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END PIECE

A comparison between children's physical activity levels at school and learning in an outdoor environment

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Physical activity levels were measured with an accelerometer in a case study including 19 children, from nine to ten years of age, in a Danish primary school. The teachers conducted their teaching in a forest every Thursday from 2000 to 2003. The purpose of this study was to measure the students' activity levels during outdoor learning days in the forest and compare them with a traditional school day on the one hand, and a traditional school day including two physical education lessons, on the other. The mean activity levels were more than twice as high on the forest days measured on two occasions. Expressed in percentages, winter (2000) measurements were 106% (range 14–194%), and summer (2001) measurements were 113% (range 41–224%) higher compared to traditional school days. Furthermore, in 2002 the mean activity level measured on a day including two physical education lessons was equal to a day in an outdoor environment. In conclusion, this case study demonstrates a significantly higher level of physical activity when indoor and outdoor learning contexts are combined. From a physical health perspective outdoor learning is recommended in the folkeskole.

Introduction

Physical activity and health

The Department of Health in Denmark concluded after conducting a literature review in March 2001, that a significant decrease in physical activity had taken place in the Danish population (Sundhedsstyrelsen, 2001). Consequently, it was claimed there was a threat to the general health of one third of the Danish population. In

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addition, a 1997 research project concluded that the general health and physical condition of school aged children had changed for the worse over the past 10–15 years (Rasmussen, Due, & Holstein, 1998). According to experts, the recommendation is one hour of moderate activity every day (Biddle, Sallis, & Cavill, 1998; Sallis, 1993; Sallis & Patrick, 1994; US Department of Health and Human Services, 1997). Today, Danish Folk schools offer one to two hours of formal physical education (PE) every week. From a health point of view this is far from enough and the question is: what obligations do schools have to provide more? The voluntary sport system and informal recreational activities offer children and youth good opportunities for physical activity. However, they do not capture or reach the estimated 20–25% of young people with little or no interest in physical activities. Since children are required to spend at least 10 consecutive years in the school system, problems relating to the obvious lack of physical activity could be solved if this were given sufficient political support and priority. From a health perspective all children should get a chance to develop positive attitudes towards regular physical activity, well being and health during school time. It is well documented that physical activity reduces a number of risk factors such as blood lipids, hypertension, body fatness (Andersen & Haraldsdottir, 1993; Andersen, Henckel, & Saltin, 1989; Riddoch & Boreham, 1995) and heart disease (US Department of Health and Human Services, 1997).

Physical activity, health and nature

More recently, research projects in pre-school institutions have demonstrated an improvement in physical fitness, motor skills and coordination and a higher ability to concentrate when children were allowed to spend time in a natural area on a daily basis (Fjoertoft, 1999; Grahn, Mårtensson, Lindblad, Nilsson, & Ekman, 1997). In Grahn's study, children in a traditional kindergarten were observed and compared to children with access to nature every day. Not only was there a significantly higher fitness level found among children spending time in the nature setting, but also less sickness and an increased ability to concentrate was identified. As mentioned earlier, children are required to spend at least 10 consecutive years in the school system and from a health perspective it is important to analyse how PE, active learning in lessons, breaks and outdoor learning can support the development and positive attitudes towards physical activity and achieve the recommended daily activity level. In this context it is of primary interest to gather more evidence and knowledge about how much outdoor teaching and fieldwork influences the physical activity level if it is included in school time. Furthermore, attention needs to be drawn to the connection between physical activity and learning.

Outdoor learning and physical activity

From empirical and personal experience, many people in Denmark with outdoor experience would argue that outdoor education offers unique opportunities for

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learning because both physical activity and abstract thinking are combined. This combination stimulates the learning process in a different way compared to classroom and traditional schooling, but research on the possible mutual benefits between outdoor learning and physical activity has not been done in Denmark. A review by Rickinson, Dillon, Teamey, Morris, Choi, Sanders, and Benefield (2004) critically examined 150 studies on outdoor learning published in English between 1993 and 2003 which encompassed three main types of outdoor learning. There were: 1) fieldwork and outdoor visits; 2) outdoor adventure education; and 3) school grounds/community projects. Related to fieldwork and outdoor visits, it was summarised that:

> Substantial evidence exists to indicate that fieldwork, properly conceived, adequately planned, well taught and effectively followed up, offers learners' opportunities to develop their knowledge and skills in ways that add value to their everyday experiences in the classroom. Specifically, fieldwork can have a positive impact on long-term memory due to the memorable nature of the fieldwork setting. Effective fieldwork and residential experience in particular, can lead to individual growth and improvements in social skills. More importantly, there can be reinforcement between the affective and the cognitive, which each influencing the other and providing a bridge to higher order of learning (Rickinson et al., 2004, p. 5).

The evidence base for cognitive and physical/behavioural benefits is less strong than for affective and social outcomes in outdoor adventure programmes, but strong evidence of the benefits is provided in two meta-analyses of previous research (Cason & Gillis, 1994; Hattie, Marsh, Neill, & Richards, 1997). Taken together, these two studies provide strong support for the beneficial impact of outdoor adventure programmes on young peoples' lives through attitudes, beliefs and self-perception, in the short as well as the long term. School ground projects can also be linked with most subject areas of the curriculum. The most important impact on learning in school grounds/community settings include greater confidence, stronger motivation towards learning, a greater sense of belonging and responsibility and a more positive relationship between themselves and their teachers (Rickinson et al., 2004, p. 5). It is concluded that, compared with research on fieldworks/visits and outdoor adventure education, there is a need for a greater number of in-depth studies on outdoor learning in school grounds and community settings (Rickinson et al., 2004, p. 41). Finally, it is underlined that only very few studies focus on the impact of outdoor education programmes on physical activity.

