

<p>Authors' contributions:</p> <p>A Study design B Data collection C Statistical analysis D Data interpretation E Literature search F Manuscript preparation G Funds collection</p>	<h2 style="text-align: center;">Overweight and obesity in childhood – how can physical activity help?</h2> <p>Christine Graf^{1A-G}, Walter Tokarski^{2ADE}, Hans-Georg Predel^{1ADE}, Benjamin Koch^{1ABDE}, Sigrid Dordel^{3ABDE}</p> <p>¹ Institute for Cardiology and Sports Medicine, ² European Sport Development and Leisure Studies, ³ Institute for School Sport and School Development, German Sport University, Cologne, Germany</p>
<p>Key words</p>	<p>Summary</p> <p>The prevalence of overweight and obesity among children and youth is increasing worldwide. In Germany, between 10 to 20% of children and adolescents are overweight or obese. An excessive energy intake, decreased physical activity and a sedentary lifestyle have been implicated as risk factors besides a possible genetic predisposition and a low socio-economic status. Energy intake seems to have stabilised over the last decades, therefore physical activity is in the centre of scientific interest. Data on children's activity and its correlation with obesity are sparse and inconsistent. Several studies described decreased motor abilities in overweight children compared to their normal weight counterparts, especially in co-ordination and endurance performance. Some authors found differences between the fitness of obese and non-obese children, others did not. Energy expenditure seems not to differ between overweight and normal weight children.</p> <p>There is a general agreement that obese children prefer sedentary habits, mainly audiovisual media like television and video games. The incidence of obesity increases with a daily television consumption of more than three to five hours. The extent, intensity, and kind of sports/exercise, necessary for preventive and therapeutic measures, are not known. Therefore, recommendations for daily routine and physical activities can hardly be formulated. This paper presents the current aspects of the role of physical activity in the development and prevention of overweight and obesity during childhood.</p> <p>Children – Overweight – Physical activity – Prevention – Motor abilities</p>

Introduction

The prevalence of overweight and obesity among children and adolescents is increasing worldwide [1,2,27]. In Germany, between 10 – 20% of children and youths are overweight or obese [3]. Juvenile overweight is accompanied by several co-morbidities like hypertension, hyperlipoproteinaemia and insulin resistance, psychosocial and orthopaedic disorders, etc. [56]. Obese children also have an increased risk of developing various chronic diseases later in life [40]. Besides a possible genetic predisposition and a lower socio-economic status, excessive energy intake, decreased physical activity and a sedentary lifestyle have been implicated as factors in the development of paediatric obesity [6]. Studies regarding children's nutrition suggest that those who are obese consume less or similar amounts of calories than their non-obese peers [9,42]. These findings have been cited

as evidence that energy expenditure and activity are reduced in obese children. Therefore, physical inactivity and sedentary habits seem to play the key role in this process. No exact definitions of physical activity or inactivity exist, and data about children's activity and its correlation with obesity are sparse and inconsistent, depending on the applied measuring procedures [46]. Some instruments for assessing physical activity are questionnaires, observations and measuring devices, e.g. heart rate monitors or accelerometers. Some authors found differences in fitness between obese and non-obese children, while others did not [4,5,57]. In our studies, we suggested to use the results of motor ability tests as an indirect indicator of activity or inactivity [18,19]. Several studies described poorer motor test results achieved by overweight children compared to their normal weight counterparts, especially regarding co-ordination and endurance performance [19,39].

The aim of this paper was to present and discuss current aspects of the role of physical activity in the prevention and therapy of overweight and obesity in childhood.

Physical activity and inactivity

The most variable component of energy expenditure is physical activity. Regular participation in physical activity is associated with substantial health benefits for children and adolescents ([7,47]; see Table 1). Furthermore, there is evidence that active youths are more likely to become active adults [21,31,52] and that energy expenditure is decreasing in both, childhood and adulthood [6,48]. Goran and Treuth [16] suggest that sedentary lifestyle is due to a growing dependence on technology and labour-saving devices, which reduced the need for physical exertion in everyday activities, e.g. increased use of automated transport rather than walking or biking; reduction in physical activity in the workplace because of computers, automated equipment, and electronic mail; increased traffic and the reduction of outdoor playing; poor urban planning that does not provide adequate bik-ing paths. Kimm *et al.* [28] found a decline in physical activity in girl’s leisure time by approximately 64% (white girls) and 100% (black girls), aged 9 years at the beginning of the study, in a 10-year follow up in the USA. In Germany, Bös *et al.* [8] showed that physical activity of schoolchildren decreased by 3 – 4 h between the seventies and nineties, lasting now only about one hour per day, including physical education lessons at school. Reduced activity may lead to reduced physical performance and motor abilities, apart from overweight and obesity. Declining physical performance may produce frustration and avoiding physical education classes or leisure time activities.

Table 1. Effects of physical activity and weight reduction (after [36], modified)

	Weight reduction	Physical activity
Hypertension	↓↓↓	↓↓↓
Diabetes mellitus type 2	↓↓↓	↓↓
Hyperlipoproteinaemia	improvement	improvement
Coronary artery diseases	↓↓	↓↓↓
Cerebrovascular disease	↓	↓↓
Tumors	↓	↓(↓)
Osteoporoses	-	↓↓↓
Sleep apnoea syndrome	↓↓	?

