knowledge linking PA with early indications of reduced health (e.g. overweight and low physical fitness) in childhood.

Potentially, such knowledge will also provide crucial information for the planning of early optimal preventive strategies against unfavourable health status in adulthood, since low PA, low physical fitness, and other cardiovascular disease risk factors have been found to track from childhood into

adolescence (Janz et al., 2000), and from adolescence into the adult years (Andersen & Haraldsdottir, 1993).

The rather few studies which have been designed to examine differences or secular trends in the level of PA in children or young people have typically assessed activity levels by the use of questionnaires (Pratt et al., 1999; Eisenmann et al., 2004). However, the validity and reliability of self reports is challenged due to the potential lack of cognitive abilities to recall detailed daily habits of the complex nature of PA among the subjects being under study, leaving self-report measures as inappropriate in particular when used in children (Kohl et al., 2000). Children tend to overestimate the time spend on PA (Sallis & Saelens, 2000), and unrealistic statements caused by fantasy, misunderstandings, and selective or bad memory have been reported (Sallis, 1991). This, of course, will leave the reliability and validity of PA levels in children based on self reports, or information gained by interviews, rather questionable.

An instrument that practically will capture duration, frequency, and intensity would hold important information on objective assessments of PA. Accelerometers provide such objectively information, and recently increasingly use of accelerometers has been made when monitoring levels of physical activity (Klasson Heggebo & Anderssen, 2003; Brage et al., 2004; Andersen et al., 2006).

However, according to the best of our knowledge, no other study has examined differences or trends in objectively measured HPA in a large number of randomly selected children.

Therefore, the primary aim in the present study is to examine the level of HPA in Danish third grade children when assessed objectively by the use of accelerometers in 1997/98 and 2003/04, respectively. Special attention is paid to specific day types in order to determine if potential differences occurred in parallel across different days of the week. Secondly, inspired by the fact that several studies (Millar & Wigle, 1986; Marmot et al., 1991) have shown that the highest prevalence of CVD risk factors, including obesity and low PA, is found in adults with low socio-

economic status (SES), the aim is to analyse potential differences across socio-economic gradients. The aims of this approach is to determine if part of the population is changing more than expected compared to the total sample. A more pronounced secular change, or even polarization in the level of HPA, could occur when distinguishing between specific day types or socio-economic subgroups, maybe leaving the overall mean unchanged.

Materials and methods

Subjects/sampling

Differences in the level of HPA were analysed through two cross sectional studies carried out in 1997/98 and 2003/04, respectively. The two studies were conducted in 8-10-year-old third grade children in the Danish municipality of Odense. Both studies are part of the “European Youth Heart Study” and follow the official study protocol, which has been extensively described elsewhere (Riddoch et al., 2005). The children were randomly sampled through a two stage cluster sampling from schools stratified according to location (urban, suburban, and rural) and the socio-economic character of its uptake area (high, middle, and low).

In the first study in 1997/98, 771 children were sampled and invited to participate. In the end, 589 children (310 girls and 279 boys, in all 76.4% of the invited children) participated in the study.

In the second study in 2003/04, 709 children were sampled, and of these 458 children (259 girls and 199 boys, in all 64.6 % of the invited children) participated.

Socio-economic status

A measure for SES was divided into two different groups - a white-collar group and a blue-collar group based on occupational information collected from a parent’s questionnaire. The International Standard Classification of Occupation schema (International Labour Organization

(ILO), 1990), which was used to define the two socio-economic groups holds information on nine major categories. White-collar was defined according to the categories 1-4 in the schema, and blue-collar according to the categories 5-9. The parent or guardian in the household with the highest level of occupation was used to define the family's socio-economic position.

Habitual Physical activity

Instrumentation

HPA was assessed with the single channel piezo-electric accelerometer, Model 7164, formerly known as the Computer Science & Applications (CSA) accelerometer and more recently known as the MTI actigraph. The instrument is designed to measure and record vertical body accelerations ranging in the magnitude from 0.05 to 2.13g, and has been described in details by Tryon & Williams (1996).

Measurement protocol, data reduction, and data presentation

In both studies, the registration of HPA was performed during the academic third grade school year. Due to a limited number of accelerometers available in the study in 1997/98, only 550 children had their HPA level recorded, after being randomly selected. Sixty-four CSA units (purchased new in 1997) were used in the study in 1997/98. In the study in 2003/04, 25 MTI units (purchased new in 2003) were distributed to a total number of 425 children, and 24 CSA units (purchased new in 1997) were distributed to a total number of 33 children.

