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INVITED REVIEW

Fatness and fitness related to exercise in normal and obese children and adolescents

J. Pařízková

Obesity Management Centre, Institute of Endocrinology, Prague 1, Národní 8, 11694, Czech Republic

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Abstract The main aim of this article is the review of selected longitudinal studies (lasting from several months up to 14 years in the same groups) investigating body fat indicators in relationship to physical activity, exercise and fitness levels in normal weight and obese children and adolescents from preschool age. Special attention was focused on complex simultaneous observations which included body composition, cardiorespiratory efficiency, motor abilities, and dietary intake in their mutual relationships, also with regard to secular changes along the last 50 years up to the present. Musculoskeletal problems related to excess fatness were also considered.

Contents

E-mail addresses: jparizkova@endo.cz, jana.parizkova@iex.cz
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1. Introduction

The increasing standard of economic conditions during the last decades enabling the full availability of food and allowing for changes in the composition of dietary intake has been contributing not only to an accelerated growth in height and weight, but also to a disproportional development of body composition, resulting in overweight and obesity. In 2011, more than 40 million children under the age of five were overweight globally, including developing countries (WHO, 2013). Nutritional intake, from the point of view of energy content and density has not been collocated to real dietary needs of the growing organism (WHO, 2010a,b,c, 2011, 2013; Vignerová et al., 2007; ENHIS, 2009; Cali and Caprio, 2009; Maffeis et al., 1998; Tucker et al. 1997; Centers for Disease Control and Prevention, 2008; Cattaneo et al., 2009; Flegal et al., 2010), as well also due to the prevalence of reduced energy output from sedentarism (Rizzo et al., 2007; Tremblay et al., 2011; Rauner et al., 2013, and others).

This situation predisposes the child for increased obesity prevalence, along with accompanying health problems later in life and can be harmful especially in children and adolescents. Metabolic syndrome, cardiovascular diseases, diabetes, orthopedic and psychological problems resulting from obesity have been manifesting during recent decades not only in adults, but also in children during their growth and development (WHO, 2010a,b,c, 2013; Lisková et al., 1998; Livingstone, 2000; Lobstein and Frelut, 2003; Rizzo et al., 2007; Rolland-Cachera, 2012; Rolland-Cachera et al., 2006; Berghöfer et al., 2008; Pařízková and Hills, 2001; Pařízková and Hills, 2005; De Niet and Naiman, 2011). However, up to the present, an exact evaluation of childhood obesity prevalence on the world scale, comparing identically defined representative samples from individual countries and using the same methods and criteria has not been reported. Even when childhood obesity prevalence has been stabilizing in some countries (Cali and Caprio, 2009; Salanave et al., 2009; Kunešová et al., 2011; Townsend et al., 2012 and others), in many other countries obesity has been increasing. This includes transitional ones, as well as the social strata in developing countries which have full availability of food (WHO, 2011).

Various studies followed the mentioned health problems from the point of view of individual aspects (e.g. BMI, nutritional, biochemical, and/or functional ones, etc.), but mainly *not with regard to their mutual interrelationships*, and only during *limited periods of time*. The aim of this review was to focus attention especially on complex studies which have followed up not only morphological parameters such as body composition, but simultaneously also the functional ones (i.e. cardiorespiratory efficiency, aerobic power, motor testing, and others), and also dietary intake and musculoskeletal problems. Main concern was on longitudinal studies of the same groups lasting up to 4, 5, 8 and 14 years of both normal weight and obese individuals, starting with preschool age.

Special attention was focused on the *early development of fitness* – which has been shown to decrease secularly along with increasing fatness since preschool age. Early development of fitness has been shown to be a *predisposition for the preservation of an adequate physical activity regime resulting in desirable good health also later in life*.

2. The role of exercise in morphological and functional development

Participation in adequate exercise has been an essential part of the care of the child for optimal development, and also for education. A positive effect has been correlated not only with health and physical performance, but also on the development of personal will and discipline, adaptability, overcoming personal discomfort, achievement of set aims, fair play, teamwork, and so forth. This applies as well up to the present where great attention to physical education and sports occurs in the best schools, Scout organizations and the like.

