

Secular Trends of Adiposity and Motor Abilities in Preschool Children

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Abstract

Height, weight, BMI and triceps, subscapular and suprailiac skinfold thicknesses and of motor performance (20 m run, broad jump from the spot, and ball throw by right hand) were repeatedly measured over six decades in several age groups of Czech preschool children (4-6 years). The first study compared results of the measurements in the 1950s (n=268) and in 2009 (n=188), and then further measurements of height, weight, and skinfolds were conducted in two kindergartens with different physical activity programs in the 1970s (n=151) and in 2011 (n=79). When comparing the last century's results and recent measurements, the average height and weight increased slightly in both studies, and BMI values fluctuated insignificantly around the 50th percentile of the present Czech growth grids for BMI. A significant increase of the values of skinfold thickness was mostly found; along with that results of the broad jump and ball throw (abilities which need some experience and adaptation) decreased significantly, and performance in the 20 m run did not change. The increase of adiposity was lower in the kindergarten with a program of increased physical activity. Gender differences in preschoolers were always found at the occasion of all measurements: adiposity in girls was slightly higher, and motor performance was always lower. A secular change of lifestyle with prevailing sedentarism worsened motor abilities along with increasing adiposity, and a positive effect of increased physical activity had a significant impact on adiposity already during the preschool age.

What is already known about this subject: The prevalence of obesity has been increasing in the industrially developed and transitional countries, and also in selected groups of developing countries since the middle of the last century resulting, *inter alia*, from increasing sedentarism. Adiposity has been enhanced in the general population of school children and adolescents, along with a decreasing level of physical fitness and motor abilities.

What this study adds: This study adds original information on secular changes during the last sixty years on adiposity and motor abilities in preschool children; this age group has been less studied up to the present, as more difficult to be followed up by complex programs of adiposity and motor abilities measurements.

Keywords: Secularity; Adiposity; Motor abilities; Preschool children

Introduction

The aim of our study was to examine secular trends of the effect of generally decreasing Physical Activity (PA) with regard to adiposity and motor performance also in preschool age, and also the effect of increased PA at early age. The somatic development in Czech children was systematically studied starting with the end of 19th century by Matiegka [1], when some functional parameters (vital capacity, motor abilities) were also assessed. Since the 1950s, representative samples up to 100,000 growing subjects were always examined in ten-year intervals [2]. Measurements of body composition (total body fat and lean, fat-free body mass) during growth was started in the late fifties using hydrodensitometry with simultaneous measurements of the air in the lungs and respiratory passages, along with skinfold thickness and functional measurements [3,4], and has continued up to present using also other methods such as Bioelectrical Impedance Analysis (BIA) [2]. Later, other growing populations in other countries were also followed up with regard to body composition [4,5].

The development of adipose tissue undergoes marked changes from the beginning of life i.e. at birth it is reduced in prematurely born children, and increased in the offspring of metabolically decompensated diabetic mothers. From birth, its amount is larger and differently distributed in girls as compared to boys. [3,4] Newborns of mothers who exercised during pregnancy had lower birth weight, lower ponderal index, smaller fetoplacental weight ratio, unchanged length and lower skin fold thickness [6].

Preschool age is defined as the “golden age of motor activity” which

is spontaneously on a very high level, and decline significantly at the beginning of school [7-10].

In children born heavier achieving later higher weight, height, chest circumference had better results in some motor tests at the age of 5 years [5,7]. During the last decades, adiposity has been increasing due to lifestyle changes, and has resulted in global epidemic of obesity. Meta-analysis of adiposity revealed continuous increase of fatness in schoolchildren and adolescents during growth since 1951 to 2004 [11], which occurred simultaneously with decreasing functional capacity characterized by aerobic and anaerobic fitness [12,13]. No similar data is available on the secular changes in children of preschool age. Recent studies revealed that increased fatness which starts at an early age brings not only overweight and obesity, but later also comorbidities such as metabolic syndrome, diabetes, hypercholesterolemia and others [14]. Reduced Physical Activity (PA) resulting in increased adiposity has been also considered as one of the main causes of these health problems. The PA effect, however, should be always properly

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defined with regard to character, intensity, frequency, regularity etc., so as to be significant [4,5].

Methods and Materials

Several groups of preschool children were followed up. First, the comparison concerned two age groups with regard to skinfolds (Harpenden caliper) and motor testing in 1977: 1) 5.0-6.0 years (n=65), 2) 6.0-7.0 years (n=86) and 2011 (1) n=41, 2) n=38). Secular changes and also the effect of the intervention in physical activity were followed in children aged 1) 3.5-4.99, and 2) 5.0-6.99 years from two kindergartens were evaluated. One kindergarten had a usual regime without introduction of additional physical activities (Kr, n=95); the second (CB, n=93) since 1998 included a special program (outdoors activities in any weather, special exercises - gymnastics, cycling, scooter etc.), called *European Health Promoting School* (<http://www.schoolsforhealth.eu/>) Skinfold thickness (e.g. triceps, suprailiac, subscapular) were compared with the results from 1957 (n=268); and all children were measured by modified Best caliper [1,4].

