Motor Abilities and Aerobic Fitness of Obese Children

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Key words
- obesity in childhood
- outpatient intervention
- motor abilities
- physical activity

Abstract

Obesity is considered to be epidemic worldwide. Stopping further progression interdisciplinary, outpatient intervention therapy programs for obese children have become increasingly important. FITOC (Freiburg Intervention Trial for Obese Children) consists of a combination of organized sports, behavioral therapy and nutritional advice. The effectiveness of the therapy is determined on the basis of anthropometrical and physical performance data. The purpose of this report is to give a differentiated view of the motor abilities of obese children and to describe changes in the course of the therapy program FITOC. Data were collected on n = 49 obese children (BMI > 97th percentile) aged 8 – 12 in a pretest at the beginning and posttest at the end of the intensive phase of the therapy. These data were compared with an age-matched German reference group. Besides the General Sports-Motor Test (Allgemeiner Sportmotorischer Test [AST]), the BMI-SDS values, the body fat mass (FM %) and the aerobic capacity (Watt/kg body weight) were recorded. In the pretest, the running exercise results and the aerobic capacity checked ranged significantly below the values of the reference group. The performance in the coordinative tests of the AST was differentiated. The medicine-ball toss was significantly above average of the reference group. In the posttest, the BMI-SDS values and the body fat mass (%FM) decreased ($p < 0.001$) and the aerobic capacity improved ($p < 0.001$). Performance in all motor abilities tests improved and the difference between the strength of the obese children and the strength of the reference group decreased. This study demonstrates that in obese children weight-bearing activities are below average but not all motor abilities.

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Introduction

Childhood obesity is a worldwide epidemic, with prevalence rates doubling or tripling over the past 15 years [9]. Germany has followed this trend with about 10 – 18 % overweight and 4 – 8 % obese children and adolescents in this age group [37]. The main causes are poor eating habits and a decrease in physical activity [2, 5]. The negative consequences of obesity as a chronic disease in adults have repeatedly been confirmed [16, 26]. But even among children, there is an increase in postural weakness and joint complaints, as well as an increased prevalence of hypertension and type 2 diabetes [32]. In addition to increased comorbidity, psychosocial limitations play an important role in the lives of these children [8]. Overweight children are not infrequently treated like outsiders. Isolated from their environment, especially during school sports, they lose interest in physical activities and suffer low self-esteem. In one study, the quality of life of obese children and adolescents was significantly less than that of normal-weight children and, in their opinion, similar to children suffering from cancer [31].

The FITOC Program (Freiburg Intervention Trial for Obese Children) is an eight-month (intensive phase) multidisciplinary, outpatient obesity intervention program for children. The program consists of regular physical exercise (three times a week) plus comprehensive dietary and behavioral education. In contrast to other approaches, parental involvement plays a major role in the FITOC program. Besides supporting their own children, the parents themselves are given theoretical and practical information about nutrition, as well as background information about the psychological and physiological problems of obese children. At four- to six-week intervals during the eight month program, seven information ses-

Table 1 The intensive phase of FITOC* (8 months)

Medical care – initial examination (IE)
▸ sports program-associated counselling (once a week)
▸ control examination (CE) after 8 months
Nutrition – baseline and control examination
▸ individual nutrition counselling
▸ sports program-associated counselling (once a week)
▸ additional nutritional consultation hours (once a week)
▸ nutritional and behavioral training
▸ 4-day nutritional calorie count (every 4–6 weeks)
▸ meetings with parents (every 4–6 weeks)
Psychological counselling, associated, flexible
Appropriate physical activities for obese children (3 times a week)
▸ body weight measurements (twice a week)
Additional meetings with parents

* Freiburg Intervention Trial for Obese Children

Table 3 Key elements of sport in the FITOC* program

Start phase (1 month): to get to know each other, group feeling, characteristics of the sport lessons: high attractivity, variety, fun, free choice for games, participation in planning contents
Learning phase (4.5 months): aerobic exercise (endurance), coordination, strength training with own body weight, knowledge about body reaction (e.g., pulse counting), noncompetitive sports, **councelling to encourage incorporation of physical activities into their daily lives**
Transitional phase (2.5 months): work out of special skills for kinds of sport, motivation to take part in sport clubs during leisure time
New found pleasure in sports activities motivates participants to work on their other problems