Aim, hypothesis and research questions

In the current situation of an increasing number of inactive children in Denmark, the school is an important setting for physical activity. Students spend many hours in school every week, but physical activity seems limited to PE classes and breaks. Can outdoor learning lessons be a supplement to increase the weekly physical activity level among students in a state school? An opportunity to analyse this question arose when two teachers from Rødkilde School in Copenhagen created a new vision for their teaching. With support from their principal, they were allowed to relocate their class into a forest every Thursday in the years 2000 to 2003. The 'nature class' had

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20% of their compulsory lessons in the forest (including mathematics, Danish, history, etc.). Only English and PE were taught in the classroom and gym, respectively. The teachers in the present case study were not trained PE teachers and therefore PE was not a part of the teaching programme on outdoor learning days.

A research team was established to analyse how teaching in a natural environment influences children in primary school, their teachers and their parents (Mygind, 2005a; Mygind, Stelter, Dietrich, & Jacobsen, 2001). As a part of this multi-dimensional and cross-scientific research project, the present study aimed to compare the children's physical activity levels at school and during learning in an outdoor environment. It was expected that the children would show a higher mean activity level in the outdoor context compared to a normal school day. The specific research questions were as follows:

1. What are the individual and mean activity levels of the nature class when measured on normal school days including breaks compared with outdoor learning days?
2. What are the individual and mean activity levels of the nature class when measured on a normal school day including two hours of physical education (PE) compared with outdoor learning days?

Method

Children and data collection

The nature class comprised 19 children—14 girls and 5 boys—aged 9–10 years, who had the opportunity to spend every Thursday in the forest in the years 2000 to 2003. In 2001 the data collection included 20 children because a new boy joined the class and stayed for half a year. It was decided to measure the physical activity level three times in the forest and three times on normal school days. The first data collection was performed on a school day and a forest day, respectively in December 2000 (winter) and again repeated in May 2001 (summer). In spring 2002, measurements were made during teaching in the forest and on a normal school day including two PE lessons. In this connection it should be mentioned that from 2000 to 2003 a detailed schedule of the many different tests was established and approved by the teachers and parents (Mygind, 2005a, pp. 32–33) and in this light the measurements could only be executed once in 2002. Each time data collection took place in one setting (school), measurements also took place in the other setting (forest) within one week to fourteen days. It was decided to include activity measurements during the time spent travelling (by train) on forest days because the teachers often used this time to prepare the day and/or make summaries of the day. Thus, the outdoor education days were 1–1.5 hours longer than normal school days. Data collection took place continuously in lessons as well as during breaks. In order to interpret some of the activity patterns on a traditional school day and a forest day examples of the content of the days are given in more detail in Tables 1 and 2.

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Accelerometer and epoch time

Physical activity was measured by the CSA (Computer Science & Applications) 7164 activity monitor. The CSA is an accelerometer designed to ascertain normal human movement. It is easy to wear and is very light (70 grams). The children became accustomed to the monitor by wearing it before recording. It was secured directly to the hip using an elastic belt that was fitted to each child. A single, vertical-axis piezoelectric bender element is displaced with movement and generates a signal proportional to the force acting on it. A microprocessor digitises the acceleration signal which is compiled over a programmed epoch interval. The monitor allows summarising activity from 6 second intervals up to one minute. As children's habitual physical activity is characterised by short bursts (often less than 10 seconds) of activity, an epoch was set at 6cps (counts per second) during data collection in winter 2000 and summer 2001. In 2002 the epoch time was set to 10cps to be sure that the number of hours for data collection was sufficient. Among CSA monitors only a variation of less than ±5% was accepted during calibration and in order to validate results further, each CSA monitor was numbered and used by the same child each time the measurements took place in the two educational contexts. Because of use in other research projects it was not possible to use exactly the same CSA 7164 monitor from year to year. The CSA monitor has been assessed as being a very useful tool for estimating energy expenditure among children and youth (Janz, Witt, & Mahoney, 1995; Trost, Ward, Moorehead, Watson, Riner, & Burke, 1998), and more recently the monitor has been further validated (Brage, 2000). The data were analysed using a non-parametric technique. Differences between physical activities in the two educational contexts were examined using the Wilcoxon Signed Ranks Test.

Results

Comparison of traditional school days and outdoor learning days

A significant difference was found when comparing a traditional school day with an outdoor learning day in 2000 and 2001 (both $p<0.001$). The mean activity level was more than twice as high during outdoor learning days as compared to traditional school days as demonstrated in Figures 1 and 2, which represent data collected during winter 2000 and summer 2001, respectively. Much variation in activity patterns was found between the children in both winter and summer measurements. Expressed as a percentage, the mean physical activity levels during winter (2000) outdoor learning days were 106% (range 14–194%) and during summer (2001) measurements 113% (range 41–224%) higher, respectively, than a traditional school day .

In Figures 3 and 4 the activity levels are demonstrated for one boy during a traditional school day and a forest day, respectively. Further details about the lessons of the day are given in Table 1 and 2.

