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Physical activity and fitness in 8-year-old overweight and normal weight children and their parents

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***Objectives*:** To compare the physical fitness and physical activity of 8-year-old overweight children (n = 53) to normal weight children (n = 65), and to determine whether a significant relationship exists between physical activity of parents and their children.
***Study design*:** A cross-sectional study.
***Methods*:** A total of 119 children from Northern Finland were recruited for the study. Waist circumference, height, weight and BMI were measured. Physical activity of the children and their parents was determined with self-administered 7-day recall questionnaires (PAQ-C). Physical fitness of the children was evaluated with 7 items of the EUROFIT-test battery (flamingo balance test, plate tapping, sit-and-reach test, sit-ups, bent arm hang and 10 × 5 shuttle run). Aerobic capacity of the children was tested with 6-minute walking test.
***Results*:** Overweigh was related to impaired performance in tests requiring muscle endurance, balance, explosive power of lower extremities, upper body strength and endurance, speed and agility in both genders and aerobic capacity in boys. Physical activity levels of overweight boys (2.41 SD 0.72) were lower than their lean counterparts (2.91 SD 0.64, $p = 0.004$); no such difference was observed in girls (2.53 SD 0.64 vs. 2.59 SD 0.68, $p = 0.741$). Physical activity was significantly associated with better performance in several physical fitness tests in boys, but not in girls. Mothers' physical activity was associated with children's physical activity ($r = 0.363$, $p < 0.001$), but no such association was found between fathers and children ($r = 0.019$, $p = 0.864$).
***Conclusion*:** This study shows an inverse relationship between excess bodyweight and physical fitness in children. Mother-child relationship of physical activity appeared to be stronger than father-child relationship. Improving physical fitness in children through physical activity might require interventions that are responsive to the ability and needs of overweight children and their families and focus on helping parents and children to be physically active together.

Keywords: *physical activity*; *fitness*; *children*; *overweight*; *obesity*; *parental physical activity.*

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Childhood obesity is already epidemic in some areas and on the rise in others. The prevalence of childhood obesity has more than doubled in many countries in the WHO European Region since the 1980s (1). Globally, in 2010 around 43 million children under the age of 5 were estimated to be overweight (2). Also in Northern Finland the prevalence of overweight and obese young people has doubled or tripled during the last decades (3). The health risks of this epidemic are profound and far-reaching. Insulin resistance, type 2 diabetes (4), hypertension (5), obstructive sleep apnea (6), poor self-esteem, and a lower health-related quality of life (7) are among the comorbidities seen more commonly in affected children and youth than their counterparts.

From a public health point of view, one major concern with juvenile obesity is the likelihood that it will track into adult life. A longitudinal study of the Northern Finland birth cohort for 1966 indicated that body mass index (BMI) at 14 years of age was the most important predictor of BMI at 31 (8). The risk of adult obesity is at least twice as high for obese children compared to non-obese children (9). Parental obesity significantly alters the

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risk of obesity in adulthood for both obese and non-obese children, especially those less than 10 years of age. It has been suggested that obesity in one or both parents influences the risk of obesity in their offspring because of shared genes or environmental factors within families (10). Recent cross-sectional study demonstrated that having an obese parent and not being involved in physical activity were strong predictors of childhood obesity at 9 years (11).

Several studies have found associations between low levels of physical activity and an increased prevalence of overweight in children (12–15). In the follow-up study of the Northern Finland birth cohort 1966, becoming inactive during the transition from adolescence to adulthood was related to overall obesity in both genders and to severe abdominal obesity in females at the age of 31 years (16). Cross-sectional studies have linked increase adolescent and children obesity to weakened physical fitness. Low physical activity may be one connecting factor between obesity and impaired physical fitness (17–20).

There are a few studies that have studied associations between weight status, physical activity and several components of physical fitness in adolescents (17,18) and in children (19,20). Two of the studies have suggested that overweight is related to poor performance in tests requiring cardiorespiratory fitness, muscle endurance, explosive power of lower extremities or speed and agility (18,19). The results showed that both physical activity and weight status were related to fitness (17) and cardiorespiratory fitness may play an important role in the prevention of overall and abdominal fatness (20,21).

In this study we examined whether physical fitness and physical activity levels were different in children with overweight and normal weight, using standardized measures of physical activity and multiple components of physical fitness. Moreover, we examined the associations between parents and their offspring's physical activity and weight status. We hypothesized that children who were overweight would have lower physical activity and physical fitness levels. We also hypothesized that there is an association between children's and their parents' physical activity.