* Freiburg Intervention Trial for Obese Children

Table 2 Follow-up phase of FITOC*

Reduced frequency of the sports program, combined with councelling the children as to how they can intensify and incorporate their own preferred physical activities into their daily lives
Individual consultation hours for children and parents (nutrition, behavior, psychosocial problems)
Additional meetings for parents
Additional meetings for children
Control examinations after 8, 12, 18, 30 months, more if required

* Freiburg Intervention Trial for Obese Children

Table 4 The extended AST*-test battery

Test	Motor ability
20-m sprint	action speed
Hurdle run	coordination under timed conditions
Coordination in precision tasks	
▸ precision toss	eye-hand coordination
▸ one-leg standing	balance
▸ ball-legs-wall	orientation
Special push-ups	strength endurance
Medicine-ball toss	speed strength
6-minute run	aerobic endurance

* Allgemeiner Sportmotorischer Test (General Sports-Motor Test)

sions with parents and seven with their children were held (▶ **Tables 1** and **2**). This program is orientated towards sports (▶ **Table 3**). Motor abilities in obese children have been studied in only a few studies [12,28]. The majority of available studies of motor abilities in children show that performance has become clearly poorer in the past few years [15,18,19]. The causes are numerous. On the one hand, there is a lack of physical exercise, caused by staying indoors, a change in leisure activities with increased media usage and, especially in large cities, a noninteractive environment [20]. On the other hand, the intake of high-caloric snacks, particularly fast-food products is increasing [38].
The purpose of the present study was to document in a pretest at the beginning and in a posttest at the end of the intensive phase of therapeutic intervention, the development and improvement in motor abilities of obese children using a standardized and evaluated test battery [3]. Furthermore, we summarize the anthropometric changes of body composition (body mass index – standard deviation score values [BMI-SDS], percent body fat mass [% FM]) and standardized ergometry performance. The step-by-step adjustments for intensity, exercise development and new components are contents of further publications.

Material and Methods

The FITOC sports program was carried out in a Freiburg sports center and consisted of 3 sessions per week. All three hour sessions consisted of moderate and vigorous endurance training with a variety of aerobic activities (e.g., games), swimming sessions, psychomotoric activities and exercises to improve coordination, flexibility, strength and speed performance capacity. The intensity for each child was checked by heart rate monitoring (Cyclosport® CTS system, Krailling, Germany). The exercise program was designed to enhance the joy of movement, body awareness, and team spirit in order to bring about long-term changes in behavioral patterns. The primary goal was to increase self-esteem and daily energy expenditure through pleasurable activities [21, 22] (▶ **Table 3**). The contents of the FITOC program are orientated at the recommendations given by a recent review about the effects of physical activity on health in school-age youth [35].

Subjects

Obese children aged 8 to 12, participating in the program, were referred by either family doctors, pediatricians or school doctors. Some were outpatients at two Freiburg university clinics (Universitäts-Kinderklinik, Kinder- und Jugendpsychiatrie der Universitätsklinik). The inclusion criteria was a BMI above the 97th percentile based upon up-to-date BMI curves for German children [23]. Children with a BMI between the 90th and 97th percentile were included in the program if they had somatic comorbidities or one overweight parent. All parents of our subjects gave their written consent to include their data in this study. The intensive phase of the therapy program was 8 months from initial examination (IE; pretest) to control examination (CE; posttest).
147 children (73 boys, 74 girls) who started treatment in a new FITOC group, absolved the General Sports-Motor Test (Allgemeiner Sportmotorischer Test [AST]). Of these, 49 children (20 boys, 29 girls, ∅ 10.7 ± 1.4 years) absolved the pre- and posttest (▶ **Table 4**). Additionally, their anthropometric variables were measured at the time-point of the pre- and posttest of the AST.
The maturational status was assessed by Largo and Prader [24, 25] and showed that all subjects were in prepubertal status.