Motor performance

Motor performance was tested by the evaluation of results from the 20 m run, the broad jump and throwing a ball [5], which are simple tests usually included in children's games. The 20 m dash, which characterizes speed, was conducted mostly outdoors in a playground or on a pathway in a park, not on a concrete or pavement. The child stands ready at the starting line, in suitable light clothing and gym shoes. At the starting line, one person gives the order, "ready, set, and go!". The second person is at the finish line recording the time. The test is repeated after a ten min rest. The standing broad jump tests the explosive strength of the lower extremities and also coordination and skill. The experimental worker demonstrates the jump, and instructs the child, "sway your arms and jump as far as possible!" Two attempts are recorded in cm, from the toes to the last foot mark. Throwing a ball (tennis) characterizes the explosive strength of the upper extremities, coordination and skill. The child stands on the line and throws the ball with the upper arch; two attempts are conducted and the results of the better one-as in previous test-is considered [5].

The last two motor abilities that were tested are more dependent on previous experience and adaptation. All methods were verified and used repeatedly in previous studies [5,7], and were well accepted as a game by all children, who were of middle class background. The statistical significance of differences among individual measurements was evaluated using a t-test. All measurements were conducted on the basis of informed consent of parents and teachers in kindergartens.

Results

As previously shown in children of school age and adolescents, adiposity characterized by skinfolds increased during the last decades in our groups of preschoolers. When comparing skinfold thickness (e.g. triceps, subscapular, suprailiac) that were measured in the fifties and seventies of the last century, with those ascertained in 2009 and 2011, the recent measurements most often showed significantly higher values, which were more apparent on the trunk (Figure 1). Simultaneously, from the recent measurements the results of motor testing - the broad jump and ball throw were significantly always worse (Figures 2 and 3).

Additional comparison concerning the effect of intervention revealed that the secular increase in fatness was smaller in children from the kindergarten where a special program of physical activity and exercise was introduced (CB). The secular increase was largest

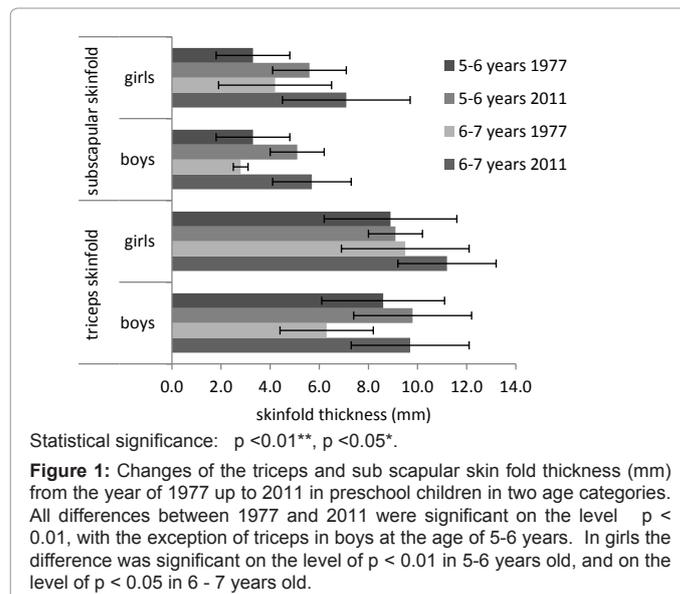


Figure 1: Changes of the triceps and sub scapular skin fold thickness (mm) from the year of 1977 up to 2011 in preschool children in two age categories. All differences between 1977 and 2011 were significant on the level $p < 0.01$, with the exception of triceps in boys at the age of 5-6 years. In girls the difference was significant on the level of $p < 0.01$ in 5-6 years old, and on the level of $p < 0.05$ in 6-7 years old.