Children were asked to wear the accelerometer for at least five consecutive days, including both weekdays and weekend days. The accelerometer was returned by the participant and data downloaded at the day of the child's physical examination. In order to distinguish true zeroes from zeroes recorded where the accelerometer had been taken off, all data files were screened for

periods of zero activity. In cases of zero activity of 10 min or longer, it was assumed that the accelerometer had been taken off, and these periods did not contribute to the required minimum minutes of valid registered HPA. All children were asked to take off the activity monitor while they were asleep. However, “Activity” between 00.00 and 06.00 h was cut away in all data files in order to avoid biased data, caused by the fact that some children forgot to take off the accelerometer.

Given these criteria, HPA data were included for further analyses if the child had accumulated minimum 10 hours of activity data per day for at least 3 days. Finally, suspicious recordings highlighted by the data-reduction program developed within the framework of “The European Youth Heart Study”, as well as extreme records highly questionable of being produced by normal human locomotion, were checked manually and excluded for further analyses if generated by broken instruments.

The data reduction program was set up to analyse activity data on a daily basis, which revealed significantly different HPA levels between weekdays and weekend days. Other have supported the idea of different levels of PA when distinguishing between weekdays and weekend days (Klasson Heggebo & Anderssen, 2003). However, according to our findings Friday apparently is to be regarded as a weekend day in this context in third grade children, meaning that the lowest activity estimates in general were found on Fridays, Saturdays, and Sundays (Kristensen et al., 2007). The distribution of day types (i.e. Mon-Thu vs. Fri-Sun) differed significantly ($p < 0.001$) between the two samples of children examined in 1997/98 and 2003/04, respectively. Therefore, when describing the differences across socio-economic gradients, children’s activities achieved during Mon-Thu were weighted by 4/7 and activities achieved during Fri-Sun were weighted by 3/7, thereby estimating one variable taking the different levels of HPA across different day types into account. This procedure was performed in order to a) achieve valid mean levels of HPA, b)

prevent biased differences, and c) reduce the number of subgroups being compared, thereby minimizing the issues related to multiple testing.

In order to yield a measure of average HPA intensity, data were expressed as total counts per registered time of total minutes (counts*min⁻¹), which previously have been shown to correlate strongly (r=0.58) with free-living PA level measured by doubly labelled water (Ekelund et al., 2001). Furthermore, threshold ranges was set to define light intensity interval (METs≤3), moderate intensity interval (3<METs≤6), and vigorous intensity interval (METs>6) using a previously published age specific regression equation (Troost et al., 2002). Cut points (rounded to the nearest hundred) for light, moderate, and vigorous activity was 0-999, 1000-3599, and >3600 counts per minute, respectively. The number of minutes spend in the different intensity intervals was proportionally adjusted to a full day of 14 h (estimated awake time for this population) with the following equation: adjusted minutes = (observed minutes in interval)*(14*60/total minutes). The percentages of total time spend in light, moderate, and vigorous activity intervals were applied post hoc in order to examine whether comparable results were observed when discriminating between the total average HPA level and different intensity thresholds of HPA.

In the study in 1997/98 the epoch was set to 60 sec, and the study in 2003/04 used 20 sec epochs that subsequently were reintegrated up to 60 sec intervals.

Data quality

Acceleration responses were examined in all units before the data collection period to make sure that all instruments were functional, and in 2003/04 an additional initiative was undertaken to ensure the quality of data. Each time an accelerometer was returned from the field during the data collecting period, the instrument was checked under standardized conditions in a mechanical setup in the laboratory in order to ensure that the instrument maintained properly function.

Mean instrument acceleration response recognized in the MTI units, which were purchased new in 2003 was calibrated according to the average acceleration response observed in the CSA units, which were purchased new in 1997 in order to insure that the two different generations of instruments would provide similar standardized outputs. Calibration was performed in four different setting in a mechanical setup, which previously has been described by Brage et al. (Brage et al., 2003a), and outputs derived when performing calibration ranged in locomotion field speed from approximately 4.0 to 8.0 km*h⁻¹ (e.g. the range from walking to running) when compared with validation in children (Brage et al., 2003b).

Participants/non-participants

1997/98

In each case of a child not participating in 1997/98, the form master was asked whether the child differed from the rest of the class in any way. All the children not participating were described as being normal with respect to body weight and level of PA in comparison with their class peers, except one child who was autistic.