Early adaptation to optimally increased physical activity and exercise has always prevented excessive adiposity and contributed to the optimal development of vital organs, muscle and skeletal tissue, etc. (Pařízková, 1963, 1977, 1989, 1993 etc.). In addition, when experienced in an optimal way, it contributes to a desirable body posture, the prevention of orthopedic problems, and positively influences psychological development. This applies not only with regard to the present status of the growing organism, but also has significant *delayed consequences* for later life. As shown by the results of experimental models using laboratory animals, significant positive delayed consequences of an adequately increased physical activity during fetal and early growth period on later status of the adult offspring were found (e.g. microstructure of the heart, lipid metabolism; Pařízková, 1978, 1979, 2010; Pařízková and Petrásek, 1978).

3. Secular effect of reduced physical activity

The reduction of physical activity and physical work load due to present lifestyle (WHO, 2013) has an essential negative impact on body composition (absolute and relative amounts of fat and fat-free, lean body mass), physical fitness and the level of the functional capacity of the organism especially during growth and development (Pařízková, 1977, 1989; Cali and Caprio, 2009; WHO, 2013; Rauner et al., 2013, and others). This impact is especially marked during preschool age when the need and the level of spontaneous physical activity are significantly highest as compared with following growth periods and adulthood (Pařízková and Hainer, 1995; Sigmund et al., 2009, 2012).

Secular comparison of the results ascertained in children and adolescents in the sixties of the last century, and those at the beginning of this millennium concerning body composition and level of physical fitness – i.e. cardiorespiratory efficiency, motor development, muscle strength, and other functional ones, showed negative changes (Olds, 2009; Tomkinson and Olds, 2007). Reduction of the level of cardiorespiratory fitness (aerobic and anaerobic power) and a worsening of motor development were revealed. Later, the reduction of muscle force also appeared (Tomkinson and Olds, 2007).

Along with the acceleration of growth in the general population during recent decades (i.e. a continual increase of height and weight), fat content in the organism has been increasing relatively more and disproportionately as compared to the other body tissues. Increased fatness has been manifesting even when the body mass index (BMI = weight kg/height m^2) has not changed more markedly: i.e. changes in body composition have been often manifested under conditions of only slightly increased BMI, as a "hidden obesity".

Body fatness of children and adolescents evaluated from skinfolds assessed in the sixties of the last century, as compared to that at the beginning of this millennium has increased (Olds, 2009). The prevalence of overweight and obesity has increased (Maffeis et al., 1996; WHO, 2013; Cali and Caprio, 2009; Rauner et al., 2013, etc.), obviously more in those with increased predispositions (e.g. in children of obese parents, grandparents and so forth), and started to appear also in younger, preschool age children (Pařízková et al., 2012a,b). Up to the present, any exact data concerning the *eventual changes of vital organs*, i.e. *whether the development of the heart, lungs etc. has also simultaneously accelerated in the same way as total body mass have not been available*.

4. Causes of increased adiposity and reduced physical fitness

The character of secular changes can be explained, *inter alia,* by the lack of motor stimulation and physical work load during growth resulting from present lifestyle choices, especially a prevailing lack of exercise (Rauner et al., 2013; WHO, 2011, 2013), also with preschool children (Pařízková, 2010). Although often criticized, children and adolescents prefer TV, videogames, computer games, cell phones, etc., and consume *inadequate nutrition* (e.g. fast food, sodas, etc.) with increased amount of simple sugars and saturated fats (Maffeis et al., 1996; Tucker et al., 1997; WHO, 2013): this *has a negative impact especially on hypokinetic* individuals. Such a cluster of factors is especially risky with regard to weight status and obesity development (De Bourdeaudhuij et al., 2012; Rodenburg et al., 2013).

The availability of suitable and safe public areas for exercise and games has reduced significantly, especially in large urban agglomerations. However, reduced activity appears even where such possibilities are still available. It seems that using transport, exciting TV programs, videogames etc. are more attractive, also that they do not require any physical strain and effort. Security problems for the supervision of child play an important role. Children who are not adapted to increased physical activity due to an inadequate regime and fitness model in their families or schooling practices, prefer therefore more physical comfort, resulting in sedentarism (Pařízková, 1982).