Table 5 Comparison pretest/posttest of FITOC(*) children

Disciplines	n	Pretest mean value ± SD	Posttest mean value ± SD	p value[1]
20-m sprint (sec)	47	4.6 ± 0.4	4.4 ± 0.4	< 0.001*
One-leg standing[2]	47	11.4 ± 4.2	11.2 ± 5.4	0.637
6-minute run (m)	49	741.2 ± 148.1	856.2 ± 170.4	< 0.001*
Hurdle run (sec)	41	29.3 ± 5.7	27.2 ± 6.7	< 0.002*
Precision-toss (points)	41	11.9 ± 5.1	14.1 ± 4.7	< 0.002*
Ball-legs-wall (points)	41	22.4 ± 9.3	27.1 ± 8.9	< 0.001*
Special push-up (number)	41	11.8 ± 2.9	13.2 ± 4.8	< 0.003*
Medicine-ball toss (m)	40	4.9 ± 1.1	5.0 ± 1.0	< 0.001*

[1] *t*-test for paired samples; * significant change from pretest to posttest; (*) Freiburg Intervention Trial for Obese Children

Anthropometry

The BMI-SDS was selected as an outcome measure for weight development at the initial (IE) and control (CE) examination. Therapy success was defined as a decrease in BMI-SDS (BMI-SDS CE < BMI-SDS IE). Body height and weight were measured with a Gilliver anthropometer and a weighing lever with a movable jockey. BMI was used as a basis for weight status. To correct for age and sex, individual BMI-values were converted to Z-scores "(SDS values = standard deviation score values)". The calculation of "SDS" values was based on the national reference data available for German children [23]. Results are indicated as BMI-SDS values. These references were derived using Cole's LMS method [6], which allows BMI in individual subjects to convert into SD scores as follows:

$$\mathrm{BMI}-\mathrm{SDS}_{\mathrm{LMS}}=\frac{[\mathrm{BMI}/\mathrm{M(t)}]^{\mathrm{L(t)}}-1}{\mathrm{L(t)\,S(t)}}$$

where BMI-SDS = individual BMI value, L = Box-Cox-Power, M = Median, and S = coefficient of variation in age (t) and sex of the individuals in the reference group. Results are indicated as BMI-SDS values.
The regression equations of Slaughter [33] were used for the prediction of body composition. These equations predict percent body fat mass (%FM) from sum of triceps (T) and subscapular (S) skinfolds (mm):
Boys: 1. %FM = 0.783 (T + S) + 1.6
Girls: 2. %FM = 0.546 (T + S) + 9.7
The collection of skinfolds was always performed by the same trained researcher and Lange-Caliper.

Ergometry

Aerobic performance was gauged with a standard bicycle ergometer (Lode, Groningen, NL) using a typical standardized test protocol starting at 25 – 50 Watts and increasing the workload 25 Watts every three minutes until exhaustion [21]. Heart rate and blood lactate concentration were also recorded every three minutes to determine the degree of exhaustion to evaluate the fitness level. In children's ergometry the degree of exhaustion depends on individual child's motivation. Thus far, the aerobic performance capacity of obese children in the FITOC program had been assessed by the cycle ergometry, but not all motor capacities had been analyzed. Therefore, the AST-test battery was selected.

Motor abilities test performance

The AST-test battery included two speed tests (20-m sprint, hurdle run), one aerobic capacity test (6-minute run), two strength tests (medicine-ball toss, special-push up) and three coordinative tests (ball-legs-wall, one-leg standing, precision toss) (**Table 4**). The test was conducted according to the test requirements described [3]. The children were informed in advance about performance of the test.

Reference values

The underlying reference values for the 8 – 11-year-old children were obtained from a representative cross-sectional study on 1400 children performed in the year 2000 [4]. For the 12-year-old children, reference values are available for three of the eight tests [4].

