**Physical activity patterns of kindergarten children in comparison to teenagers and young adults**

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**Background:** Due to the increasing occurrence of obesity and low physical activity (PA) reported in school children there is a need to investigate PA patterns of preschool children. Our aim was to identify the PA of preschool children in comparison to the PA of teenagers and young adults.

**Methods:** PA of 104 Czech preschool children (aged 5–7 years), 1174 teenagers (aged 12–17 years) and 787 young adults (aged 18–24 years) was determined using Caltrac accelerometry. PA was evaluated on the basis of activity energy expenditure (AEE – kcal kg⁻¹ day⁻¹). Subjects were monitored over 7 days to include a weekend. **Results:** The AEE in preschool children was significantly higher in comparison to all age groups of teenagers and young adults during both weekdays and at the weekend (P < 0.0001). On weekdays during leisure time, preschoolers were considerably more physically active than all categories of teenagers and young adults (P < 0.001). Preschoolers show similarities in PA level between weekdays and weekends, unlike the older age groups. **Conclusion:** It seems to appear that organized daily PA (2 × 20 min of exercising on carpet, 50–70 min of walking outdoors) in preschool children along with enough space for spontaneous PA establishes prerequisites for their further healthy development.

**Keywords:** activity energy expenditure, leisure-time, school, weekdays, weekend

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**Introduction**

Constantly increasing occurrence of obesity, muscular imbalances, low physical activity (PA) and excessive time of physical inactivity (PI) in school has prompted researchers to investigate PA in preschool children.¹² The increase of overweight and obesity in preschool children is primarily assigned to decreasing PA, environmental factors and unhealthy diet as some US studies have shown.³ Another study has reported a positive association between higher levels of PA in preschool children and lower weight gain and lower body fat later in the period of early adolescence,⁴ indicating the importance of PA promotion in early childhood. In coincidence with these studies, we understand the term PA to be body movement produced by skeletal muscles and resulting in energy expenditure.⁵ On the other hand, PI is understood as sedentary behaviour.

One longitudinal study of 3–5-year-old children has revealed a positive association between the occurrence of obesity in children and their parents.³ Children from families with higher socioeconomic status who own more movement-stimulating toys (climbing frames, chutes, swings, balls, various riding toys) are significantly more physically active both at home and in kindergarten during break sessions than children from families with lower socioeconomic status.⁶

Others have suggested that PI is the key determinant in the increase in overweight and obese children.⁷ However conflicting data are available—a low association between watching TV, playing computer or video games per day in 4–7-year-old boys.⁸ Environmental factors such as sufficient safe space for playing, movement-stimulating toys, the educational background of teachers in kindergartens and the daily programme in kindergartens play a significant role in the PA level in preschool children.⁹,¹⁰,¹¹ For example one study of children from a kindergarten located on the outskirts of Hong Kong, with sufficient indoor and outdoor space, has shown that children were significantly more physically active (P < 0.05) than those in kindergartens located in the city centre in high buildings that provide only indoor space for playing.¹¹ Dowda et al.¹² found that 3–5-year-old children in kindergartens in which the majority of teachers have a college education spend more time performing moderate-to-vigorous PA in the playground in comparison to children in kindergartens in which teachers have no college education.

Sallis et al.¹² report stability of PA undertaken both at home and during breaks in kindergartens and elementary schools in children aged 3–6 years, but upon entering elementary school children’s PA decreased almost in half during breaks and moreover the amount of encouragement to perform PA from the teachers decreased. Previous literature clearly shows a decline in PA with age.¹³–¹⁶ However, few studies have investigated the age effect on PA in preschool children.¹⁷ The age-associated decline in PA in adolescents appears to be stronger in girls than boys and in vigorous activities more than in moderate activities.¹³–¹⁶ Given the strength and consistency of the age-related decline of PA, it is useful to examine the pattern of the decline by age, time of day or week, gender, season, type of activity and other factors.