5. Secular changes of adiposity and the effect of exercise in preschool age

Reduction of physical activity is especially harmful during preschool age, due to the ontogenetical and developmental trends which include the highest level of spontaneous physical activity at that period of growth (Pařízková and Hainer, 1990, Sigmund et al., 2009, 2012; Sigmundová et al., 2011; LeBlanc et al., 2012). Earlier increase of BMI and body fatness during the period of *adiposity rebound* (AR) when the level of spontaneous activity starts to decrease has been considered as a predisposition of increased obesity development later in life (Rolland-Cachera et al., 2006). A significant secular increase of skinfold thickness was mostly observed in Czech preschool children – first in the fifties, then in the seventies of the last century, up to the beginning of this millennium (Pařízková et al., 2012a,b). Adiposity was always greater in girls, and during the mentioned decades, increased in the same way as in boys. Similar increase was observed also in preschool children of other countries (Timmons et al., 2012; Smith et al., 2013 and others).

However, children measured in 2011 in a kindergarten with a special regime of physical activity who participated in a Schools of Health in Europe program (which included increased, organized, and spontaneous activity inside or outside under conditions of any weather; the inclusion of organized exercise – e.g. gymnastics, sport games, bicycling, in winter skis and other winter sports; schoolsforhealth.eu, 2004), their skinfold thickness as compared to the results ascertained in 1957, increased significantly less than children with the usual régime of physical activity, obligatory in all kindergartens in the Czech Republic (Pařízková et al., 2012a,b).

In the same preschool children that were followed up in 2011, it was also found that their motor abilities have changed similarly as in older school children. The results in selected motor tests (i.e. jump from the spot and ball throw) were significantly worse than in 1977 (Pařízková et al., 2012a,b). This concerned mainly motor abilities which are necessary to learn, and which depend upon a certain degree of adaptation, i.e. the possibility to experience them in the open air outside (playgrounds, parks) or inside in an adequate facility (gymnastic halls). Only the results in the 20 m run – no secular differences were found (may be due to being a more natural activity, also due to increasing body height), and no gender differences were observed as well. These repeated cross-sectional and longitudinal measurements indicate that along with increasing adiposity, motor abilities deteriorated too, which follows from inadequate physical activity and motor stimulation since preschool age (Pařízková, 1996, 1998a, 2008). It was also revealed that preschool children who were spontaneously very active tended to be less fat, and had significantly higher serum levels of HDL; i.e. the percentage of their body fat correlated significantly with serum level of total cholesterol and triglycerides (Pařízková et al., 1986).

6. The effect of adaptation to exercise in schoolchildren and adolescents

Body composition measurements (using hydrodensitometry with simultaneous measurements of the air in the lungs and respiratory passages, as a "golden standard"; Pařízková, 1961, 1977, 1989) revealed reduced body fat and enhanced development of lean body mass in schoolchildren adapted to exercise, *provided it was of particular character (dynamic – aerobic weight-bearing exercise, of adequate intensity, duration, and frequency)*. Cardiorespiratory efficiency and aerobic power, i.e. the ability of the organism to transport oxygen to working tissues, especially muscles, increased as an essential condition for a more efficient utilization of lipid metabolites during work load (evaluated as oxygen consumption during maximal work load on a tread-mill or bicycle ergometer, related to kilogram of body weight or lean body mass/min – max O_2, "oxygen ceiling"; Pařízková, 1977, 1982, 2008).

Young athletes (14–16 years old, from sport clubs but not champion athletes) usually had cca 5–8% of body fat, as compared to normal, but not regularly exercising subjects (14–16%; Pařízková and Heller, 1991); for comparison, obese adolescents could achieve cca 30 %, but often a higher percentage of body fat (Pařízková and Hills, 2005). In young trained athletes, an increased *cardiorespiratory efficiency* and *aerobic power* was always highest; on average this was 57–58 ml O_2/kg body weight/min. This parameter was found significantly lower in normal weight, non-exercising boys of the same age (50–52 ml O_2/kg body weight/min), and the lowest value was revealed in the obese of similar age (38 ml O_2/kg/min; Pařízková, 1977, 1982, 1989). BMI was significantly highest only in the obese, but BMI in non exercising and athletic boys did not differ. Longitudinal observations of the mentioned groups of exercising adolescents revealed further enhancement of positive changes of body composition and aerobic power. Similar results were gained also in International Biological Programme (IBP; Pařízková, 1982, 1989).

However, the *energy intake* of adolescent athletes was in all instances significantly highest in trained athletes in dynamic sport disciplines (up to 22 Mj/day; Pařízková and Heller, 1991), i.e. it was highest both in absolute values and also as related to body weight. Adaptation to increased exercise in growing athletes always prevented the consequences of increased food intake (Pařízková and Heller, 1995).