2003/04

After completing the data collection, body weight and body height was measured by the physician at the schools the children usual attended in all third grade children invited to participate in the study in 2003/04. Post hoc analyses revealed no differences in height, weight, or BMI between the non-participants and the children participating in the study.

Statistics

Linear regressions with robust standard errors were used to describe all potential differences in the level of HPA as the dichotomized parameter year of study was treated as the independent variable in the different models (i.e. 1997/98=0 & 2003/04=1, respectively).

An interaction term between a) year of study and day type, and b) year of study and SES was applied to the different regression models in order to test for possible polarized differences across day types and socio-economic gradients, respectively.

Reliability is related to the accumulated number of valid days when monitoring HPA at an individual level (Trost et al., 2000). Therefore, all differences were presented both as crude estimates and as adjusted estimates weighted according to the accumulated number of valid days.

An interaction term between gender and day type was applied post hoc in both samples of examined children in order to examine whether gender differences in the level of HPA differed when distinguishing between the days Mon-Thu and the days Fri-Sun.

All statistical analyses were performed using STATA 8.

Ethics

All parents gave written informed content for their daughter/son to participate, and all children gave verbal content. The study was approved by the local scientific ethics committee for the counties of Vejle and Funen, and follows the rules stipulated in the Helsinki declaration.

Results

Valid activity

In the study in 1997/98, valid HPA was obtained in 381 children (203 girls and 178 boys) during Mon-Thu, and during Fri-Sun 349 children (183 girls and 166 boys) had activity data recorded, as

determined by the criteria set to define valid data. The mean number of valid days accumulated during Mon-Thu and during Fri-Sun were 2.25 ± 1.02 and 2.11 ± 0.77 , respectively, and average daily registered times (minutes) were 790 ± 59 and 757 ± 66 .

In 2003/04, 416 children (238 girls and 178 boys) provided valid activity during Mon-Thu, and 416 children (240 girls and 176 boys) also met the inclusion criteria during Fri-Sun. The mean numbers of valid days accumulated during Mon-Thu and during Fri-Sun were 2.10 ± 0.57 and 2.39 ± 0.68 , respectively, and average daily registered times (minutes) were 801 ± 69 and 785 ± 78 .

Mean ages for girls and boys who achieved valid HPA data in 1997/98 were 9.6 ± 0.4 and 9.7 ± 0.4 years, respectively. Mean body weight (kg) for girls was 33.0 ± 6.1 and boys' average body weight was 33.8 ± 6.3 .

In 2003/04, mean ages were 9.7 ± 0.4 and 9.9 ± 0.4 years for girls and boys, respectively. Girls' mean body weight was 34.2 ± 6.9 , whereas mean body weight for boys was 34.5 ± 7.0 .

Socio-economic status

Information on SES was available on 559 and 423 children in 1997/98 and 2003/04, respectively. The number of children not only provided with socio-economic information but also with valid HPA data during both Mon-Thu and Fri-Sun was 333 (171 girls & 162 boys) in the study in 1997/98, and 391 (224 girls & 167 boys) in the study conducted in 2003/04.

Differences across gender and day types

In girls, no significant differences were observed in the level of HPA during Mon-Thu or Fri-Sun between 1997/98 and 2003/04, neither when performing crude analyses nor when applying adjusted weights according to the accumulated number of valid days. When performing the crude analysis, a borderline significant ($p=0.082$) interaction was observed between year of study and

day type in girls, indicating a tendency towards a polarized change in the level of HPA across different day types between 1997/98 and 2003/04. The tendency towards interaction decreased ($p=0.141$), however, when performing the adjusted analysis weighted according to the accumulated number of valid days (Figure 1 & Table 1).

In boys, no significant differences were observed in the level of HPA during Mon-Thu or Fri-Sun, neither when performing crude analyses nor when applying adjusted weights according to the accumulated number of valid days (Figure 1 & Table 1).

Day type and gender variations

Significantly gender and day type variations have previously been observed in the level of HPA in the two samples of children being examined in the present study (Kristensen et al., 2007). In the present study, an interaction was furthermore observed between gender and day types in both samples ($p=0.01$ & $p=0.04$, respectively). Post hoc analyses revealed that gender differences in the level of HPA were more distinct during Mon-Thu than during Fri-Sun. During Mon-Thu in 1997/98, boys were found to be 28% more active compared to girls ($\beta=170.9$, $p<0.001$), whereas boys only reached 11% more activity than girls during Fri-Sun ($\beta=66.8$, $p=0.027$). During Mon-Thu in 2003/04, boys were 25% more active than girls ($\beta=154.3$, $p<0.001$). During Fri-Sun, however, boys were only found to be 16% more active compared to the girls ($\beta=90.8$, $p<0.001$) (Figure 1).