Conflict data from previous studies of PA in young people may be attributed to differing methods that have been employed for determining levels of PA. However, accelerometers and pedometers are considered convenient for field monitoring of PA, especially if the combination of both of them and other techniques, such heart-rate monitors or PA record-sheets, is undertaken.¹¹,⁴,¹⁸

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Kindergartens may play an essential role in disease prevention and maintenance of PA in children throughout their lifetime. Children’s activities are pedagogically organized for the first time in kindergartens, however the effect this has on children’s PA is unknown. Whether the levels of PA in preschoolers are sufficient to prevent illness and preserve wellness in this age category remains to be identified, as well as the factors that influence PA.

Therefore, the primary purpose of this study is to examine the age- and sex-associated differences in PA, using activity energy expenditure (AEE), in preschool children, teenagers and young adults, and secondary to compare the AEE to health recommendations for PA.

Methods

Selection and description of participants

The aim of the study and the procedure of PA monitoring was explained to the parents during school meetings and written informed consent was obtained from all parents of preschool children. After a detailed presentation and explanation of the study, 11 kindergartens out of 22 approached agreed to participate. During September and October 2005 and under comparable daily climate (semi-cloudy and sunny weather, 17–22 °C), weekly PA and PI were monitored in preschoolers aged 5–7 years. In total, 122 preschool children started the weekly PA monitoring. Only 104 children (boys n = 51) who completed the whole 7-day monitoring were included in the analysis. None of the participants were classified as obese or from ethnic minority groups. The children included in the analysis participated in the daily programme of the kindergartens. Every day each of the participating kindergartens provided a 50–70-min walk outdoors and two 20–min exercises on the carpet (competitive movement games, steps and dance variations, relaxing, breathing and other type of exercises). This PA programme is common for all kindergartens in the Czech Republic.

For comparison 1961 subjects, aged 12–24 years, who had been tested in 2000–05 using the same method were chosen. The monitoring was conducted once a year either during the period of March–May or September–November. Subjects were recruited from elementary and secondary schools and universities and split into age groups as follows: 12–13 years (n = 157), 14–15 years (n = 428), 16–17 years (n = 589), 18–19 years (n = 494), 20–21 years (n = 137) and 22–24 years (n = 156).

This comparative study was approved by the Institutional research ethics committee of Palacky University. The study was voluntary and no incentives were paid to the participants.

Measures and procedures

A standardized methodology of PA field-based monitoring was adopted using the procedures described in the SPARK project.39 Weekly PA and PI monitoring was based on continuous, all-day monitoring using the Caltrac accelerometer (total and activity energy expenditure) and individual record sheets (in which frequency, intensity, type and time of PA and frequency, type and time of PI are recorded).

The Caltrac is a one-axial accelerometer that measures vertical movement and is small in size (9.7 × 7.0 × 1.3 cm, 78 g). Total and AEE is estimated by entering the subject’s age, height, weight and gender. A cumulative energy expenditure values is displayed on a small liquid crystal screen.29 The Caltrac functions through a piezoelectric bender element consisting of two layers of piezo-ceramic material with a brass centre. When the trunk accelerates, the transducer bends and produces a charge that is proportional to the force exerted by the subject. This creates an acceleration–deceleration wave and the area under this wave is summed, yielding the final count value.21 In determining caloric energy expenditure values, the Caltrac uses the following equation to calculate resting metabolism based on the subject’s age, height, weight and gender22; female [kcal min⁻¹] = ((331 weight [lbs]) + (351 height [in.]) − (352 age [yrs]) + 49854)/100 000 and male [kcal min⁻¹] = ((473 weight [lbs]) + (982 height [in.]) − (531 age [yrs]) + 4686)/100 000.

AEE from the Caltrac represents the value of energy of a given PA i.e. total energy expenditure without resting metabolism.20 Expressing AEE in a relative value (kcal kg⁻¹ day⁻¹) is recommended for the comparison of somatically different groups of girls and boys of various age categories.23

Due to the non-existence of a ‘golden standard’ of PA and PI field monitoring, and the fact that each of the techniques describes a different aspect of PA and PI, the combination of Caltrac accelerometer × individual record sheets was used.14,24 Caltrac and other accelerometers worn on the waist are calibrated for monitoring of locomotory activities (walking, jogging and running), however they tend to underestimate common everyday life activities (housework, self-attendance, etc.). Therefore, in our study we used FITT characteristics (frequency, intensity, type and time) of a given PA reported in record sheets to correct the energy expenditure according to the Compendium of Physical Activities.25