The effect of regular, aerobic, and adequately intense exercise on body fatness was best reflected in an eight-year longitudinal study of groups of the same exercised and control boys from 10.8 to 17.8 years and 24 years, respectively; the ratio of body fat (evaluated by means of hydrodensitometry) was lowest and aerobic power (max O_2; on a treadmill) was significantly highest in the exercised group (starting 2 years after the beginning of training, light athletics, and sport games). Significant interrelationships between mentioned characteristics were always found. More detailed changes reflecting the effect of exercise were revealed in a five-year longitudinal study in girl gymnasts (followed up from 11 to15 years), in which subcutaneous body fat repeatedly decreased or increased significantly during each year, due to the effect of increasing and/or decreasing intensity of training and changes of dietary intake. Body fat increased always significantly after a repeated interruption of training, in spite of a simultaneously significant decrease of food intake (Pařízková, 1977).

As found in another study, the ratio of body fat in young adult athletes adapted to a dynamic, aerobic workload (e.g. cross-country skiers) also significantly correlated with the activity of enzymes involved in beta-oxidation of fatty acids in rectus femoris muscle biopsies (Pařízková et al., 1987). In growing subjects, muscle biopsies could not be taken.

7. Body composition and functional capacity in growing obese

In obese children not only is body weight, BMI, and fat percentage increased, but the *distribution of fat* is also *different*; it increases relatively most on the trunk and the abdomen, which is considered as a possible marker of the development of metabolic syndrome later on. In obese children and adolescents the indices relating abdomen circumference to body height, and skinfolds on the trunk to those on the extremities were found to be significantly higher, as compared to the same indices in normal weight peers (Pařízková et al., 2011).

In addition, in most of growing obese a reduced level of cardiorespiratory efficiency and aerobic power (max O_2 during maximal work load on a treadmill or bicycle ergometer) was repeatedly revealed (Pařízková 1977, 1993, 1998b; Pařízková et al., 2002; Pařízková and Hills, 2005). Absolute values of oxygen uptake did not always differ between the obese and normal subjects (Goran et al., 2000), but when related to the kg of the total and/or lean body weight, they are significantly lower in the obese (Pařízková, 1977, 1989, 1993). But most important was that the maximal level of oxygen uptake appeared in the obese after a shorter duration and after a lower speed of running on the treadmill. As compared to the normal weight subjects, this means that the ‘‘oxygen ceiling’’ was achieved during reduced physical performance. *Weight bearing ability*, i.e. the performance during activities including the transfer of onés own body weight has been always most negatively influenced by an increased fat ratio, and exhaustion always appeared earlier. A vicious circle including increased tiredness of the obese has also discouraged dynamic exercise even more.

In children with longer lasting obesity, lean body mass may have increased too. *Muscle strength* could therefore be normal or even increased in the obese. Also, the *skill of smaller muscle groups* may not be always negatively influenced by obesity (Pařízková and Hills, 2005). Results of various sport tests were mostly adverse in the obese. Mutual correlations among morphological and functional characteristics in the obese were mostly highly significant.

8. Food intake in the growing obese

With regard to their food history, the energy intake in the studied obese subjects varied markedly, and could be mostly checked only when they started to be treated. Obese children usually consumed a diet which did not correspond to the RDAs and to their individual energy needs, and more often consumed inadequate foodstuffs (Pařízková and Hills, 2005; Pařízková et al., 2002) as shown in several studies (e.g. Maffeis et al., 1996; WHO, 2010a). However, often their energy intake did not differ much from young athletes. As follows, the reduction of energy output due to inactivity had an essential role in adiposity development, mainly in predisposed individuals (especially those with obese parents and other members of the family).

The definition and preparation of a diet with recommended dietary allowances (RDA) according to individual characteristics, which guarantees a desirable development of the patients of different age, gender, degree and duration of overweight and obesity, requires both theoretical knowledge and experience. Therefore, a monitored diet excluding inadequate items such as sweet beverages and fast food is the most available and physiologically supportive, along with the introduction of a régime of suitable and sufficiently intensive exercise aimed to the increase of energy output (Pařízková, 1993, 1998b; Pařízková and Hills, 2005; Pařízková et al., 2002). In this manner, children could even eat – when the degree of obesity is not excessive or morbid – nearly according to their appetite and liking.