At the baseline examination of the CHILT project (Children’s Health Interventional Trial), overweight and obese children proved inferior to the non-obese ones in co-ordination and endurance performance [19] and this was confirmed by other authors. Namely, Okely *et al.* [39] found in 4363 schoolchildren (Grades 4 – 10) poorer motor test results in overweight subjects in principal motor skills such as endurance performance and general motor development; Chen *et al.* [11], in a nationwide fitness survey, described a negative correlation between the BMI and physical fitness that included running, standing long jump, bent-leg curl-ups and sit-and-reach test; Treuth *et al.* [54] showed that a lower total energy expenditure and muscle oxidative capacity predicted higher rates of fat gain. On the other hand, Maffeis *et al.* [33] described a higher total energy expenditure in obese than in non-obese children, despite a longer duration of sedentary activities.

Despite the discrepancy concerning the reasons for reduced physical activity, it has been agreed that sedentary habits, mainly using audio-visual media such as television and video games, are preferred by obese children [13,17]. The incidence of obesity seems to increase rapidly with a daily television consumption exceeding 3 – 5 h [10,17,45]. First-grade obese children watched television approximately twice longer than normal weight children, i.e. 88 vs. 69 min per day, respectively, or 572 vs. 246 min per week, respectively [18,20]. Results of the Framingham Children’s study confirm that the amount of time spent on watching TV or playing video games is an important risk factor for the development of excess body fat during childhood [41]. By the age of 11 years, children who watched TV more than 3 h of per day, had significantly higher skinfold thickness compared with those who watched less than about 2 h a day. But not all studies on children found a positive association between watching TV and obesity. In a meta-analysis done by Marshall *et al.* [37], the association between watching TV, physical inactivity and body fatness was mostly too low to be of substantial clinical relevance. Robinson *et al.* [44] found only a weak association between watching TV and either obesity or physical activity. DuRant *et al.* [14] followed a group of 3 to 4 year-old children and found that those who watched TV longer were physically less active, although there was no increase in measures of obesity. The reason for these relationships has not been definitely clarified. Television watching is associated with a high caloric intake [55]. In addition, Klesges *et al.* [29] found that energy expenditure while watching TV was significantly lower than when the children were doing nothing at all.

Physical activity in the prevention of overweight and obesity

The apparent association between childhood obesity and its carry-over into adulthood with the accompanying risks for hypertension, cardiovascular and metabolic diseases, makes the prevention of childhood obesity and physical inactivity a major target for intervention [49,50]. In addition to the above assumption that overweight children prefer sedentary habits and avoid physical activity, clear preventive strategies emerge: reduction of sedentary habits and an increase of physical activities in leisure time and daily routine. Although the specific physiological role of exercise in weight loss is not completely understood, exercise appears to increase fat oxidation [53] and prevent loss of lean body mass and the associated decrease in metabolic rate [25].

Worldwide family- and school-based programmes with an emphasis on healthy lifestyle, provided inconsistent results. However, in a recently published Cochrane review, Summerbell *et al.* [51] concluded that the amount of high quality data, confirming the effectiveness of obesity prevention programmes, is limited.

The non-cooperativity of parents limits the efficacy of programmes exclusively school-based. In the first step of our CHILT project (CHILT I), we examined the effect of a school-based intervention on BMI and motor abilities (endurance performance and general motor development) in 12 randomly selected primary schools compared with 5 randomly selected control ones [21]. The teachers were instructed to give one health education class per week (20 – 30 min), to enhance classroom and break activities and to optimise physical education lessons; daily activity at school increased by at least 10 – 15 min.

Body height and weight were measured and BMI was computed. General motor development was deter-

mined by applying a co-ordination test (KTK) and endurance performance (6-min run) [8,18,19]. After nearly 4 years of intervention, no difference in the prevalence of overweight and obesity was found between the experimental and control schools or in the endurance or complete KTK, but the performance in lateral jumping and balancing backwards (components of the KTK) was better in experimental schools than in the control ones. The results were adjusted for age, test result at the entrance examination, gender and BMI-classification at final examination. Therefore, we concluded that preventive intervention in primary schools offers an effective means to improve selected co-ordinative skills in children, but does not influence the incidence of overweight and obesity when parents are not included. Manios *et al.* [34,35] found a significantly reduced increase in BMI and an improved fitness in the intervention group after 3 or 6 years of school interventions in Cretan children aged 6 at the beginning. Besides the school-based intervention, seminars were organised for parents to improve their health knowledge. Mueller *et al.* [38] showed a higher reduction of skinfold thickness after one year of a combined family- and school-based intervention. The families were trained in healthy nutrition, asked to reduce TV time, and to increase physical activities by more than one hour a day.

Physical activity in the therapy of overweight and obesity

Within the therapy programmes for obese children and adolescents, physical activity plays a substantial role [3,26]. The main physiological and psycho-social effects of physical activity during the therapy of obese children are demonstrated in Table 2.