Material and methods

Study design and participants

The study design is a cross-sectional survey of 8-year-old treatment-seeking overweight children and normal weight children and their parents.

Recruitment of overweight children and their parents

Voluntary overweight children and their parents were recruited to participate in a family-based treatment for overweight children through school nurses from 4 Northern Finnish cities (Oulu, Rovaniemi, Kemi and Ylivieska) in Finland in 2006 and 2007. The overweight children were invited to join either the experimental group or the control group. To qualify for the study, children had to be born during 1998–1999 and their BMI SD score (BMI z-score) relative to WHO norms had to be greater than 1 (22). Nurses were instructed to invite to the study all those students, who had started their school at a particular time period and who fulfilled the recruitment criteria. Twenty-three overweight girls and 30 overweight boys participated in the study. Fifty-one mothers and 34 fathers participated in the study.

Recruitment of normal weight children and their parents

A parent-report postal questionnaire enquiring physical activity habits was delivered to all 175 normal weight children born 1999 in 4 schools in the city of Oulu. The schools were selected from different parts of Oulu city (non-randomly). Eighty families (46%) returned the questionnaire. Five children were excluded due to unavailable weight and height data. Ten of the children were classified as overweight (BMI z-score >1 WHO) and excluded. There were 65 normal weight children (29 girls and 36 boys) in the final analysis. Fifty-two mothers and 49 fathers of normal weight children returned the physical activity questionnaire and participated in the study.

All mothers ($n = 103$) who participated in the study were biological mothers who lived with their children. Eighty-nine percent (74/84) of the fathers who participated in the study were biological fathers who lived with their children on weekdays.

All the parents filled in a questionnaire enquiring their age, weight, height, smoking, level of education, occupation, form of dwelling and number of the child's siblings. Education was classified into (a) Basic or/and vocational school, (b) High school and vocational school, and (c) University or Polytechnic. Mother's and father's occupation were classified into (a) employed, (b) full-time student, (c) child care leave, (d) unemployed, and (e) retired. Form of dwelling was classified into (a) apartment house, (b) row or semi-detached house, and (c) detached house. Also children's sleeping time was assessed using information obtained from parents. They were asked, How many hours of sleep does your child get in a 24-hour period? Possible answers were (a) 12 h or more, (b) 10–11.9 h, (c) 9–9.9 h, (d) 8–8.9 h, (e) 7–7.9 h and (f) less than 7 h.

Anthropometric measurements

Weight and height of overweight children and their parents were measured by a qualified nurse using standardized equipment. Body weight was measured to the nearest 0.1 kg by using a standardized scale (Seca Alpha Model 770; Seca Hamburg, Germany) in light clothing. Height was measured without shoes to the

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nearest 0.1 cm using a right-angle ruler placed on the head against a tape measure secured to the wall. Weight and height of normal weight children's parents was obtained from a parent-report postal questionnaire.

BMI was calculated as weight in kilograms divided by the square of height in meters (kg/m^2) for parents and for children. In this study children's overweight and obesity were defined using the international age and gender specific cut off points for BMI (23). Overweight and obese children were analyzed as one group, defined as overweight. Parents were classified as overweight, if their BMI was ≥ 25 kg/m^2 (24). Waist circumference (WC) was measured once in standing position by a measuring tape, midway between the lowest rib and the superior border of the iliac crest.

Physical activity

In this study physical activity of the children was assessed with The Physical Activity Questionnaire for Older Children (PAQ-C) (25). Parents were asked to help their children fill in the questionnaires. The PAQ-C is a self-administered 7-day recall questionnaire that consists of 9 questions (items). PAQ-C is designed to provide a general measure of physical activity levels during the school year (25) and has demonstrated acceptable internal consistency and validity (26–30).

Physical activities are described as sport or dance that make you sweat or make your legs feel tired, or games that make you breathe hard, such as tag, running, bicycling, and others. Each item is scored on a 5-point scale, with higher scores indicating higher levels of activity. To form a composite score for item 1, the mean of all activities on the activity checklist (including 24 physical activities/sports) was taken (''no'' activity being 1, ''7 times or more'' being 5). Items 2 to 7 asked about the physical activity levels during physical education classes, recess, lunch time, right after school, evenings and weekends.