Differences across socio-economic gradients

No significant changes in the level of HPA had occurred across socio-economic gradients between 1997/98 and 2003/04 in girls or boys, neither when performing crude analyses nor when applying adjusted weights according to the accumulated number of valid days. Furthermore, no significant

interaction was observed between year of study and SES in girls or boys, indicating no polarization in the level of HPA across socio-economic gradients between 1997/98 and 2003/04 (Figure 2 & Table 2).

Post hoc analyses examining differences in the percentage of total time spend in light, moderate and vigorous activity intensity intervals

The average daily accumulated minutes in the different intensity intervals can be seen in Table 3.

When performing post hoc analyses describing the potential differences across light, moderate, and vigorous activity intervals, girls were found to spend significantly less time ($\approx 1.3\%$) in the light intensity interval during Mon-Thu but significantly more time ($\approx 1.1\%$) in the moderate intensity interval in 2003/04 when compared to 1997/98. During Mon-Thu, boys spend significantly more time ($\approx 1.2\%$) in moderate intensity interval in 2003/04 when compared to 1997/98. Compared to 1997/98, a tendency was observed that blue-collar girls did spend less time ($\approx 1.9\%$) in the light intensity interval but more time ($\approx 1.2\%$) in the moderate intensity interval in 2003/04, after adjusting for the accumulated number of valid days. Tendencies towards polarized differences in the percentage of total time spend in light, moderate and vigorous activity level was observed in girls across day types between 1997/98 and 2003/04.

Discussion

According to the best of our knowledge, this study is the first to examine potential differences in the level of HPA over time in two large comparable groups of randomly selected children when using objective assessments by the use of accelerometers. The study has one main finding and two secondary findings.

Firstly, no significant differences had occurred in the level of HPA (i.e. counts*min⁻¹) between 1997/98 and 2003/04, neither when paying special attention to different day types nor when looking at the two samples across socio-economic gradients.

Secondly, in agreement with previous findings (Falgairette et al., 1996) gender differences were found to be more distinct during Mon-Thu than during Fri-Sun.

Thirdly, when examining differences across different intensity intervals post hoc, evidence of a slightly changed HPA behaviour was observed in the light and moderate intensity level during Mon-Thu, and in the blue-collar girls.

Differences in the percentage of total time spend in light, moderate and vigorous activity intensity intervals

The present results observed across the percentage of total time spend in light and moderate intensity intervals were all logical explainable when compared to the present results describing the differences in the average total HPA level (i.e. counts*min⁻¹). Hypothetically, increased participation in organised sports (often placed during weekdays) could add to the explanation of the observed increase in time spend in moderate intensity level and the observed tendencies towards polarized differences in the percentage of total time spend in light, moderate and vigorous activity level across day types in girls between 1997/98 and 2003/04. We have no data available to support this hypothesis, however, increased participation in sport clubs has previously been observed during recent decades in youth in Scandinavia (i.e. Sweden) (Westerstahl et al., 2003). In general, it should be emphasized that multiple tests were performed when applying post hoc analyses across different intensity levels of HPA, and after Bonferroni's correction no significant differences between 1997/98 and 2003/04 were observed. Furthermore, substantial controversies have been related to the standard definition of PA threshold cut-points in accelerometers and the

appropriate length of epochs in the research literature. An epoch period set to one minute when measuring children will falsely reduce the time spent in high or vigorous activity levels substantially (Nilsson et al., 2002) due to the short burst nature of physical activity in this population. This, of course, will add to the reservations and limitations when interpreting results discriminating between different intensity levels of HPA.

Previous studies examining differences or secular trends in physical activity in children and young people

Rather few studies have been designed and conducted in order to examine differences or secular trends in the level of HPA in children or young people. However, a study by Eisenmann et al. (2004) proved evidence of increased leisure time PA in Canadian adolescents between 1981 and 1988, but thereafter activity remained relatively stable until the end of examination in 1998.

Evidence supporting stable conditions has been observed in US adolescents in a study by Pratt et al. (1999) who observed no decline in self-reported vigorous PA between 1993 and 1997.

Generally, stable conditions in vigorous physical activity and TV watching of adolescents have also been recognized from 1986 to 2002 in seven European countries (Samdal et al., 2006). In a previous Danish study, Holstein et al. (2007) found no evidence of a changed proportion of 11 and 13 years old children who reported to be vigorously physical active or physically inactive in their leisure-time when examined in the period 1988 to 2002. However, the proportion of 15 years old adolescents who reported to be physically inactive had increased during the same period of time, whereas the proportion of adolescent boys being vigorously physical active was observed to decrease.