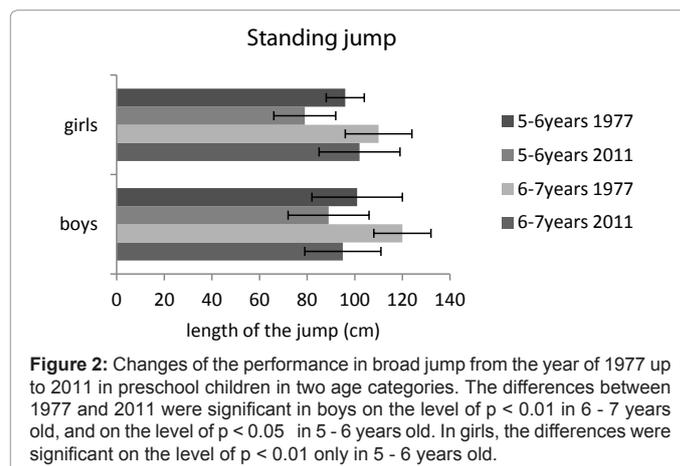


Figure 2: Changes of the performance in broad jump from the year of 1977 up to 2011 in preschool children in two age categories. The differences between 1977 and 2011 were significant in boys on the level of $p < 0.01$ in 6-7 years old, and on the level of $p < 0.05$ in 5-6 years old. In girls, the differences were significant on the level of $p < 0.01$ only in 5-6 years old.

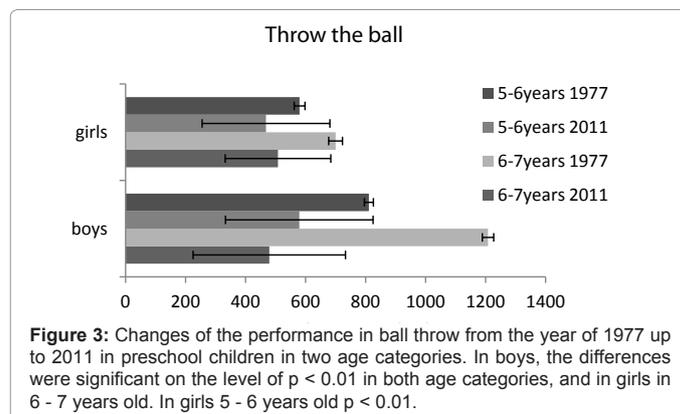


Figure 3: Changes of the performance in ball throw from the year of 1977 up to 2011 in preschool children in two age categories. In boys, the differences were significant on the level of $p < 0.01$ in both age categories, and in girls in 6-7 years old. In girls 5-6 years old $p < 0.01$.

in the kindergarten with a usual program without special motor stimulation and exercise (Kr). In both measurements, BMI fluctuated insignificantly and was around fiftieth percentile for the particular age groups, along with slightly increasing height and weight. Compared with the measurements in the 1950s, the recent measurements showed increased values of triceps, subscapular skinfolds and suprailiac

skinfolds (measured by modified Best caliper) [3,4] (Figures 4a and 4b). Significant gender differences were also found at the occasion of all measurements. Increase of fatness was more apparent on the trunk (suprailiac, subscapular skinfolds).

Discussion

When following secular changes of height and weigh from the end of the nineteenth century [1] up to the present, a marked increase of values and higher BMI in children 6-7 years old was found [2,5]. Results concerning changes in adiposity and motor abilities in preschoolers since the middle of the last century corresponded to those previously ascertained in school children and adolescents, i.e. meta-analysis of the results of aerobic and anaerobic power and measurement of triceps skinfold and calculated total fat percentage showed an increased adiposity and decreased level of functional capacity. Increase of adiposity along with the decreasing aerobic and anaerobic fitness has been considered as an obvious marker of reduced level of physical activity and prevailing sedentarism, also concerning the growing population [11-13]. Secular changes of adiposity along with the changes of motor abilities in earlier, preschool age have not been evaluated before; however, the positive effect of increased PA and exercise adequate for this age category was revealed [3-5]. Faster development (e.g. psychological, etc.) of motor stimulated infants was already found and the results of this research were summarized by Koch [15].

Obviously, changes in lifestyle are even more significant during certain critical periods, e.g. the age of Adiposity Rebound (AR) between 5-6 and 6-7 years- [16-18], which coincides with increasing

subcutaneous fat, e.g. sum of ten skin folds [4], and decrease of spontaneous physical activity level [8-10].