Children were also asked (item 8) to describe their physical activity with 1 of 5 classes: (a) All or most of my free time was spent doing things that involve little physical effort, (b) I sometimes (1–2 times) did physical things in my free time (e.g. played sports, went running), (c) I often (3–4 times) did physical things in my free time, (d) I quite often (5–6 times) did physical things in my free time, (e) I very often (≥ 7 times) did physical things in my free time. The reported value was used for items 2 to 8.

To form a composite score for item 9, the mean of all days of the week was taken. Once a value between 1 and 5 had been given to each of the 9 items used in the physical activity composite score, the mean of these 9 items was used as the final PAQ-C summary score.

Parents completed a 7-day recall questionnaire for adults. At first (item 1) parents were asked whether they had taken part in different physical activities (checklist included 27 sports or physical activities) during the past 7 days. The alternative answers were: (a) none, (b) 1–2 times, (c) 3–4 times, (d) 5–6 times and (e) ≥ 7 times. To form a composite score for item 1, the mean of all activities/sports was taken.

Items 2 to 5 asked parents about physical activity in the mornings, afternoons, evenings and weekends during the past 7 days. The alternative answers were: (a) none, (b) 1 time, (c) 2–3 times, (d) 4–5 times and (e) ≥ 6 times. Reported value was used for items 2 to 5. Parents were also asked (item 6) to describe their physical activity using 1 of 5 classes: (a) All or most of my free time was spent doing things that involve little physical effort, (b) I sometimes (1–2 times last week) did physical things in my free time (e.g. played sports, went running), (c) I often (3–4 times) did physical things in my free time, (d) I quite often (5–6 times) did physical things in my free time, (e) I very often (≥ 7 times) did physical things in my free time. To form a composite score for item 7 the mean of all days of the week was taken. Once a value between 1 and 5 had been given to each of the 7 items used in the physical activity composite score, the mean of these 7 items was used as the final PAQ summary score.

Physical fitness

Physical fitness of the children was evaluated with the EUROFIT Physical Fitness Test Battery, which is designed for assessment of health-related fitness in children and adults (31). The test is a set of 9 physical fitness tests covering balance, flexibility, speed, endurance and strength. The participating children completed 7 items of the test battery. The standardized and validated test battery was devised by the Council of Europe for children of school age and has been used in many European schools since 1988. All children and at least 1 parent of overweight child was tested. Fitness tests were carried out by an experienced exercise physiologist. Aerobic capacity of the children was tested with 6-minute walking test (32).

(a) *Flamingo Balance Test:* This test assesses the ability to balance successfully on a single leg. Subjects stood on a wooden bar, with shoes removed, keeping balance by holding the instructor's hand. The number of falls in 60 seconds of balancing was used as the outcome.
(b) *Plate tapping:* This test assesses the speed and coordination of upper limb movement. The subject moved the preferred hand back and forth between the discs over the hand in the middle as quickly as possible. This action was repeated for 25 full cycles (50 taps). Two attempts were allowed and the best time to cover the test was used as the outcome.
(c) *Sit-and-reach test:* This test assesses upper thigh and lower back flexibility. Subjects were asked to

bend the trunk and reach forward as far as possible while sitting on the floor with knees extended. Two attempts were allowed and the best result was used as the outcome.

(d) *Standing broad jump:* This test measures the explosive power of the legs. The subjects made a jump as far as possible, landing on both feet without falling backwards. The maximum horizontal distance attained was measured in centimetres. Two attempts were allowed.

(e) *Sit-ups:* This test measures the endurance of the abdominal and hip-flexor muscles. The result was shown as the number of completed sit-ups in 30 seconds.

(f) *Bent arm hang:* This test measures upper body relative strength and endurance. The subject was assisted into position and the timing started when the subject was released. Timing stopped when the child's chin fell below the level of the bar or the head was tilted backward to enable the chin to stay level with the bar. Time in seconds was used as the outcome.

(g) *10 x 5 shuttle run:* This is a test of speed and agility. Marker cones were placed 5 m apart. When instructed by the timer, the subject ran to the opposite marker, turned and returned to the starting line. This was repeated 5 times without stopping (covering 50 meters total), and time in seconds was used as the outcome.

(h) *6-minute walking test:* This is a test assessing exercise capacity at sub-maximal level. The subjects were asked to walk up and down the measured course at their best pace but not to run or race. The tests were undertaken in small groups. Encouragement and announcement of time remaining were given to the children. The distance walked within 6 minutes was used as the outcome.