Other surveys, which previously have examined differences or secular trends in PA in children or adolescents, have typically focussed on PA data in a range of more specific contexts due to the

absence of suitable baseline data representing a more copious spectrum of PA. No evidence of an overall declined participation in physical education classes and activity during these classes was observed among adolescents when examined in 1991 and 2003, respectively (Grunbaum et al., 2004; Lowry et al., 2004). In another study from Sweden (Westerstahl et al., 2003), more adolescents were found to participate in leisure-time sports activity in 1995 than in 1974, whereas a considerable decrease in the level of leisure-time PA was observed in Scottish adolescents between 1987 and 1991 (Uitenbroek & McQueen, 1992).

However, these surveys all used questionnaires or interviews when quantifying the level of PA. Subjectively statements on PA (e.g. intensity and duration) may be biased by decreased levels of fitness or reduced exposure of specific activities, which falsely might cause an increased level of perceived exertion. Furthermore, self reports will generally challenge the validity of the observed results, as previously described in the paragraph "*Introduction*".

Inconsistent results published in the research literature might at least partly be due to various definitions used in order to capture the concept PA, as well as due to different measurement techniques applied when assessing PA. However, in a recent review Dollman et al. (2005) concluded that there is no evidence supporting that PA is declining in children and young people when no particular contexts of PA are specified. However, PA in clearly defined contexts such as transportation, organised sport, and physical education in school settings was reported to be declining in several countries.

According to the best of our knowledge, no other study has previously examined if differences or secular trends in HPA differed across socio-economic gradients in a large scale population study in children. However, during the years 1990 to 2002 persistently increased levels of leisure time vigorous PA was observed in children with high SES when describing the socio-economic patterning of PA (Inchley et al., 2005). Rather inconsistent findings have generally been reported

when examining the association between SES and PA in younger people in single cross sectional studies (Sallis et al., 2000). However, in adults low education has been found to be adversely related to the level of PA when examined during follow up in a longitudinal study (Droomers et al., 2001). A positive association between SES and PA in adults has also been observed by Galobardes et al. (2003). However, the disparity remained stable throughout the examined period from 1993 to 2000, thereby failing to prove evidence of any further adverse secular trends across socio-economic gradients.

General strengths and limitations

The major strengths in this study imply objectively assessment of HPA in two large cohort studies where identical sampling procedures were applied. In both studies the sampling frame was a complete list of public schools in the municipality of Odense (Odense is the third largest city in Denmark).

Limitations in the present study include the relatively large number of non-participants, especially in the study conducted in 2003/04, as well as the rather subjective statement given by the form master when considering participants vs. non-participants characteristics in 1997/98.

Considering the thorough sampling procedure introduced to secure a representative sample of third grade children, as well as the acceptable participation rate, we find no reasons to believe that the study in 1997/98 suffered from severe selection bias, although questionable if only one non-participating child differed with respect to body weight and PA level when compared to the class peers. In the study in 2003/04, we were extraordinarily offered access to anthropometric measurements (i.e. height, weight, and BMI) on all third grade children invited to participate in the present study. Subsequent analyses did not reveal any differences between participants and non-participants, as already described in the paragraph "*Participants/non-participants*". These

findings, combined with the use of identical sampling frame used in the study in 1997/98, also indicate that the sample in 1997/98 did not suffer from bias caused by non-participants, especially considering the higher participation rate when compared to the study conducted in 2003/04.

Data quality and validity

Valid activity files

In the end, valid activity files during Mon-Thu were reached in 70% and 91% of the total number of children being monitored in 1997/98 and 2003/04, respectively. During Fri-Sun, valid activity files were achieved in 63% and 91% of the children registered in 1997/98 and 2003/04, respectively. This indicates a substantial number of children, especially in the study in 1997/98, not meeting the criteria set to define valid data. The increased number of children in 1997/98 not meeting the criteria of inclusion is explained in particular by an increased number of instrument breakages in the study in 1997/98. However, in 2003/04 this problem was substantially reduced due to the quality checks performed in order to insure that the instruments maintained properly function.