Longitudinal observations always revealed that the *optimal balance between energy intake and output was achieved when both of them were on a high level:* e.g. in regularly exercising adolescents the food intake was significantly higher than RDAs, but their adiposity was low and level of fitness was high (Pařízková and Heller, 1991).

9. Effect of reduction treatment and prevention in the obese by exercise

As indicated by the above given observations, dynamic, aerobic exercises (i.e. participation in sport games, running, jumping and the like) have been always recommended for the rectification of increased fatness in the obese, along with a monitored diet. However, when obesity has been already excessive, at the beginning it has been necessary to start according to the status of the patient: i.e. exercise under the water, then in positions of lying, sitting, kneeling etc. until the moment when the bearing of one own's body weight is easier, and when motor abilities are more developed. Exercise should be guided and controlled by experienced pedagogues, and special care must be taken for the prevention of accidents.

During growth, reduction treatment is a difficult task – it is necessary first of all to **change body composition** – to reduce body fat, but to do so **along with continuing growth** – increasing in body height, and development of vital organs and all other body tissues. Direct measurements of body composition are necessary, as body weight and BMI do not always disclose achieved changes due to reduction treatment.

Various approaches have been reported. The best option has always been the combination of inpatient and outpatient treatment (Pařízková and Hills, 2005; Adam et al., 2013 and others). Community interventions and intersectorial collaboration for treating and preventing obesity lasting several weeks or months have been more recently undertaken. Studies have been giving the results of introducing also special regimes of activity e.g. in the family, the model of which is essential especially at the beginning of life (Steinsbeck et al., 2012), or introducing an intervention regime during and after school time (Lazzer et al., 2008; Martinez-Vizcaino et al., 2008; Dobbins et al., 2009; Sigmund et al., 2009; Yin et al., 2012), including exercise, cognitive-behavioral counseling with a monitored diet. Positive results were gained mostly in the majority of follow-ups where the results were evaluated before and immediately after the intervention, but more rarely, also repeatedly (e.g. Kelishadi et al., 2008).

10. Inpatient treatment of obese children

Permanent supervision and control of treated obese children and adolescents have always given optimal results. Since the fifties of the last century, at the occasion of the separation of the Obesity Outpatient Department from the Endocrinological Department in the Pediatric Clinic in Prague, the treatment of children with simple obesity was conducted. Longitudinal observations included the results of inpatient treatment (in the most severe and complicated cases), and also with seven-weeks of treatment in special summer camps overseen by pediatricians–obesitologists, and physical education specialists (Pařízková, 1977). This approach was proven to be mostly efficient and repeated in other inpatient institutions (Karner-Rezek et al., 2013), specialized spas (Lisková et al., 1998), or summer camps for the growing obese (Pařízková and Hills, 2005). The greatest problem has been the financial cost of such treatments, especially because to be efficient, they have required a longer time period and eventual repetitions.

The use of exercise has been more and more favored, as it is mostly physiological and less costly. An individualized approach based on an *exact diagnosis* (excluding pathological cases) and an *evaluation of the overall status* of the child – i.e. developmental level, duration and degree of obesity, body composition, functional capacity, motor and psychological development, was always indispensable.

All kinds of suitable *exercise*, sport disciplines, aerobics, trekking, dancing and others have been used repeatedly in the programs of summer camps (Pařízková and Hills, 2005). Recommended regimes should be individually tailored, attractive, amusing, and introduced according to the character of the particular obese subject, so as to be accepted and conducted with pleasure. A *monitored high quality diet* according to age and the degree of obesity (but with not too much reduced energy which has reduced growth in height; Pařízková, 1977, 1993) has always been included as a part of treatment. *Cognitive-behavioral counseling* included individual instructions concerning overall life style, food behavior and physical activity régime. Special *psychological interventions* have been also applied: obesity can result from psychological problems, and also causes many of them. The personality of obese children therefore requires a particular approach and management (Liskova et al., 1998, Pařízková et al., 2002; De Niet and Naiman, 2011; Kirschenbaum and Gierut, 2013, and others).

After reduction treatment, positive changes of body composition and efficiency of cardiovascular system were always significant. Oxygen ceiling, i.e. maximal oxygen uptake was achieved after a greater physical work load (e.g. achieving of a longer running time with greater speed on the treadmill), indicating higher performance capacity than before treatment. Along with the reduction of BMI and fat and the increase in percentage of lean body mass, heart rate, oxygen uptake during maximal and/or standard work load, (especially in relative values) decreased. The *same work load was therefore performed with lower energy expenditure and heart rate*, i.e. more economically than before treatment, due to adaptation to exercise and simultaneous reduction of fat.