The AEE from Caltrac is recorded onto an individuals chart several times a day (morning after wake-up, start of school, end of school, evening before going to bed). The second chart lists 21 types of PA involving transportation, conditioning, occupation, sports and leisure activities. The last chart concerning PI consists of 6 items: sitting and lying watching TV; sitting before a PC; sitting or lying when studying, reading and playing; sitting in a park, in a cinema or a restaurant and sitting in a vehicle.

Age was computed from date of birth and date of testing. Stature was measured using an Anthropometer A–319 and body mass was measured using calibrated Tanita WB 110 SMA. Both stature and mass were measured to the nearest 1 cm and 0.5 kg, respectively.

In the morning elastic belts were distributed to the children with pouches containing the Caltrac accelerometers and individual record sheets. Children wore the belt continuously for 7 days excluding sleeping, hygiene and bathing for a minimum of 8 h a day. The elastic belts were secured tightly in position on their right hips. Each morning after waking, and each evening before going to bed, the parents recorded the time and the values of AEE from the Caltrac onto their child’s individual record sheet. In the evening they also recorded the type, time and intensity (moderate or vigorous) of everyday PA and the type and time of PI. The teachers in the kindergartens recorded the value of AEE when children came to kindergarten and when they left for the day.

Statistics

Data were analysed using SPSS for Windows, version 14.0 (SPSS, Inc., Chicago, IL). Four two-way (7 age categories × 2 genders) MANOVAs were conducted to examine the age and gender effect on AEE. Weekdays, weekends, school and leisure time were used as the dependent variables. In order to identify the differences in AEE between age categories of boys and girls in different time of day (school × leisure time) and time of week (weekdays × weekends), a post hoc Scheffe test was used. The estimate of the strength of the relationship between the independent and dependent variables was represented as coefficient ω².
Results

Relative values of AEE were significantly higher in kindergarten boys and girls in comparison to all other age groups (figures 1 and 2). Weekday AEE differed significantly across age \( [F (6, 2065) = 23.553, P < 0.0001, \omega^2 = 0.060] \) and between genders \( [F (2, 2065) = 39.402, P < 0.0001, \omega^2 = 0.017] \). At the weekend, we observed similar significant differences in AEE as at weekdays; across age \( [F (6, 2065) = 27.496, P < 0.0001, \omega^2 = 0.071] \) and between genders \( [F (2, 2065) = 14.264, P < 0.0001, \omega^2 = 0.006] \). AEE at the weekend was lower than during school/week days for all subjects except for 5–7-year-old girls and boys (figures 1 and 2).

On weekdays, preschoolers were considerably more physically active than all categories of teenagers and adults. At weekends preschoolers are on average almost twice as more physically active than teenagers and young adults (girls: 1.69× and boys: 1.73×). Post hoc analysis revealed statistically significant differences between the preschoolers and all groups \( (P < 0.01) \).

Before 15 years boys were more physically active than girls, however, there is an apparent decline of PA in boys over the age of 15 years. In girls there is a small but insignificant increase in PA after the age of 20 (figures 1 and 2). From 15 years upwards, there are no statistically significant differences between AEE in girls and boys (neither at weekends nor on weekdays, or at school or at leisure time).

There are significant differences in leisure-time AEE on weekdays across age \( [F (6, 2065) = 27.729, P < 0.0001, \omega^2 = 0.071] \) and between genders \( [F (2, 2065) = 33.551, P < 0.0001, \omega^2 = 0.014] \). Post hoc Scheffe test affirmed that leisure-time AEE in preschoolers is considerably higher than leisure-time AEE of teenagers and young adults in all age categories \( (P < 0.001) \) (figures 3 and 4).

We found the highest stability in performing PA in preschoolers \( (r = 0.62–0.96, P < 0.001) \) in comparison to all ages.