Furthermore, due to an excessive number of instruments available in the study in 2003/04 it was possible for us to ask a child to wear the accelerometer again, if forgotten to begin with. However, the reduced exclusion of children who failed to reach valid HPA files in the study in 2003/04 was predominantly explained by a reduced number of instrumental breakdowns, which must be expected to be random across the range of PA level (i.e. non-differential selection). Therefore, although valid activity files were reached more frequently in children in the study in 2003/04 we find little reason to believe that the figures describing the differences in the level of HPA were biased by the increased number of subjects being excluded due to instrument breakages in the study in 1997/98.

The final number of children complying with all inclusion criteria might not seem impressive. However, especially after having discovered the considerable amount of broken instrument, missing data, and limited number of valid days we believe that the thorough precautions carried out in order to increase data quality should not be compromised in order to increase the participant rate, as this indeed would reduce the data quality and validity.

Due to instrumental breakages and the limited number of children both complying with information on SES and the inclusion criteria set to define valid HPA files the sample sizes were substantially reduced when distinguishing between children coming from families with different socio-economic backgrounds. This caused that only poor statistical power could be obtained when comparing differences in HPA across socio-economic gradients. In fact, a post hoc analysis revealed that with the statistical power set at 0.8 it was only possible for us to detect mean differences ranging from 73 to 110 counts*min⁻¹ when comparing differences in HPA in specific socio-economic subgroups of boys and girls, respectively.

Minimum number of registered valid days

Four days of PA registration has previously been shown to be representative of a whole week (Troost et al., 2000). However, in order to reduce the number of children failing to reach the required minimum number of valid days in the present study we included the child if she or he accumulated valid activity in minimum three days, since the interest in HPA was placed on a group level. In order to try to compensate for any possible reduced validity especially in subjects encumbered with a more limited number of valid days, all analyses describing the potential differences in HPA were performed both as crude analyses and as adjusted analyses weighted according to the accumulated number of valid days (i.e. more valid days equal higher weights). However, adjusted analyses did not introduce any appreciable effects - although not identical with

the crude results. Part of the explanation for this observed limited effect probably lies in the fact that the majority of all children actually accumulate the same number, or very close to the same number, of valid days. Furthermore, post hoc analyses revealed no difference in the level of HPA between the children who achieved 3 valid days and the children who achieved 4 valid days or more. Therefore, on a group level we believe that our figures represent a realistic estimation of the level of HPA.

Reactive modification of the physical activity level

When accelerometry is applied in order to register the level of HPA in children it might introduce an undesirable reactive behaviour. Hypothetically, this could partly be explained by an increased motivation or awareness and interest when having the personal level of PA registered, possibly leading to a modified level of PA in children being monitored. Such a problem is hard to avoid, unless repeated measurements are performed. However, in large scale population studies the procedure of repeated measurements is less feasible. Observations indicating that the level of PA might be modified through the excitement of being selected to participate in a study where the daily PA level is monitored have been reported in adults (Stovitz et al., 2005). However, another study conducted in children revealed no indication of reactivity when assessing PA levels with pedometers (Vincent & Pangrazi, 2002). In the present study, no evidence of reactivity was observed when comparing the level of HPA in the first monitoring day with subsequent monitoring days post hoc, neither in 1997/98 ($p=0.40$) nor in 2003/04 ($p=0.65$).

Seasonal variations

The fact that registrations were performed during the academic third grade school year means that the monitoring of HPA was performed at different seasonal time points, which in the end will

contribute to an increased validity when trying to assess the mean level of HPA in a group of children. Seasonal variations are likely to be associated with outside temperature and other weather conditions, and data indicating that children's level of PA seems to be increasing during spring and summertime have previously been revealed (Goran et al., 1998).

Due to a comprehensive logistic work load assessments could not be initiated until the beginning of November in the study in 2003/04. Therefore, the study in 2003/04 did not include registrations in the months of August, September, and October. However, only ten children had their PA level monitored in August in the study in 1997/98, and a post hoc analysis controlling for the effect of months revealed no biased differences due to the effect of seasonal variations. Generally, even if assessments are distributed identically across the different months it might be hard to predict the change of biased results due to the effect of months when comparing different studies if you do not have any detailed retrospective information on the weather condition across the different months.