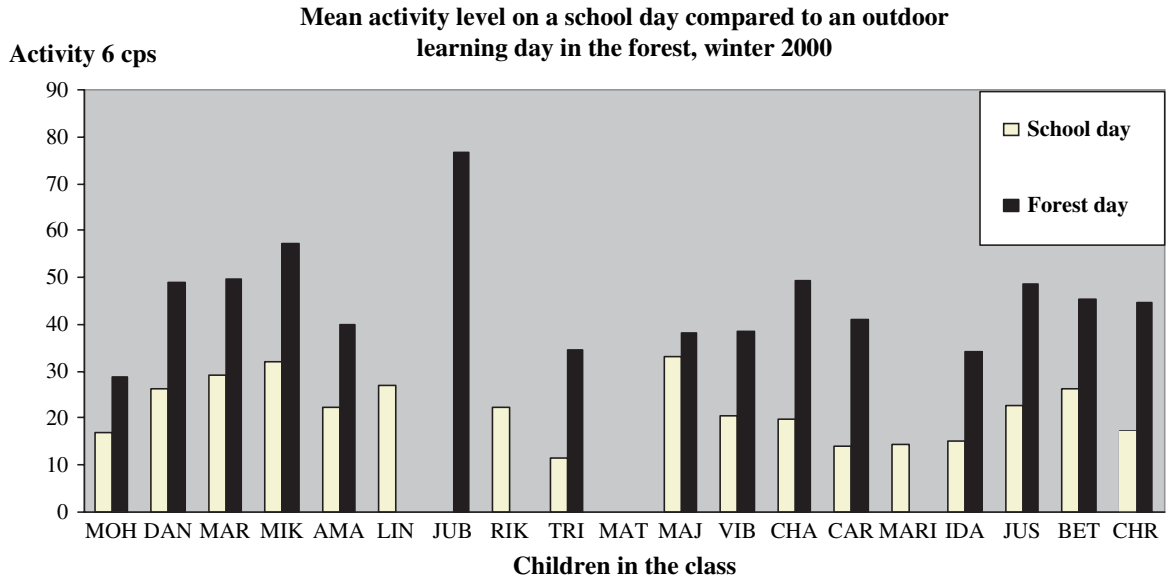

Figure 1. The mean physical activity levels (6cps) for each child are pictured representing a traditional school day and an outdoor learning day, respectively. Comparisons can only be made between 14 children as 5 children were absent on one or both days

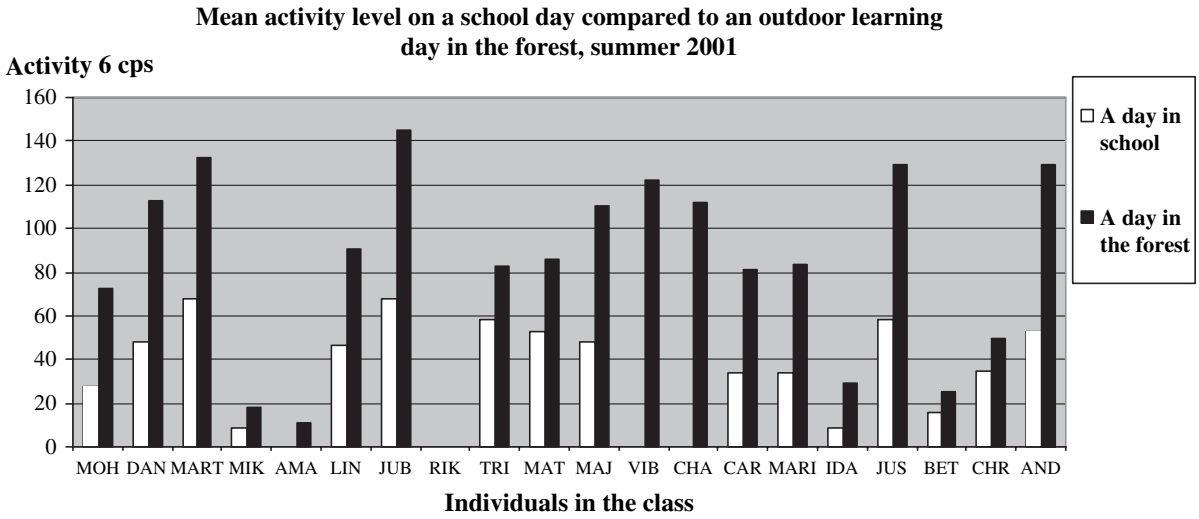

Figure 2. The mean physical activity levels (6cps) for each child are pictured representing a traditional school day and an outdoor learning day, respectively. Comparisons can be made between 16 children. Four children were absent on one or both days

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Comparison of a school day including two PE lessons and an outdoor learning day

In May 2002, a comparison was made between a traditional school day including PE and a day in the forest. Unfortunately, only nine children had comparable data sets (Figure 5). Illness and, on four occasions, malfunction (missing data) during PE