Statistics

Assessment was made using SPSS 11.01. The Kolmogorov-Smirnoff test revealed that in all investigated parameters, the distribution did not show statistically significant departure from normality. The independent samples *t*-test was used to compare the results of the FITOC children in the motor abilities test-performance with the values of the reference group in pre- and posttest. Differences between the individual value of each child and the reference values were measured at pre- and posttest. From these individual differences, the mean values and standard deviations were calculated for pre- and posttest.
The independent samples *t*-test was applied to determine sex differences in BMI-SDS and weight-dependent ergometry performance. The variation in the number of subjects between the different test items is explained by missing values or a lack of reference values for the 12-year-old children besides 20-m sprint, 6-minute run, and one-leg-standing. *T*-test for paired samples was used to evaluate the changes in motor capacity, BMI-SDS and Watt/kg body weight between the IE and CE. The significance level was set at $\alpha = 0.05$.
The study was approved by the University of Freiburg Ethics Committee.

Results

BMI-SDS

The BMI-SDS decreased significantly from 2.4 ± 0.4 to 2.1 ± 0.5 ($p < 0.001$) (**Table 5**). There was no significant difference between boys and girls in the IE ($\mathrm{BMI\text{-}SDS}_{♂\ \mathrm{and}\ ♀} = 2.35$; $p = 0.991$) and in the CE ($\mathrm{BMI\text{-}SDS}_{♂} = 2.09$, $\mathrm{BMI\text{-}SDS}_{♀} = 2.10$; $p = 0.944$).

Body fat mass (%FM)

In the global group the body fat mass decreased significantly from 47.5 to 43.8% after the intensive treatment phase ($p = 0.001$). There were no significant gender differences.

Ergometry

The ergometric aerobic performance capacity improved significantly from 1.7 ± 0.3 Watt/kg body weight (BW) to 2.1 ± 0.5

Table 6 Statistics of the FITOC(*) values and the AST** reference group

Disciplines	Difference FITOC reference group		
	Pretest	Posttest	p value[1]
20-m sprint (sec)	0.3 ± 0.3	0.2 ± 0.3	0.002*
One-leg standing[2]	– 0.5 ± 4.7	– 0.3 ± 5.3	0.838
6-minute run (m)	– 241.4 ± 149.8	– 180.6 ± 176.0	0.010*
Hurdle run (sec)	8.0 ± 6.0	5.6 ± 6.6	0.001*
Precision-toss (points)	– 1.8 ± 3.8	0.4 ± 4.1	0.016*
Ball-legs-wall (points)	– 7.6 ± 7.7	– 3.7 ± 6.6	0.003*
Special push-up (number)	– 3.3 ± 2.6	– 1.6 ± 4.9	0.025*
Medicine-ball toss (m)	0.3 ± 0.7	0.5 ± 0.7	0.090

[1] *t*-test for paired samples; * significant change of the difference between FITOC- and reference group from pretest to posttest; (*) Freiburg Intervention Trial for Obese Children; ** Allgemeiner Sportmotorischer Test (General Sports-Motor Test)

Table 7 Comparison pretest/posttest of FITOC(*) children

Disciplines	n	Pretest mean value ± SD	Posttest mean value ± SD	p value[1]
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[1] *t*-test for paired samples; *significant change from pretest to posttest; (*) Freiburg Intervention Trial for Obese Children

Watt/kg body weight ($p < 0.001$). There was a difference between boys and girls in the IE ($n = 38$: 17 boys: 1.82 ± 0.33 Watt/kg body weight; 21 girls: 1.66 ± 0.34 Watt/kg body weight), but it was not significant ($p = 0.151$). In the CE, there was no sex difference (boys: 2.18 ± 0.52 Watt/kg BW; girls 2.02 ± 0.40 Watt/kg BW; $p = 0.276$).

Pretest (IE)

FITOC children were significantly poorer in all tests compared with the values of the reference group, except the medicine-ball toss and one-leg standing. In these abilities, obese children had a comparably (or better) normal performance at the beginning of the therapy program (**Table 6**).

Posttest (CE)

Performance improved in all motor abilities tests, but not significantly in one-leg standing (**Table 7**). Also, posttest results of the FITOC children were poorer than the reference values in all weight-bearing performances (20-m sprint, 6-minute run, hurdle run) (**Table 6**). A decrease of the difference between the FITOC children and the reference values, except for one-leg standing and medicine-ball toss, is seen (**Table 6**).