Biking and swimming

The validity of accelerometer based estimates of HPA is challenged in the field in particular if the subjects examined are frequently involved in biking or swimming activities, since assessment with the uni-axial accelerometer underestimates bicycling intensity with up to 90% when mounted to the hip (Brage, 2000), and since the instrument is restricted to a dry environment. It is well known that the Danish population is one of the most frequently user of the bicycle for transportation in the world, and Danish children have been reported to be even more frequently involved in biking activities than adults (Andersen & Haraldsdottir, 1994). Therefore, the absolute level of HPA is likely to be underestimated due to the poor registration of PA obtained from swimming and biking in particular. Potentially, substantial underestimation of these two specific activities will not only increase random variation in the PA level across the examined group of subjects, but in worst case

a possible general shifts in biking and swimming activities between 1997/98 and 2003/04 would of course strongly challenge the validity of the results describing the potential differences in the HPA level. In the present study, information was available in order to examine how often the children bike to school. A post hoc analysis revealed that 38% of all children reported to be using their bike for transportation when travelling to school, both in the study 1997/98 and in the study in 2003/04. This indicates no biased differences due to the poor registration of bicycling, although no general biking information was available.

Impact of socio-economic status on habitual physical activity

Although not being a question of research in the present study our figures indicate that boys with high SES are less physically active in comparison with boys coming from families with low SES - both in the study in 1997/98 and in the study in 2003/04. Usually controversies have related to whether SES and PA are positively associated or not related at all (Sallis et al., 2000). Therefore, the negative relation between SES and HPA observed in the present study can only be considered as an unexpected finding. Studies in both adolescents and adults (van Lenthe et al., 2005; Carver et al., 2005) indicate that cycling habits vary by socioeconomic characteristics, which in combination with the frequently biking of Danish children potentially will introduce a bias when trying to compare absolute levels of accelerometer-assessed HPA in children with diverse socio-economic backgrounds. However, a post hoc analysis revealed no difference across SES in the frequency of biking to school, neither in boys ($p=1.0$) nor in girls ($p=0.84$). Apparently, this indicates that bicycling did not cause biased levels of HPA across SES. It should be emphasized, however, that no information regarding general biking, duration, and intensity was available.

Conclusion

In conclusion, this study revealed no significant differences in the mean level of total HPA in Danish third grade children when compared in 1997/98 and 2003/04, neither when paying special attention to specific day types nor when looking at the two samples across socio-economic gradients. However, a limited statistical power caused by a combination of the large variation in HPA and the limited combined compliance with information on SES and valid activity files, should be considered when interpreting the results across socio-economic gradients. Gender differences in the level of HPA were found to be more distinct during Mon-Thu than during Fri-Sun. Although not statistically significant after Bonferroni's correction, post hoc analyses indicated that children during Mon-Thu did spend slightly more time in moderate and slightly less time in light intensity levels of HPA in 2003/04 when compared to 1997/98. A tendency was also observed that blue-collar girls did spend slightly more time in the moderate intensity interval in 2003/04 when compared to 1997/98.

Perspectives

This study does not support the idea that Danish children of today are getting less active. However, it should be emphasized that HPA levels were compared at only two different time points separated by six years. Therefore, it is not possible to predict potential long term changes in the level of HPA over several decades of time when solely based on the present results. Furthermore, further studies should be implemented in subjects of different ages in different countries in order to verify whether our results reflect more widespread trends.

The important issue of whether or not children and young people are active enough to reduce lifestyle related risk factors still needs to be further clarified. In relation to that the attention should be drawn to the importance of that adequate universal intensity cut-points, based on accelerometer

output validation performed when taking potential confounders (e.g. gender, age, body size, and biomechanical characteristics) into account, are established. Finally, our study indicates that gender and day type variations in the level of HPA are important aspects in relation to public health policies where interventions aimed to increase the level of PA in children and young people are planned or carried out.

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Table 1. Regression coefficients (β) describing differences in the level of HPA between 1997/98 and 2003/04. Regression coefficients are presented both as crude estimates and as adjusted estimates weighted according to the accumulated number of valid days. P-values are derived from robust standard errors

	Crude model			Adjusted model according to the accumulated number of valid days		
	β	95% CI	P	β	95% CI	P
Girls						
Mon-Thu	19.8	-19.3;58.9	0.319	21.3	-18.2;60.8	0.290
Fri-Sun	-34.8	-82.4;12.9	0.152	-24.3	-70.6;22.0	0.304
Test for polarized differences across Mon-Thu and Fri-Sun between 1997/98 and 2003/04			0.082	0.141		
Boys						
Mon-Thu	7.75	-46.5;62.0	0.779	4.6	-52.5;61.7	0.873
Fri-Sun	1.76	-53.2;56.7	0.950	-0.2	-57.5;57.1	0.994
Test for polarized differences across Mon-Thu and Fri-Sun between 1997/98 and 2003/04			0.879	0.906		