Table 2. Physiological and psycho-social effects of exercise in the therapy of overweight and obese children and adolescents [3,26]

- Weight maintenance or reduction
- Improvement body composition, increase of muscle mass, reduction of fat mass
- Increase of the total energy expenditure, esp. in combination with dietary strategies
- Improvement of physical performance and motor abilities
- Positive influence on potential cardiovascular risk factors, like hypertension, glucose intolerance, hyperlipoproteinaemia etc.
- Positive influence on potential cardiovascular risk factors, like hypertension, glucose intolerance hyperlipoproteinaemia etc.
- Improvement of posture and orthopaedic disturbances
- Psycho-social well-being, self-esteem and quality of life
- Feeling of success
- Reduction in negative felt exercise associated situation, e.g. during physical education classes
- Learn psycho-social strategies in keeping with failures

Within the second step of our CHILT-project (StEP Two programme), a school- and family-based interdisciplinary intervention for overweight *and* obese children from primary schools (Grades 1 – 4), the increase in BMI tended to be lower in the intervention group after nearly 9 months, despite its higher starting value in that group.

There was a significant reduction of systolic blood pressure post-intervention and a smaller one of diastolic pressure [22]. Following our intensive family-based ambulatory programme at the German Sport University for at least 8 year-old obese children and their parents (CHILT III), BMI standard deviation score, the marker for the degree of overweight [3], markedly decreased compared with the controls, while absolute and relative physical performance (power output, W) and $\dot{V}O_{2max}$

significantly increased [23]. Similar results were shown for the Freiburg Intervention Trial for Obese Children (FITOC), an interdisciplinary, outpatient family-based programme for obese children, consisting of regular physical exercise and comprehensive dietary and behavioural education. After 8 months of intervention, BMI as well as BMI-SDS, decreased compared to the controls and it was accompanied by a decrease in LDL-cholesterol. The fitness levels (expressed in W/kg) improved in the intervention group, but not in the control one. Therefore, weight maintenance or weight reduction, are long-term objectives, but improvements in physical fitness also reflect the therapeutic success. Overweight, but fit, adults have a lower cardiovascular risk than unfit lean persons [32]. At present, no data are available which also confirms such observations for children [30].

Table 3. Recommendation for the children's activity pyramid [24]

	Duration	Intensity	Heart rate *	Examples
Daily activities	6× at least 5 to 10 min	-	-	Go to school by foot or bicycle; Housework, e.g. raking leaves, room tidying, vacuum cleaning
Moderate activities	4×15 min (= one hour)	Not sweating or panting	Approx. 130 to less than 160 bpm	Physical education lessons, organised sports;
Intensive activities	2×15 min (= 30 min)	Sweating or panting	≥ 160 bpm	Leisure activities like playing with friends or family members (swimming, in-line skating, hide-and-seek) **
Inactivity/media consumption	4×15 min (below 12 years of age) or 4×30 min (above 12 years of age)	-	-	Television, media use (PC, video games)***

* Heart rate – not obligatory (for definition see [4])

** The classification of these examples to moderate or intensive activities depends on the self-reported intensity (sweating or panting).

*** Obligatory, creative or relaxing activities like school time, drawing, reading and creative hobbies are excluded.

Conclusions and Recommendations

The extent, intensity, and kind of sports/exercise, employed as a preventive and therapeutic measure, is not precisely known. Recommendations of the American Heart Association [27] and others [48,50,58] appeared to demand the daily physical activity to last at least 60 min a day. In adolescents, resistance training should be combined with aerobic activity to gain muscle and bone mass. Sedentary habits, especially television, computer use and video games, should be reduced to less than 2 h per day. The German Society for Sports Medicine and

Prevention recommends 45 to 60 min of moderate physical activity [59] within the therapy against obesity. Based on these data and findings regarding physical activity in German children [8], we developed a children's activity pyramid for inactive and overweight children ([24]; see table 3). As a rule, daily activities are followed by moderate and intensive leisure activities targeting 2 h a day. Media use is reduced to one hour per day for children younger than 12 years, and to two hours for children older than 12 years [12].

Physical activity plays an important role in the reduction and maintenance of body weight. Because of

the increasing number of overweight and obese children and adolescents worldwide, preventive strategies are necessary and should concentrate on the reduction of sedentary habits and increased physical activity [51]. Longitudinal data pertaining to effective preventive and therapeutic measures are, however, sparse but it seems that the specific needs of children from different settings should be considered. Without the involvement of parents, the effect of school-based intervention is limited [21,43]. For overweight and obese children, intensive and interdisciplinary training programmes for the whole family are necessary to implement lifestyle changes [15,26], and to assure that a measurable benefit on cardiovascular factors is achieved [22,30].

Further examinations are indispensable to clarify the interactions between sedentary habits, dietary factors and physical activity and to identify parameters predicting, which children profit from which kind of preventive or therapeutic measures, and which settings can be offered to which target group. Future studies need to determine the type, intensity, and duration of exercise that would produce acceptable adherence and consequent long-term weight loss, and to ascertain the reinforcing factors that determine the behavioural choices of youths.

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