Ethical consideration

The study was approved by the Oulu University Hospital ethics committee. An informed consent was obtained from all the study parents. All participating children were informed about the nature of the study.

Statistical analyses

International gender- and age-specific cut-off points for BMI were used for overweight and obesity definition, and the participants were divided into 2 categories: normal weight and overweight/obese. Sex differences in physical activity and physical fitness are well known and therefore data were stratified by sex for analysis. The Kolmogorov-Smirnov test and frequency histogram with normal overlay were used to test for normality of the distributions. All anthropometric measurement values were normally distributed. Two-sample unpaired t-test was used to analyze the differences in continuous variables. For the dichotomous variables, the chi-square test was used to evaluate the significance of the differences between normal and overweight children and their parents. Pearson correlation was used to analyze the associations between physical activity and different components of physical fitness. Linear regression analysis with enter method was used to model the relationship between physical activity of the children and physical activity of the mothers and BMI of the mother and children weight status. The level of statistical significance was $p < 0.05$. All statistical tests were performed by PASW (SPSS) Statistics 18 for Windows.

Results

Among boys (n = 66) BMI indicated overweight in 21.2% (n = 14) and obesity in 24.3% (n = 16). Among girls (n = 53), the proportions were 17.0% (n = 9) and 28.3% (n = 15). Characteristics of the participating children by gender and BMI categories are shown in Table I.

The means (SD) of different components of physical fitness for overweight compared to normal weight boys and girls are shown in Table II. The distance of standing broad jump in boys was significantly longer than that in girls ($p = 0.003$). Boys were significantly faster than girls in the 10 x 5m shuttle run ($p = 0.031$).

Normal weight boys performed better than overweight boys in flamingo balance ($p = 0.014$), standing broad jump ($p < 0.001$), sit-ups ($p = 0.002$), bent arm hang ($p < 0.001$), 10x5 shuttle run ($p = 0.018$) and 6-minute walking test ($p = 0.001$). Normal weight girls performed better than overweight girls in flamingo balance ($p = 0.026$), standing broad jump ($p = 0.004$), sit-ups ($p = 0.001$), bent arm hang ($p < 0.001$) and shuttle run ($p = 0.007$). In addition, for the plate tapping and sit and-reach (tests that do not rely on body lifting and moving), overweight girls and boys had better performance than normal weight girls and boys, see Table II. Among both genders, overweight and obese children tended to get quite similar results in different components of fitness tests, except for boys whose performance in flamingo balance deteriorated along with increase of BMI from overweight to the cut-off points for obesity [17.4 (8.7) vs. 25.2 (6.8), $p = 0.011$].

The physical activity levels [mean (SD)] for overweight compared to normal weight boys and girls are shown in Table III. Overweight boys [2.41 (0.72)] were less active than their lean counterparts [2.91 (0.64), $p = 0.004$], but no such difference was observed in girls [2.53 (0.64) vs. 2.59 (0.68), $p = 0.741$]. Physical activity levels were somewhat higher in normal weight boys [2.91 (0.64)] compared to normal weight girls [2.59 (0.68)], but the difference was not statistically significant ($p = 0.057$). No difference was observed in physical activity levels between overweight boys [2.41 (0.72)] and girls [2.53 (0.64), $p = 0.547$].

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Table I. Characteristics of the children (n = 119). All values are mean and (SD), unless otherwise stated