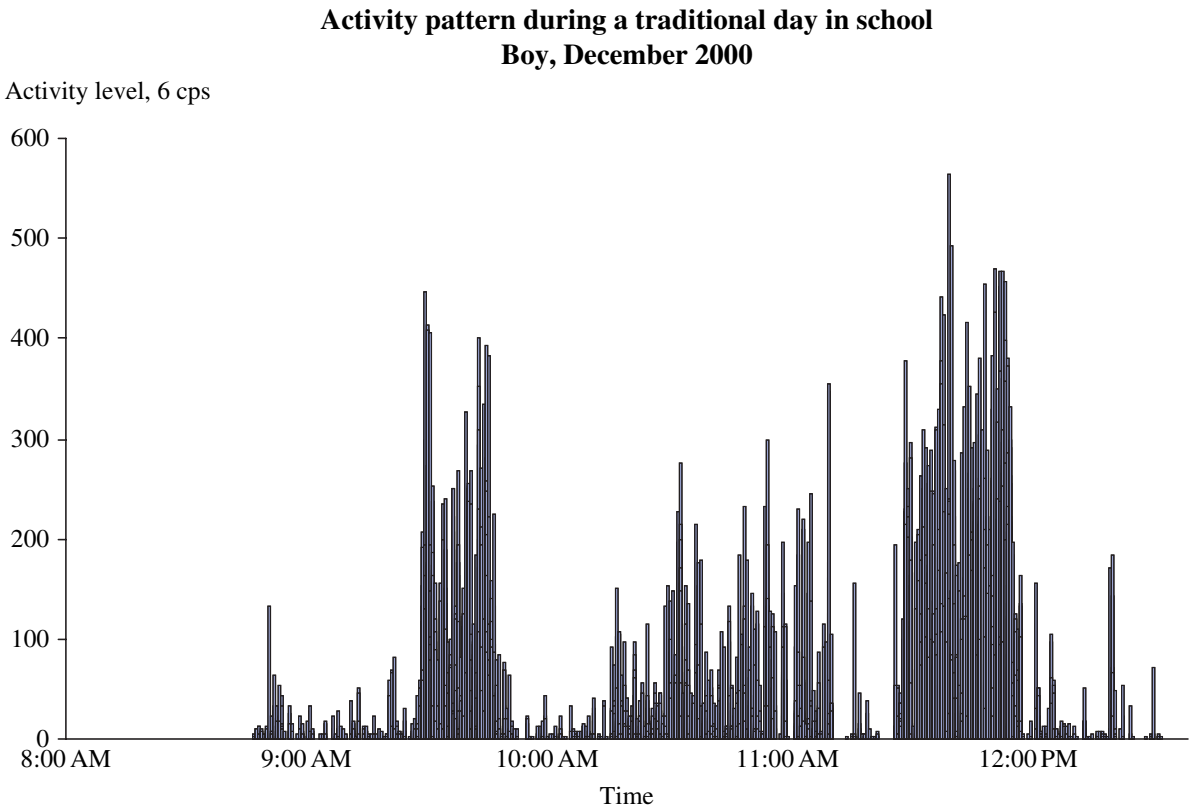

Figure 3. Variations in physical activity (6cps) for one boy during a traditional school day. Breaks were just before 10:00am and around 12:00pm. For further details see Table 1

activities caused a decrease in the number of comparable samples. The mean activity levels in the two educational contexts were 175 10cps and 170 10cps, respectively (see Figure 5). No differences were found in the mean activity levels between the two educational contexts ($p<0.52$).

Forest days were generally characterised by moderate and continuous activity with intermittent bursts of high activity. Examples are given in Figures 4 and 7. The school day with PE lessons from 8:00–9:30am showed a general high intensity level of activity as a consequence of the sport chosen on that particular day (Figure 6). The boys trained and played basketball while the girls undertook relays and interval runs in separate gym halls. Heart rate monitors were not used, but from direct observation, the PE lessons could be defined as high intensity training stimulating motor skills as well as the central cardiovascular system and aerobic fitness.

Discussion

The main purpose of the present case study was to compare how different educational contexts have an impact on the physical activity levels of school children. Physical activity patterns were analysed across three different learning fields

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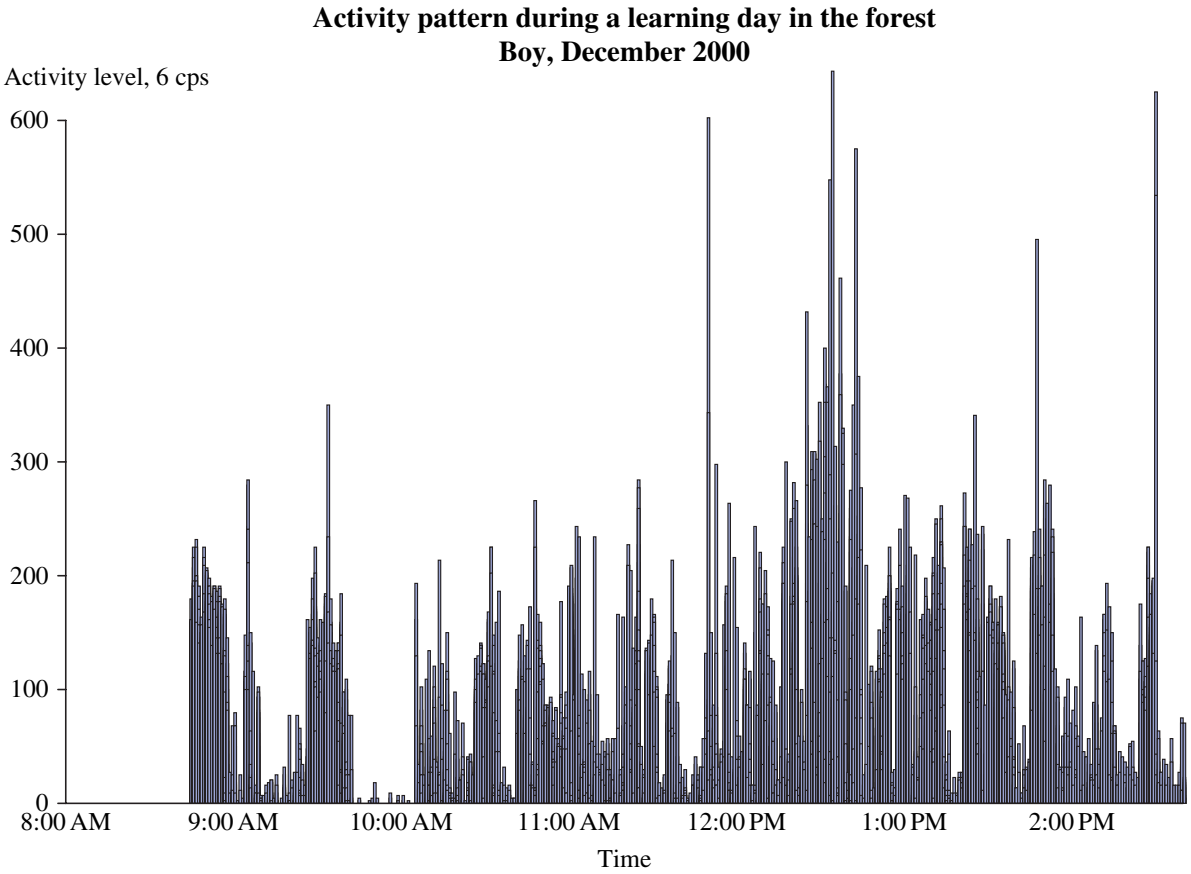