Table 2. Regression coefficients (β) describing differences in the level of HPA across socio-economic gradients between 1997/98 and 2003/04. Regression coefficients are presented both as crude estimates and as adjusted estimates weighted according to the accumulated number of valid days. P-values are derived from robust standard errors

	Crude model			Adjusted for weights according to the achieved number of valid days		
	β	95% CI	P	β	95% CI	P
Girls						
Blue-collar	29.5	-28.3;87.3	0.314	34.3	-21.0;89.6	0.222
White-collar	-22.9	-75.1;29.3	0.389	-20.3	-72.2;31.5	0.441
Test for polarized differences across blue- and white-collar between 1997/98 and 2003/04			0.185			0.155
Boys						
Blue-collar	-8.2	-86.6;70.2	0.837	-23.9	-108.0;60.3	0.576
White-collar	15.5	-46.3;77.3	0.622	27.8	-37.5;93.1	0.403
Test for polarized differences across blue- and white-collar between 1997/98 and 2003/04			0.640			0.338

Table 3. Average daily accumulated minutes in different intensity intervals (mean and SD). Minutes are adjusted to a full day of 14 h and presented across different day types (i.e. Mon-Thu vs. Fri-Sun)

	Mon-Thu				Fri-Sun			
	Girls 1997/98	Girls 2003/04	Boys 1997/98	Boys 2003/04	Girls 1997/98	Girls 2003/04	Boys 1997/98	Boys 2003/04
Light	686 (54)	675 (53)	645 (69)	634 (55)	684 (76)	690 (55)	665 (76)	661 (65)
Moderate	136 (48)	145 (45)	162 (54)	173 (43)	139 (63)	135 (48)	152 (62)	154 (54)
Vigorous	18 (17)	20 (15)	33 (25)	33 (24)	17 (19)	15 (12)	22 (23)	24 (20)

Figure 1. Gender distribution of habitual physical activity by day types and year of study. Columns are crude means \pm SE

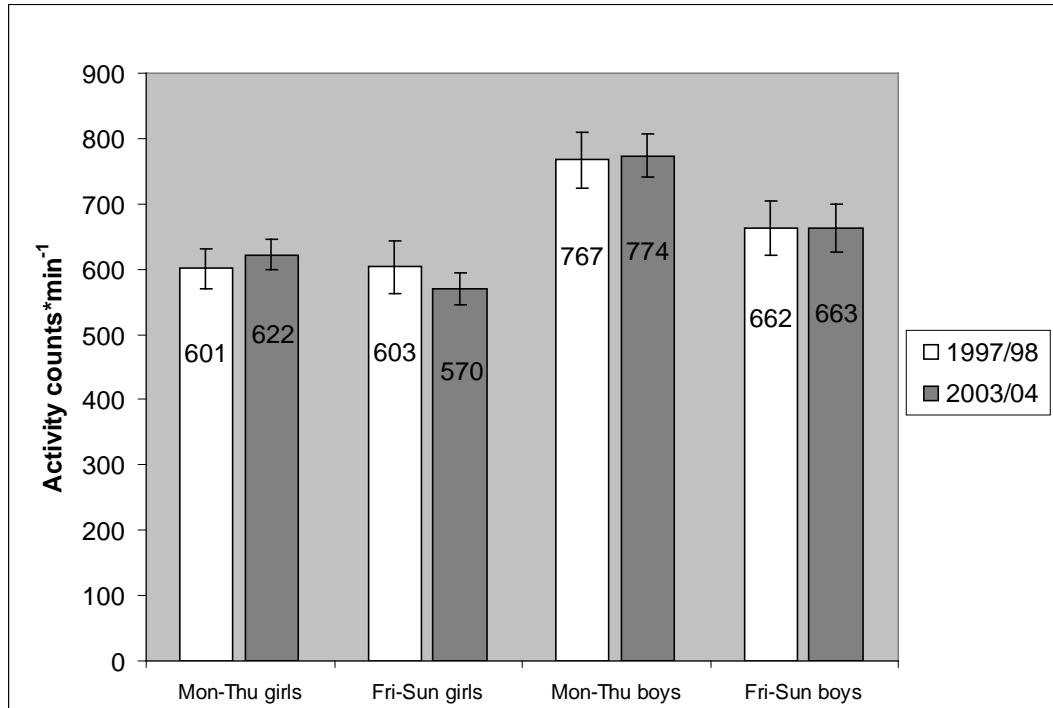


Figure 2. Gender and socio-economic status distribution of habitual physical activity by year of study. Columns are crude means \pm SE