	Normal weight			Overweight			
	All (n = 65)	Boys (n = 36)	Girls (n = 29)	All (n = 54)	Boys (n = 30)	Girls (n = 24)	p
Age, years	8.0 (0.4)	8.0 (0.5)	8.1 (0.4)	8.0 (0.4)	8.0 (0.4)	7.9 (0.4)	0.619[a]
Weight, kg	25.9 (2.9)	25.9 (3.0)	25.9 (2.8)	40.9 (7.1)	42.2 (8.4)	39.3 (4.8)	<0.001[a]
Height, cm	129.1 (5.4)	128.7 (5.5)	129.5 (5.3)	133.8 (5.3)	134.6 (6.1)	132.9 (4.0)	<0.001[a]
BMI, kg/m^2	15.5 (1.0)	15.7 (1.1)	15.4 (1.1)	22.7 (2.7)	23.3 (3.0)	22.2 (2.2)	<0.001[a]
WC, cm	54.8 (2.8)	55.3 (2.6)	54.2 (3.0)	73.0 (8.6)	74.5 (10.0)	71.0 (5.8)	<0.001[a]
Mother's age, years	37.5 (6.0)	36.9 (6.5)	38.2 (5.4)	36.8(5.4)	36.5 (5.6)	37.3 (5.2)	0.522[a]
Father's age, years	39.6 (6.0)	39.0 (6.3)	40.3 (5.8)	39.6 (6.0)	39.4 (5.5)	39.9 (6.8)	0.999[a]
Siblings, n	2.2 (1.5)	2.1 (1.3)	2.3 (1.8)	1.9 (1.4)	1.8 (0.9)	2.1 (1.9)	0.344[a]
Overweight mother, n (%)	8 (15.1)	4 (13.8)	4 (16.7)	33 (68.8)	20 (74.1)	13 (61.9)	<0.001[b]
Overweight father, n (%)	18 (36.7)	10 (35.7)	8 (38.1)	15 (88.2)	10 (90.9)	5 (83.3)	<0.001[b]
Someone smoking in the family, n (%)	13 (20.6)	7 (20.0)	6 (21.4)	28 (52.8)	16 (53.3)	12 (52.2)	<0.001[b]
Child's sleeping hours, n (%)							
10–11.9	34 (52.3)	15 (41.7)	19 (65.5)	20 (37.7)	8 (26.7)	12 (52.2)	0.244[c]
9–9.9	28 (43.1)	18 (50.0)	10 (34.5)	27 (50.9)	17 (56.7)	10 (43.5)	
8–8.9	2 (3.1)	2 (5.6)	–	5 (9.4)	5 (16.7)	–	
7–7.9	1 (1.5)	1 (2.8)	–	1 (1.9)	–	1 (4.3)	
Form of dwelling, n (%)							
Apartment	10 (15.4)	4 (11.1)	6 (20.7)	12 (22.6)	7 (23.3)	5 (21.7)	0.111[b]
Row/semi-detached	12 (18.5)	5 (13.9)	16 (55.2)	16 (30.2)	8 (26.7)	10 (43.5)	
Detached	43 (66.2)	27 (75.0)	7 (24.1)	25 (47.2)	15 (50.0)	8 (34.8)	
Mother's education, n (%)							
Basic or/and vocational	17 (26.6)	10 (24.1)	7 (24.1)	19 (35.8)	10 (33.3)	9 (39.1)	0.584[b]
High school and vocational	26 (40.6)	14 (40.0)	12 (41.4)	19 (35.8)	11 (36.7)	8 (34.8)	
University/Polytechnic	21 (32.8)	11 (31.4)	10 (34.5)	15 (28.3)	9 (30.0)	6 (26.1)	
Father's education, n (%)							
Basic or/and vocational	21 (35.0)	10 (30.3)	11 (40.7)	27 (62.8)	15 (62.5)	12 (63.2)	0.010[b]
High School and vocational	17 (28.3)	11 (33.3)	6 (22.2)	4 (9.3)	3 (12.5)	1 (5.3)	
University/Polytechnic	22 (36.7)	12 (36.4)	10 (37.0)	12 (27.9)	6 (25.0)	6 (31.6)	
Mother's occupation							
Employed	51 (78.5)	29 (80.6)	22 (75.9)	41 (77.4)	23 (76.6)	18 (78.3)	0.671[c]
Full-time student	5 (7.7)	4 (11.1)	1 (3.4)	5 (9.4)	3 (10.0)	2 (8.7)	
Child care leave	7 (10.8)	3 (8.3)	4 (13.8)	4 (7.5)	2 (6.7)	2 (8.7)	
Unemployed	1 (1.5)	–	1 (3.4)	3 (5.7)	2 (6.7)	1 (4.3)	
Retired	1 (1.5)	–	1 (3.4)	–	–	–	
Father's occupation							
Employed	56 (93.3)	32 (94.1)	24 (92.3)	38 (88.4)	21 (91.3)	17 (85.0)	0.398[c]
Full-time student	–	–	–	2 (4.7)	1 (4.3)	1 (5.0)	
Child care leave	2 (3.3)	2 (5.9)	–	1 (2.3)	–	1 (5.0)	
Unemployed	2 (3.3)	–	2 (7.7)	1 (2.3)	–	1 (5.0)	
Retired	–	–	–	1 (2.3)	1 (4.3)	–	

[a]p-value for the difference between normal weight and overweight children (two-sample unpaired T-test).
[b]Pearson's χ^2-test for pair wise comparison between normal weight and overweight children.
[c]Fisher's Exact Test for pair wise comparison between normal weight and overweight children.