Figure 4. Variations in physical activity (6cps) for one boy during outdoor learning between 8:00am and 3:00pm. Lessons and breaks are included. For further details see Table 2

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including lessons and breaks: (1) three school days in the forest (2) two traditional school days and (3) one traditional school day including PE lessons. Very few schools included outdoor learning in the year 2000 but today, an increasing number of teachers use the outdoor environment as a learning field and more than 60 schools in Denmark have outdoor teaching programmes included in the schedule in primary schools (www.udeskole.dk). Many teachers are convinced that outdoor learning has a positive impact on physical activity. However, previous research has not quantified or measured activity levels in indoor and outdoor educational contexts and from that perspective, the present study was expected to give research-based evidence.

The expected higher physical activity level during outdoor learning measured by CSA accelerometers confirmed the hypothesis in the present case study and thus adds quantifiable evidence to the experience given about physical activity and learning in an outdoor environment. Children in the traditional school environment are expected to be sedentary, stay calm and concentrate on what the teacher has to say, read or write, etc. In the forest with no tables and chairs, teachers have to plan and organise their teaching in other ways.

Table 1. Observation at school on Monday, 4 December 2000 (see also Figure 3)

8:00am	Christmas stories and singing.
8:30	Different Christmas activities in the classroom
9:30	Break
9:50	Mathematics
10:20	Mathematics, work in groups measuring height, length of arm, legs, steps etc.
11:30	Break
12:05pm	Maths continued
12:45	End of school day

Table 2. Observation of a forest day on Thursday, 7 December 2000 (see also Figure 4)

8:00am	Christmas story telling.
8:15	Teacher explained how to navigate in the forest. Symbols, map reading, tracks, campsite, etc.
8:40	Walk to the train
9:00	Travel by train
9:30	Walk to a house in the forest (Bakkehus) to pick up relevant material
9:50	Answering a questionnaire inside the Bakkehus
10:10	Walking through the forest. Orienteering activities in two groups and in two different parts of the forest, theory of map reading, etc.
11:30	A short lunch break at the camp fire and orienteering activities are continued
12:20pm	End of the first orienteering activities
12:30	Break
12:50	Orienteering activities: searching for the control placed by the other group
13:45	Return to the Bakkehus
14:45	Finish at Rødkilde School

Physical activity during teaching in- and outdoors

The teachers in the present case study were not trained PE teachers and therefore PE was not a part of the teaching programme on outdoor learning days. This should be kept in mind during interpretation of the results. The main goal was to improve and develop teaching methods and learning processes related to mathematics, Danish, history, etc. The results in this study showed that an outdoor learning day more than doubled the mean activity level when compared with a traditional school day. If expressed in percentages, the mean activity level was 106% (measured in December 2000) and 113% (measured in May 2001) higher on outdoor learning days than on traditional learning days. When analysing the activity patterns of all the children in the forest, the majority of the day covered low to moderate activity with sporadic peaks reaching high intensity levels (see Figures 4 and 7). All the children showed a lower activity pattern on the traditional school days with bursts of medium or high intensity levels only during the breaks (Figure 3).

Teaching in the forest included more problem solving tasks and the children worked together in small groups. The children took responsibility to solve the problems given