Longitudinal observations of the achievements in various motor testing, i.e. running different distances, jumping, throwing, performance in various sport games, and also dancing improved, and serum lipids level, blood pressure, serum insulin decreased, revealing the improvement of metabolic fitness (Pařízková 1993, 1998; Pařízková and Hills, 2005; Pařízková et al., 2002; Pařízková, 2011). This was confirmed in other studies also showing further changes, e.g. decrease of leptin and increase of ghrelin (Kelishadi et al., 2008), decrease of C-peptide (Gajewska et al., 2010) and of visfatin (Krzystek-Korpacka et al., 2011), increase of orexin A (Bronský et al., 2007), and others.

11. Effects of the interruption of exercise

As mentioned above, exercise aimed to significantly influence body fat content must not only be intense enough, but also of a certain character – preferably aerobic, and dynamic one; frequent, regular, permanent and long lasting, and best as a part of a daily regime. When exercise does not correspond to these criteria (which is mostly the case in children as referred by uncontrolled questionnaires), its effect is often not as significant – at least with regard to the parameters most often followed up. But when *adequate exercise* is *interrupted, increase of body fat was found very soon,* even when *food intake after the omission of exercise was decreased* (Pařízková, 1977, 1982).

As revealed in a 4 year longitudinal study of reduction treatment in summer camps with obese children of 11–14 years old, resulting in decreased weight, BMI, percent of body fat, functional capacity, blood pressure and serum lipid level, and in increased aerobic power (max O_2), and motor performance – after the return to their usual life conditions (i.e. lack of activity, inadequate food intake, etc.) during the school year at home, BMI and adiposity increased, and functional capacity decreased. After repeated reduction treatments of the same obese patients, body composition improved along with fitness level again, and after their interruption again worsened. But after four repeated treatments the final status, as compared with the initial one, was significantly improved (Pařízková, 2008; Pařízková and Hills, 2005). This study confirms the *need for longitudinal care and treatment of the obese as one intervention is not sufficient*. Similar fluctuation of weight along with serum insulin, ghrelin and leptin during various periods of reduction treatment and/or its interruption in the obese were also observed (Kelishadi et al., 2008).

Significant reactions of body fat were revealed in a longitudinal study in adolescent girl gymnasts from 11 to 15 years old during periods of varying intensity during training (Pařízková, 1977; Pařízková and Hills, 2005). Sum of skinfold thicknesses always reflected repeated increases and decreases of the intensity of training during school years and holidays, during all five years of the follow-up. Especially after the interruption of training, body fat increased in spite of the reduction of food intake (Pařízková, 1977; Pařízková and Hills, 2005). Other characteristics (i.e. weight and BMI) did not reflect the effects of the changes in training intensity. As apparent, for the preservation of optimal body composition and fitness level the permanent continuation of the exercise and physical activity régimes, without longer interruption, is indispensable.

12. Musculoskeletal problems due to excess body fat and reduced fitness

Due to the *inadequate loading of the areas of growth activities of the epiphyses,* excess body fat has started to appear as a key, but potentionally modifiable risk factor for the development of musculoskeletal problems (Paulis et al., 2013). Until recently, in the growing obese the attention was focused mainly on skeletal and joint problems, such as the risk of fractures and osteoarthritis. Moreover, excess body fat has a negative effect on soft tissues – e.g. tendons, fascias, cartilages, etc. (Widhalm et al., 2012).

Functional and structural limitations resulting from the additional load on the locomotor system by excess fat, result in *aberrant mechanics of movements*. Increased stress on connective tissues can therefore cause musculoskeletal accidents (Wearing et al., 2006; Chang et al., 2010; Stovitz et al., 2008; Mauch et al., 2008; Chen et al., 2012; Matusik et al., 2012), which further reduces the level of physical activity and fitness.

The most frequent problems of the obese are flat feet, scolioses, pains of the back, shoulder, hip and knee joints; tibia vara and valga; deteriorated body posture; and muscle flabbiness; etc. (Wearing et al., 2006; Stovitz et al., 2008; Chang et al., 2010, 2012; Mauch et al., 2008; Widhalm et al., 2012). The early beginning of such problems is due to the early development of excess weight starting with preschool age. Cross-sectional and longitudinal evaluations showed the *deterioration of body posture in all, even normal-weight preschool children* (Pařízková, 2008, 2010) which were confirmed *along with increasing adiposity* at the beginning of this millennium.