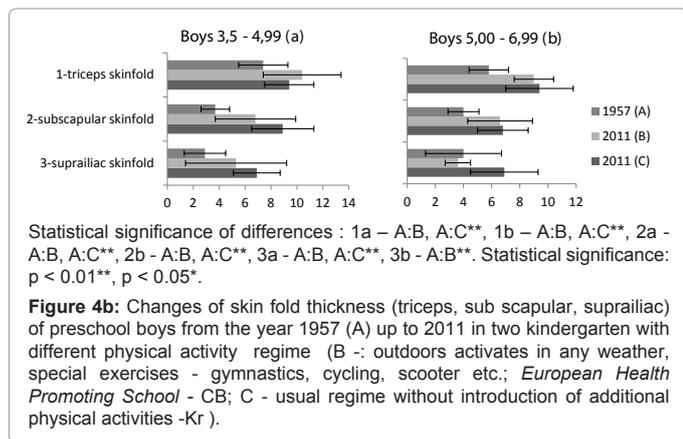
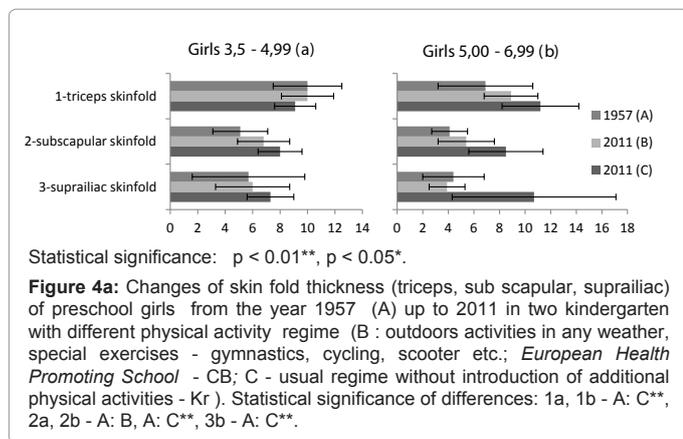
Previous measurements in kindergarten children (aged 4-6 years) with individually different level of spontaneous physical activity revealed that the most active ones tended to have slightly lower BMI and body fatness, better results of a modified step test, slightly higher energy intake, but significantly higher HDL [5,7]. The percentage of body fat correlated significantly with the level of Total Cholesterol and Triglycerides (TC and TG) already at this age [19,20]. A positive effect from special preschool physical education classes organized together with the mother, father and/or any other caretaker, showed significantly higher levels of skill and physical performance, e.g. in broad jump, throwing a ball, and resulted along with lower skin fold thickness [5]. Similar positive effects were also revealed in other studies concerning children of early age [21]. As shown by the results of this study, the effect of a special physical activity regime and physical education in kindergarten also improves performance in broad jump and produces lower adiposity (Figures 2 and 3) [22], similarly as during later years. This was demonstrated by the longitudinal study of groups of boys with different level of sport training from 10.7-17.7 years, and with a group of girl gymnasts from a sport school who were followed up longitudinally from 11 to 15 years [4]. Significant adequate exercise regime proved an efficient component in weight and fat reduction of obese preadolescent children [4,7,14].

The level of skill development as shown by motor testing, important especially as a marker of PA level, was always reduced in children measured at the beginning of this millennium, when the lifestyle changed significantly from the 1950s. As a result of insufficient PA and decreased energy output, adiposity increased even during this earlier age. Sedentarism in children of preschool age [23] in our studies was not manifested by more marked BMI changes, but mostly by increased adiposity and especially worsened motor abilities and PA level [5]. Lifestyle changes with decreased PA have reduced the realization of adequate body composition, functional capacity, aerobic power, motor performance development, all of which are already manifest during preschool age-especially with regard to the abilities requiring certain experience and adaptation due to an adequate PA regime.

Secular changes of motor abilities were confirmed in further follow-ups repeated in preschoolers in 1977 (n=3712) and 2010 (n=1847): changes of height, weight slightly increased, BMI fluctuated insignificantly around the 50th percentiles, but the results of broad jump and throwing a ball were significantly lower at the occasion of recent measurements [24]. As follows from previously mentioned studies, BMI was not always sensitive enough to reflect the aforementioned secular and other changes of adiposity and motor abilities, which were revealed by measuring skinfolds and motor testing.

Conclusions

Increase in adiposity along with a deteriorating level of motor development and skill indicate that the reduction of PA level during last decades has been significant also at an early age. Reduction of the motor potential and physical fitness level along with increased fatness are undesirable predisposition for the future, i.e. an uncoordinated child who tires too easily, too early, and who may not be able to develop and maintain an adequate PA regime later in life. With regard to the increase in obesity prevalence in all age categories [14] this indicates a significant contribution to obesity from the reduction of PA level from young, preschool children, when the level of physical activity is spontaneously the highest. As BMI does not always reflect sufficiently



the lifestyle changes, “hidden” or enhanced adiposity and/or obesity may be the case, and the changes of body composition and motor development should also be evaluated.

At least, the effect of present sedentarism manifested by worsened motor abilities and increased adiposity should be excluded as early as possible, i.e. in youngest children; the impact of family lifestyle, and/or kindergarten regime is essential. When considering all comorbidities which accompany obesity sooner or later, the rectification of this urgent problem should already start during early childhood. Increased occasions for spontaneous children’s games, adequate motor stimulation and physical education suitable for this age are recommended. Later interventions are also important, but much more difficult, and often not permanent; “positive health” should be developed using adequate physical activity and exercise since the earliest life, as the “health of children is the key to the health of adults” (WHO).

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