Among boys, high physical activity levels were associated with better performance in flamingo balance test ($r = -0.241$, $p = 0.051$), standing broad jump ($r = 0.394$, $p = 0.001$), sit-ups ($r = 0.413$, $p = 0.001$) and bent arm hang ($r = 0.384$, $p = 0.001$), but such associations were not observed in girls. After adjusting for weight status, high physical activity levels were only associated with better performance in standing broad jump ($r^{12.3} = 0.272$, $p = 0.029$) and sit-up tests ($r^{12.3} = 0.324$, $p = 0.008$) in boys.

The parents' physical activity levels are shown in Table IV. Mothers who were normal weight reported higher

Table II. Differences in physical fitness values between normal weight and overweight boys and girls (n = 118) given as means (SD)

	Boys				Girls			
Physical fitness	All (n = 66)	Normal weight (n = 36)	Overweight (n = 30)	p[a]	All (n = 52)	Normal weight (n = 29)	Overweight (n = 23)[b]	p[a]
Flamingo balance (number of falls)	18.8 (8.5)	16.5 (7.8)	21.6 (8.6)	0.014	16.2 (8.2)	13.8 (6.8)	19.1 (9.0)	0.026
Plate tapping, time to complete 50 taps (s)	18.4 (3.3)	18.4 (3.1)	18.3 (3.6)	0.854	17.8 (3.6)	18.1 (3.7)	17.3 (3.5)	0.423
Sit-and-reach (cm)	22.6 (5.4)	21.7 (4.5)	23.6 (6.3)	0.144	23.0 (5.2)	22.0 (4.5)	24.3 (5.7)	0.116
Standing broad jump (cm)	119.3 (16.6)	126.9 (14.1)	110.2 (15.0)	<0.001	109.9 (16.7)	115.7 (15.5)	102.7 (15.7)	0.004
Sit-ups in 30 sec (n)	9.3 (6.1)	11.4 (5.6)	6.8 (5.9)	0.002	8.4 (5.6)	10.6 (5.3)	5.6 (4.8)	0.001
Bent arm hang (s)	8.2 (10.3)	13.6 (11.3)	1.8 (2.5)	<0.001	6.3 (7.8)	10.3 (8.4)	1.2 (1.2)	<0.001
10 × 5 shuttle run (s)	25.2 (3.1)	24.3 (2.5)	26.1 (3.6)	0.018	26.3 (2.7)	25.5 (2.6)	27.5 (2.5)	0.007
6 min walking test (m)	673.2 (54.7)	692.9 (53.9)	644.9 (42.8)	0.001	678.5 (66.1)	694.1 (61.2)	657.5 (135.1)	0.270

[a]Two-sample unpaired T-test.
[b]One girl did not attend the fitness tests.

levels of physical activity than overweight mothers [2.56 (0.63) vs. 2.16 (0.59), p = 0.002], but no such difference was observed in fathers [2.44 (0.62) vs. 2.46 (0.59), p = 0.917].

The mothers of normal weight boys (n = 28) reported higher levels of physical activity than the mothers of overweight boys (n = 29), [2.60 (0.66) vs. 2.29 (0.55), p = 0.051], but no such difference was found in girls [2.47 (0.63) vs. 2.23 (0.68), p = 0.231]. Physical activity levels were somewhat lower in fathers of overweight girls than fathers of normal weight girls, but the difference was not statistically significant [2.11 (0.82) vs. 2.57 (0.59), p = 0.057]. Physical activity levels were similar in fathers of overweight and normal weight boys [2.52 (0.71) vs. 2.37 (0.54), p = 0.422].

Linear regression model revealed that boys' physical activity level was significantly associated with weight status, mother's physical activity and mother's BMI, these variables explaining 26.1% of the variance. Girls' physical activity level was associated with their mothers' physical activity level, explaining 12.4% of the variance, Table V. Physical activity of overweight children was associated with the physical activity of the mothers, which explained 10% of the variance (β = 0.314 95% CI 0.05–0.67, p = 0.025).