A study of *flat foot syndrome* in 7–12-years old obese children showed a prevalence of 59%, which was higher in boys (67%) than in girls (49%; Chang et al., 2010). The structure of the foot was impaired in obese children – e.g. the longitudinal medial arch (MLA) and the angle of foot (FA) – was decreased, and the Chippaux – Smirak index was increased. A significant correlation of z-score for BMI and MLA was revealed, and following longitudinal observations showed that this relationship was getting closer with increasing age and increasing obesity (Villaroya et al., 2009). Fat deposition on the foot has been complicating the evaluation of flatfootedness, but it was shown that in the obese, adipose deposition also increased, along with simultaneously decreased MLA (Ruddiford-Harland et al., 2011). A longitudinal study of the development of flat feet in preschool age showed during later years its greater prevalence in younger, obese boys who were also characterized by greater laxity of joints (Tobias et al., 2013; Chen et al., 2012).

The nutritional status characterized by z-score of BMI correlated significantly with the seriousness of *scoliosis* in 13.37 year old subjects (Matusik et al., 2012). *Pains of the lower part of the back* were found in 10–18 years old subjects caused mainly by the characteristics of the physical activity level and BMI (Akdag et al., 2011). Pains of other joints, especially the hip joint, were revealed in another follow-up of obese children (Stovitz et al., 2008; Akdag et al., 2011). *Silent slipped capital femoral epiphysis* and a high prevalence of tilt deformities were also revealed in obese children and adolescents which might predispose for later hip osteoarthrosis in obese adults (Wabitsch et al., 2012). Similarly as flat feet, this symptom interferes with normal physical activity, which is more and more reduced.

13. Conclusions and perspectives

The role of adequate exercise in the optimal development of body composition, functional capacity, physical and metabolic fitness has been always well known. Prevailing sedentarism resulting in a secular increase of overweight and obesity appears to be more threatening, as this situation has been still continuing in spite of their plateauing in selected countries. The prevalence of excess fat remains generally too high, and at present concerns also categories of children of a very young, preschool age. Reduced skill and deterioration of functional status of children who are clumsy, get tired more easily after quite a short period of time, reduces spontaneous active games and exercise even further since preschool age. The more such an inclination persists until later age, the more it is difficult to introduce adequate all-life desirable physical activity regime. Exercise was known as an efficient factor for increased utilization of fat, due to increased aerobic power, and reduction of its deposition in the human body. In spite of this knowledge, a more exact definition of the regimes of physical activity and exercise aiming for an optimal morphological and functional growth and development starting with preschool age have not been elaborated satisfactorily for present environmental conditions yet.

When defining exercise recommendations for adequate development, it is necessary to consider in all individuals their stage of development, morphological and functional predispositions, nutritional status, psychological and other personal traits. All that varies in children and adolescents markedly since preschool age (Pařízková, 2010). Most efficient intervention with the use of exercise should therefore start since early periods of life: e.g. a system of motor stimulation of youngest children since the first year of life was elaborated previously (Koch, 1978), continuing in preschool and school age. Such an approach, however, concerns, all other developmental aspects, e.g. adequate food behavior, which is at present also very difficult to be introduced early due to the prevalence of globalized consumer marketing for energy dense foods (Pařízková and Hills, 2005; Pařízková et al., 2002; WHO, 2013).

Proper functional and body composition development of the child are an indispensable component of "*positive health*" along with its preservation up to the advanced years, and prevention of metabolic and other diseases which reduce active life and longevity. "*Health of children is the key to the health of the whole population*" (WHO, 2010b, 2013). To achieve active individual attitudes and involvement in exercise during the whole life, all efforts – including consistent physical activity and exercise regimes, mostly from a physiological approach, have to be emphasized and *inventively developed since the earliest years of life*. Such arrangements, however, have to consider present environmental life conditions. Even when this has been known, the prevalence of obesity today, underscores the need for increasing attention to the application of these findings – not only by parents and pedagogues, but of all involved. This includes pediatricians, obesitologists, healthcare providers, public administrators, politicians, and other specialists, who by their position and influence, can under current life conditions, contribute to developing preventive strategies for the interventions necessary to reduce obesity.

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