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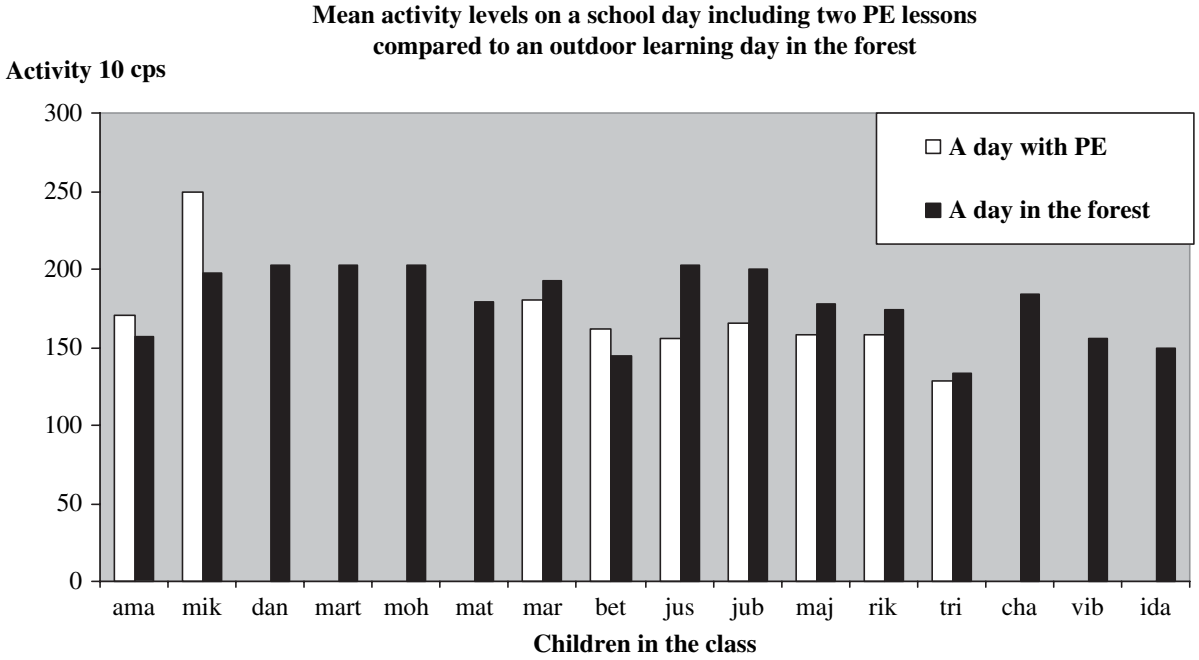

Figure 5. The mean physical activity levels for each child are pictured representing a traditional school day including two lessons of PE and an outdoor learning day, respectively. Comparisons can only be made between nine children

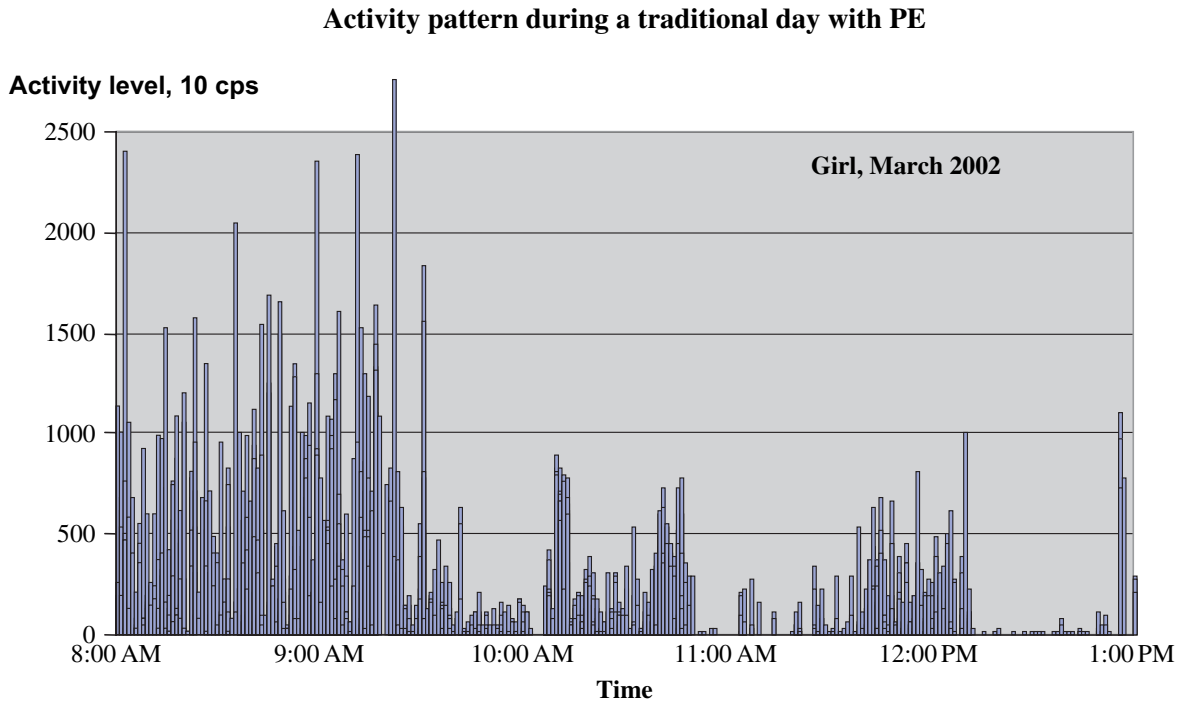

Figure 6. Variations in physical activity (10cps) of one girl during a day at school with two lessons of PE (8:00–9:30am). After PE there were lessons of Danish and Maths until 1:00pm with breaks just before 10:00am and around 12:00pm