Discussion

In this study, overweight was related to impaired performance in tests requiring balance, explosive power of the lower extremities, muscle endurance, upper body strength and endurance, speed and agility in both genders, and exercise capacity in boys. Our data also indicated a significant mother-child relationship of physical activity. The parent-child relationship of overweight is strong in both genders. Improving physical fitness in children, for example through increasing physical activity,

Table III. Physical activity levels (PAQ-C)[a] of the normal weight and overweight children (n = 118)

	Normal weight				Overweight					
Physical activity	n	Median	Mean (SD)	95% CI	n	Median	Mean (SD)	95% CI	p[b]	p[c]
Child's PAQ-C (n = 118)										
All children	65	2.84	2.76 (0.67)	2.60 to 2.93	53	2.40	2.46 (0.68)	2.27 to 2.65	0.017	
Girls[d]	29	2.43	2.59 (0.68)	2.33 to 2.85	23	2.37	2.53 (0.64)	2.25 to 2.80	0.741	
Boys	36	3.00	2.91 (0.64)	2.69 to 3.12	30	2.41	2.41 (0.72)	2.14 to 2.68	0.004	0.351

p-value two-sample unpaired T-test.
[a]1 = very low activity, 2 = low activity, 3 = moderate activity, 4 = high activity and 5 = very high activity.
[b]p-value for the difference between normal weight and overweight children.
[c]p-value for gender differences.
[d]One girl did not complete the physical PAQ-C questionnaire.

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Table IV. Physical activity levels[a] of the parents (n = 185)

	Mothers				Fathers			
	All (n = 103)	Normal weight (n = 58)	Overweight (n = 41)	p[b]	All (n = 82)	Normal weight (n = 32)	Overweight (n = 32)	p[a]
Physical activity mean (SD)	2.40 (0.64)	2.56 (0.63)	2.16 (0.59)	0.002	2.40 (0.66)	2.44 (0.62)	2.46 (0.59)	0.917

[a]1 = very low activity, 2 = low activity, 3 = moderate activity, 4 = high activity and 5 = very high activity.
[b]p-value for the difference between normal weight and overweight parents based on means (two-sample unpaired T-test).

might require interventions that focus on helping parents and children to be physically active together and are responsive to the ability and needs of overweight children and their families.

Our findings concerning the associations between overweight and impaired performance are consistent with other studies (17,18). The differences could be explained by the fact that when performing tasks that require carrying or lifting their own body, overweight individuals are at a disadvantage because fat tissue behaves as an inert load (17,18) or/and due to reduced motivation to provide maximal effort during strength testing (33).

This study examined physical activity levels in relation to physical fitness in children. It was observed that physical activity was associated with significantly better physical fitness performances in boys, but no such association was found in girls. Boys with higher physical activity levels got better results in tests requiring balance (the flamingo balance), explosive power of the lower extremities (standing broad jump), muscle endurance (sit-ups) and upper body strength and endurance (bent arm hang). Similar findings have been observed among prepubertal and pubertal boys – physically active boys attained better results in almost all performance tests than non-physically active boys (17,18). However, when studying 8-year-old children Stigman et al. (21) discovered no statistically significant difference between self-reported physical activity and cardiorespiratory fitness. The discrepancy of the findings may be due to different methodological and analytical strategies.

Several studies using accelerometers have observed physical activity differences between normal weight and overweight children in both genders (13–15,34). This study showed that in this sample of clinically overweight boys physical activity levels were lower compared to age-matched normal weight boys. Notably, no weight-related differences in physical activity were observed in girls. These findings are consistent with other contemporary data on young people using objective (35–37) and self-reported (38,39) measures.

It is difficult to explain why there were no differences in physical activity between overweight and normal weight girls, but some previous studies using physical activity questionnaires have demonstrated that overweight girls (40) and adults (41) tend to overestimate their activity. In several studies physical activity levels have been significantly lower in girls compared to boys (13,42,43). However, in our study there were no significant differences in physical activity levels between girls and boys. This finding is consisted with other contemporary data on young children (12).