Discussion

The purpose of this study was to compare the differences in the motor abilities of obese children and a German reference group in a pretest in order to evaluate the success of the therapy program in a posttest. Beside a decrease or stability in BMI-SDS, an improvement in motor abilities and aerobic capacity is one important criterion for the therapeutic success of the FITOC program.

In the posttest of our study, we found a significant decrease in BMI-SDS values and body fat mass. Ergometric aerobic performance improved significantly. Longitudinal studies of the relationship between overweight and physical fitness in children showed a negative correlation between physical activity and the BMI [20], as well as initial body fat mass values [17]. A low level of physical activity is coupled long-term with low physical fitness and weight gain [13]. The positive effect of physical activity on the body composition and on the body weight of overweight people has been recognized [29].

Scientific considerations and cost led to the selection of the sports-motor test. The following items were taken into account in the test selection:

- Inclusion of basic motor abilities for strength, speed, endurance, coordination
- High level of objectivity, reliability and validity (test quality criteria)
- Economy and simplicity of performance
- Availability of sex- and age-specific current normal values
- Special requirements for overweight and obese children.

The AST has high test-retest reliability (0.93) for the test battery [3] and the motor abilities strength, endurance, coordination and speed are included. Few materials are required beyond the equipment available in a gymnasium. The test can be performed with a group size of 15 children in a double sports lesson (1.5 hours) with three examiners. This test covers all motor capacities.

The evaluation of sports training in the therapy setting is an important component of an effective and successful therapy program given the increasing importance of quality management. The sports content must be tailored to the capabilities of obese children and encourage them to take part [34]. The change in the child's motor abilities competence as well as natural movement patterns may have a greater influence on a long-term healthy lifestyle than focusing only on cardiorespiratory fitness [36]. The sports-motor test fulfils the requirements in light of the examination and development of the complex pattern of motor abilities in children.

In the 6-minute run, which reflect an endurance aerobic component, the values were below the reference in the pre- and in the posttest. Foger and our own study [11,21], which examined motor performance capacity more closely, found aerobic endurance and coordination highly deficient.

In tests requiring coordination (hand-eye coordination, standing on one leg), flexibility or speed of upper limb movement, body fat is not likely to hinder performance [7]. Complex movement control, however, like orientation, differentiation, and coupling (ball-legs-wall test, hurdle run) as well as cognitive capabilities are clearly underdeveloped. Obesity greatly influences a child's running capacity (20-m sprint) and the performance of strength endurance push-ups. A negative relationship between body-fat and performances on weight-bearing tasks in 12 – 27-year-old subjects was found [7]. The excess body fat must be moved during weight-bearing tasks, obese children avoid weight-bearing tasks due to lack of experience and the energy required [1].

The better results of the medicine-ball toss are due to its greater body mass which positively effects speed strength. One reason for this result could be greater back strength.

The decrease of the difference between the FITOC children and the reference values show that the motor capabilities can be improved in the age between 10 and 12 [4,35]. For this reason, it is necessary within a sports program to motivate overweight children to desire more physical activity in this phase of their motor development. Sports clubs are too competitively oriented and thus poorly suited for less fit children and the obese. It is important for obese children to enjoy physical activity and receive encouragement. A sports program for obese children has to focus on the special needs of obese children [21].

A 6-minute run at the end of the sports therapy is an easy way to ascertain aerobic capacity. Drinkard et al. could show that an endurance running test correlates with the BMI values and the cycle-ergometric data [10]. Many studies, which compare overweight and normal-weight children with respect to fitness show inconsistent results [14,30]. Imprecise methods of measurement may be the main cause. It is unclear whether, in addition to frequency, the type, intensity and duration of the individual sports activities were taken into account. Physical activity at times was expressed as absolute energy expenditure with no correction having been made for the body mass of obese children [7,27]. Physical fitness includes several components such as aerobic fitness, muscular strength and endurance, flexibility, coordination and speed [1].

In summary, it could be demonstrated that overweight children do not function at a low level in all motor capacities. The target criteria of BMI-SDS and fat reduction coupled with an increase in physical performance capacity were fulfilled. Our results confirm that training can improve aerobic fitness and motor abilities competence in obese children. Considering the massive health and well-being implications of childhood obesity these motor abilities lead to social integration and lifestyle changes.

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