### Figure 1
Comparison of activity energy expenditure on weekdays and at weekend days between preschool and adolescent girls in different age categories

### Figure 2
Comparison of activity energy expenditure on weekdays and at weekend days between preschool and adolescent boys in different age categories
analysed groups of teenagers and young adults. The stability was assessed according to Spearman rank correlation coefficients between AEE on weekdays and AEE at weekends and between AEE at school and during leisure time.

Discussion

The primary aim of this study was to examine the age- and gender-associated differences in PA, using AEE, in preschool children, teenagers and young adults. The uniqueness of PA in preschool children is not only its volume but also the fact that only in this age category PA at weekends is higher than on school days. This is in agreement with the work of Burdette and Whitaker27 who also reported higher PA at weekends than on school days in 3-year-old children. Similarly to earlier studies, we have found significant differences in the energy expenditure between preschool girls and boys on school days and on weekend days.28

There appears to be a stability of PA in preschoolers that is not affected by the time of week (weekdays × weekends) or time of a day (school × leisure time). According to the ways of spending leisure time on weekdays, it is tautological that when comparing groups of different age categories, we have found the highest school AEE in children at kindergarten. In relation to the fact that preschoolers spend comparable time at kindergarten (mean ± SD; girls 4.53 ± 1.57 h day⁻¹ and boys 4.95 ± 1.51 h day⁻¹) as adolescents spend in other types of schools (females 4.62 ± 1.43 h day⁻¹ and males 4.92 ± 1.57 h day⁻¹), this comparison is thus relevant.

The results showing that preschool children are physically active regardless of the type of day and daily regime may be attributed to the fact that preschool children cannot distinguish between school time or free time. The high level of AEE in the preschoolers may be also attributed to the design of the kindergartens daily programme. Although the daily programme in kindergartens definitely provides more opportunities to perform PA than programmes at schools, it is essential...
to note that preschool programmes also have long periods of PL, including lying or sleeping for 60 min after lunch every day and time spent sitting during a morning snack break (10–20 min), lunch (15–30 min) and afternoon snack break (10–20 min).

To support children’s health Corbin, et al. recommend to perform PA minimally 60 min a day which equals energy expenditure of 6–8 kcal kg−1·day−1. Cordian et al. calculated that the minimal values of energy expenditure during PA that is sufficient to maintain health for a regular office worker is 11 kcal kg−1·day−1. However, in order to enhance health the recommended value is set at 90 kcal kg−1·day−1. Fromel et al. suggest 9 kcal kg−1·day−1 in girls and 11 kcal kg−1·day−1 in boys in majority of days in a week as an approximate health indicator of the PA efficiency. In relation with these recommendations and earlier results, we have assessed the AEE to be appropriate, in relation to health enhancement, only in preschoolers and in boys aged 12–13 years. In girls aged 12–13 years, women aged 22–24 years and boys aged 14–15 years PA is sufficient. However, in all other analysed groups PA does not establish sufficient preconditions for maintaining health or enhancing physical fitness. Similarly, in a study of weekly PA monitoring of 375 children and youth aged 6–18 years using the CSA accelerometer, Pate et al. reported that 100% of boys and girls in the age category of 6–8 years meet the Healthy People 2010 recommendation to perform moderate PA for at least 30 min, five or more days a week. On the contrary, the lowest percentage of boys (79.6%) and girls (72.9%) who meet the health recommendations concerning moderate PA are found in the oldest monitored age category of 16–18 years.

It would be interesting to observe whether the results found in the current study follow a similar pattern in overweight and obese children. Only preschoolers with normal weight were monitored in the current study, and it was observed that their PA meets the health recommendations and establishes preconditions for their further healthy development. Moreover, their PA is homogenous regardless of the type of day or time of day or gender. Therefore, we do not know whether PA in preschoolers who are overweight and obese or who are of low weight is lower than in preschoolers with normal weight. Future studies need to also examine the Body Mass Index of parents, and type of babysitting of preschoolers in their leisure time (parents, grandparents, siblings, tutor). A pilot study by Gaines, et al. reveals a low correlation between PA preferences of preschoolers and the parents’ perception of their children’s preferences. Therefore, we also recommend the need to investigate PA preferences in preschoolers and to compare it with PA performed in practice.

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