Few studies have investigated the relationship between parent and children's physical activity; research using self-reported (44) and objective (35,44–48) measures of parental physical activity has shown differing results, from no relationship (35,45) to significant positive relationships with children's physical activity (44,46–48). In our study mother's physical activity was significantly associated with children's physical activity in both genders and weight groups. This finding is in conflict with earlier studies conducted in Finland (49,50) which

Table V. Determinants of physical activity level in 8-year-old children (n = 118) according to linear regression analysis

		Boys (n = 66)		Girls (n = 52)[a]	
Dependent	Independent	β (95% CI)	P	β (95% CI)	p
Children's physical activity at 8 years	Mothers physical activity level	0.32 (0.08–0.65)	0.014	0.35 (0.70–0.66)	0.017
	Child's weight status	−0.43 (−1.04–0.19)	0.005		
	Mother's BMI	0.30 (0.00–0.07)	0.046		
R^2			$r^2 = 0.261$		$r^2 = 0.124$

[a]One girl did not complete the physical PAQ-C questionnaire.

only observed significant associations between mothers and daughters. In the previous publications the mean ages of the participants were 11 and 12 years. Physical activity levels were assessed using self-administered questionnaires.

This study supports the previous findings (11,10) that there is a strong relationship between parents and their offspring's weight status. Overweight parents tend to have overweight children. This pattern is easy to accept because in addition to genetic resemblances, family members show similarities in behavioural risk factors associated with overweight, including energy and percent of fat intake, food preferences and physical activity (51).

Strengths and limitations

Lack of motivation and understanding for the need of 6-minute walking test may have affected the performance in children. The motivational aspects during the fitness tests were not assessed. However, the 6-minute walking test has been demonstrated to be a reliable and valid functional test for assessing exercise tolerance and endurance in children (32).

Physical activity was assessed by a 7-day recall, which has obvious limitations, as do all self-report methods used in children. Self-report techniques were used in this study, because they were convenient, cost-effective and exerted a minimal amount of burden on the study participants and their parents. Furthermore, questionnaires are a useful tool to gather information from a large number of people (25). The questionnaire provides a general estimate on the basis of self-report and does not provide any objective measurements and is based on subject's memory (25). Although PAQ-C has been validated against direct measures of physical activity (25) and has good internal consistency (26), it may not have been sensitive enough or specific enough to assess the physical activity of the children. Direct measures of physical activity, such as accelerometers (13,14), would strengthen studies that address the relation between physical activity and weight status in children.

For comparison, normal weight children from different parts of Oulu city were invited to join the study as a control group. The attendance rate was rather low (46%), which was probably due to the fact that the participants were required to take part in the physical fitness tests arranged at school. Consequently, it is possible that the participants of the control group were in a better physical condition than their peers on average.

The data on parent and their offspring's physical activity are based on parents' reports, which may have influenced the parent-child association. There is a possibility that mothers may have filled the questionnaire together with the children, and therefore the association is only true for mothers, but not for fathers. The physical activity questionnaire for adults used in this study has not been validated. The cross-sectional design of the data does not allow us to draw causal interferences. However, the study clearly show differences in physical activity levels in clinically overweight boys compared to their normal weight counterparts and differences in several components of physical fitness in overweight and normal weight children. Unfortunately, pubertal growth was evaluated only in overweight children at the clinical examination. Unfortunately we do not have information about pubertal growth of the normal weight children. However, we assume that most of these normal weight children would have been classified as Tanner stage I, since only 2 overweight girls were classified as Tanner stage II.

Nurses were instructed to invite to the study all those students, who had started their school at a particular time period and who fitted the overweight/obesity scale. However, not all overweight children were invited to the study due to numerous reasons. Recruitment process went on for 2 years, and during that time some of the nurses' posts changed, so new nurses and substitutes were not informed of the study in time. Nurses have also possibly used their own judgment when inviting parents, that is, parents whose willingness to take part in the study was considered low were not recruited. Also nurses' own interest towards the study might have affected the way they presented it to the parents. Furthermore, the main factor for the participant selection was the family's own interest to seek help for their child's overweight. Therefore the results of the study cannot be translated to describe the situation in general, but rather in those families, that have a positive attitude towards the treatment.

Conclusion

This study demonstrated that overweight boys were physically less active than their lean counterparts; this difference was not observed in girls. Furthermore, overweight was related to impaired performance in tests requiring muscle endurance, balance, explosive power of lower extremities, upper body strength, endurance and speed and agility in both genders and exercise capacity in boys. Our data indicated a significant mother-child relationship of physical activity. Consequently, mothers may play an important role in promoting children's physical activity by taking notice of their own behaviour. The parent-child relationship of overweight is strong in both genders. Improving physical fitness in children, for example through physical activity, might require interventions that focus on helping parents and children to be physically active together and are responsive to

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the ability and needs of overweight children and their families.

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