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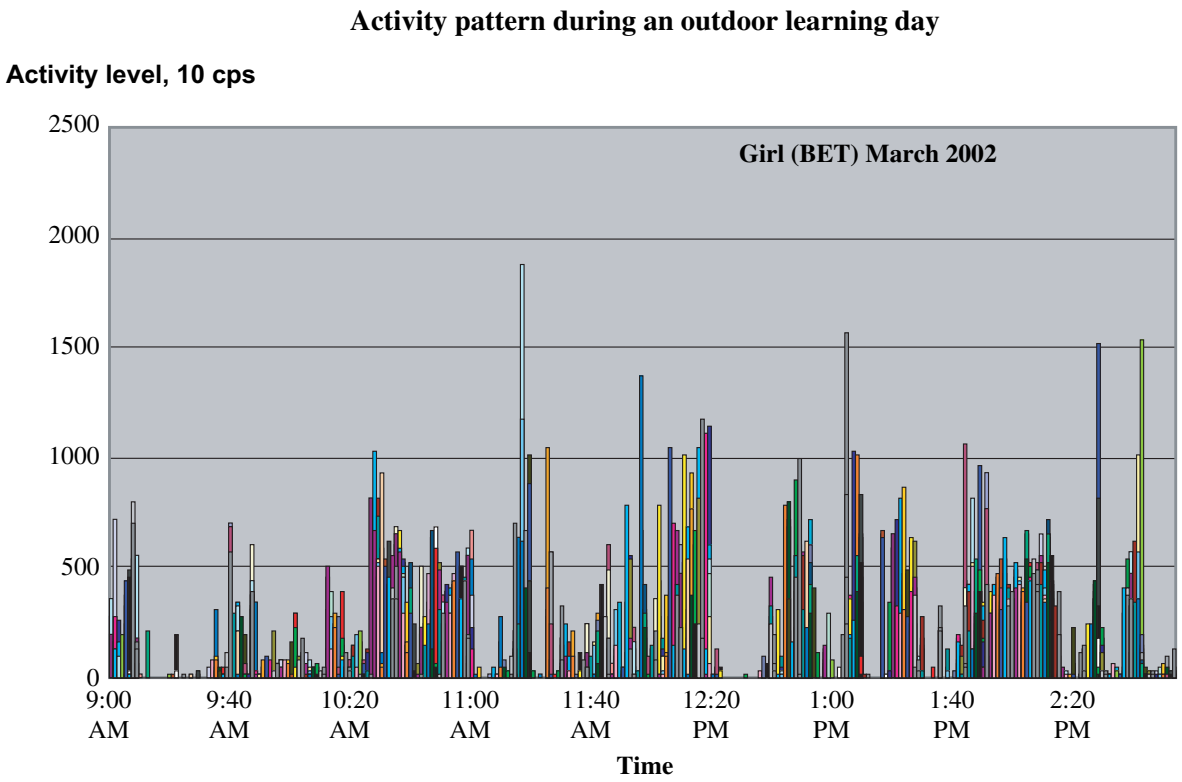

Figure 7. Variations in physical activity (10cps) of one girl during an outdoor learning day including Danish, maths and history. From 9:00– 9:40am was accounted for by travelling by bus and train, and then walking to the location in the forest accounted for 9:40-10:00am. Outdoor learning activities continued until 2:00pm including a break around 12:30

under supervision of the two teachers (Mygind, 2005a). On rare occasions the teachers would use inductive teaching methods in the classroom and in fact this happened on one of the days where the activity measurements took place. In mathematics, the teacher decided to involve the children in group work and the children were told to measure different objects inside and outside the classroom. Consequently, the activity increased to a moderate level (see Figure 3 from 10:20 to 11:30am). The activity pattern from this teaching session has much in common with the general activity pattern found during teaching activities in the forest (Figures 4 and 7) and illustrates how physical activity is connected to the teacher's choice of learning methods.

Validation and reflections about the measured activity level

From a physiological point of view, inactivity during teaching seems to be the general and expected picture in the classroom, while outdoor learning seems to increase physical activity. It is not possible to make any generalizations from the gap in activity levels between the two educational contexts, but it should be mentioned that the day in the classroom in December 2000 differed from a normal teaching situation, because the day included group work and active learning. Consequently the outcome was a higher mean activity level than normal teaching situations. Furthermore, while measuring activity on the forest day in 2000 the children were required to answer a

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questionnaire about school life, social relations and physical activity (Mygind, 2005b). This rather unusual event caused a 40-minute period of total inactivity (see Figure 2 from 9:40 to 10:20am) which was not a normal situation on forest days. These examples speak in favour of an even higher gap in activity levels between the two learning fields. Although not quantified, statements from questionnaires answered four times during the project period by the children as well as statements from the teachers (Mygind, 2005b) and parents (Jacobsen, 2002) indicate that the general physical activity level was significantly higher during outdoor learning.

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Comparing one outdoor learning day and a school day with PE lessons

What are the individual and mean activity levels of the nature class when measured on a normal school day including two hours of physical education (PE) compared with outdoor learning days? The second research question was of special interest because the data make it possible to compare measured and described physical effort on a school day including two PE lessons and on an outdoor learning day. Unfortunately, it was only possible to collect data once in March 2002. Being part of a cross-scientific research project the numbers of times each researcher could interrupt the daily teaching were limited. Between 2000 and 2003 a detailed schedule of the many different tests was established and approved by the teachers and parents (Mygind, 2005a, pp. 32–33) and in this light the measurements could only be executed once in 2002.

Unfortunately, illness among the children and missing values reduced the number of measurements obtained (Figure 4). The mean activity levels were 175 10cps during one outdoor learning day compared with 170 10cps on a school day with two PE lessons (Figure 5). However, the results indicate that it is feasible to conduct such a comparison. In other words, no differences were found in the mean activity levels between the two educational contexts ($p<0.52$) and consequently, it could be argued that an outdoor learning day, from a physical movement point of view, has an impact equivalent to that of two regular PE lessons on a normal school day. This, however, does not mean that the physiological response or training effects were the same in the two contexts. From observation, the PE lessons were characterised by a very high activity level due to basketball activities (boys) and interval training and relay types of games (girls) on the day the measurements took place (Figure 6). From a physiological point of view, the PE lessons would be expected to stimulate the cardiovascular system to a higher extent than the forest activity (compare Figure 6 and 7), but this can not be verified as heart rate was not recorded. Due to the uneven and rough floor in the forest, a mainly coordinative and motor skill type of development is likely to take place, rather than a stimulation of the cardiovascular system. Nevertheless, from a health perspective the two contexts observed seem to complement each other and at the same time it addresses a question to the ongoing discussion whether physical activity in itself, or the active learning situation in the outdoor context, has a positive impact on learning.

Physical activity and cognition in children

'Core academic' programs seem to be prioritised and the importance of physical education or activity oriented programs in Denmark is more or less ignored. The same observation is described in other countries, i.e. the School Health Policies and Program Study 2000, where 'the percentage of schools that require physical education in each grade declines from around 50% in grades 1 through 5, to 25% in grade 8, to only 5% grade 12' (Burgeson, Weschler, Brener, Young, & Spain, 2001, pp. 291–292). Although the importance of physical activity and the connection to learning is not the main focus in the present study, a few comments will be addressed concerning this issue, because body and mind are one entity, and anything that happens to one will affect the other. The relationship between physical activity and mental functioning is of particular interest in the school system because such a large portion of the school day is spent working in the cognitive domain. It could be claimed that PE, as well as outdoor learning programs, are needed for their physical benefits, and therefore, the need to justify these programs for their cognitive benefits is not a major focus. Many educators believe that PE or outdoor activities have a positive impact on concentration, learning and academic success. In particular, four large-scale studies examining the effects on academic performance have been carried out: the South Australia study (Dwyer, Coonan, Leith, Hetzel, & Baghurst, 1983), the Trois Rivieres study (Shephard, Lavallée, Volle, LaBarre, & Beacage,1994), the Vanves project (Shephard, 1997) and Project SPARK (Sallis, McKenzie, Kolody, Lewis, Marshall, & Rosengard, 1999). In each of these studies time spent by students in PE was significantly increased at the expense of time spent in academic classes. In three of the studies, significant improvements in academic performance were found with increased PE, and in the fourth (the South Australia study), there were no significant differences in performance. These results are important because the extra time spent in PE has shown physical benefits and the use of school time for PE as opposed to academic subjects resulted in either improvements or no change in academic performance. These findings are relevant to the present case study where the mean physical activity level probably more than doubled every week over three years while combining academic subjects and physical activity. Educators have suggested that movement, particularly in very young children, stimulates cognitive development (Leppo, Davis, & Crim, 2000; Pica, 1997). This would suggest that it is the movement involved in activity that is important rather than the actual physical exertion.

Despite the findings of the four studies mentioned above, research findings have been conflicting and a strong relationship between physical activity and cognitive performance has yet to be established in order to strengthen the arguments for including, for instance, outdoor learning in the weekly schedule. More recently a meta-analysis studied the relationship between physical activity and cognition in children. A total of 44 studies were selected pertaining to the relationship between activity and cognition or academic performance in children (Sibley & Etnier, 2003). A significant overall effect size (ES) of 0.32 indicates that, for children, physical activity has a positive association

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with cognition. It is concluded that the effect found in the quantitative analysis brings consensus to a body of literature that in the past has been considered to be inconclusive and that 'the results of this analysis, however, suggest that physical activity may actually be related to improved cognitive performance and academic achievement and provides evidence for the argument that physical activity should be a part of the school day for both its physical health and cognitive benefits' (Sibley & Etnier, 2003, p. 253). In other words, the increased physical activity level found during outdoor learning is comparable to the total activity level of a normal school day including two PE lessons, and is of great importance if linked to physical health and cognitive benefits.

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Outdoor learning and overweight children

The activity patterns measured in the two learning fields in this Danish case study reflected the teacher's pedagogical strategies and from observations it was obvious that the outdoor environment is conducive to inductive learning methods, which include more physical activity as compared to the normal classroom situation. The outdoor environment, however, should not replace the traditional classroom setting, but should rather be complementary, as both learning contexts are important to children's needs. It is notable that two overweight children were two and three times more active on the forest day compared to a normal school day, respectively. This observation raises the question whether inactive and overweight children particularly, who do not like PE or sport activities, might benefit from compulsory teaching in the outdoors. Because the focus lies on thematic teaching and learning, physical activity opportunities are undertaken unconsciously, forming a serendipitous consequence of the teaching process. The role of outdoor learning and overweight children should be an area of future research. A compulsory combination of out- and indoor teaching might have the potential to activate the estimated 20% of young people with little or no interest in physical activities.

The Danish Folk School offers one to two hours of physical education lessons each week. In order to maintain or improve children's health, experts have recommended at least one hour of moderate activity every day. The outdoor learning days seem to be a good supplement to PE and a significant step in meeting these recommendations and with the above mentioned meta-analysis in mind, perhaps positive cognitive impacts should be expected. However, further physical activity measurements would be desirable in order to verify the results of the present case study and address some of the questions raised. Research in the combination of physical activity and academic learning (active learning) is of interest and a challenge for future research.

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