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ORIGINAL ARTICLE

Chronic care treatment of obese children and adolescents

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Abstract

Objectives. Clinically-relevant protocols for the treatment of childhood obesity are lacking. This study report results for a clinic-based structured treatment program for chronic childhood obesity. *Methods*. Patients were measured at baseline and for up to 24 months; there were no prior eligibility criteria. At baseline, height, weight, Tanner stages, testicular size, time of menarche, and social class of the parents were registered. A structured, tailored treatment plan including best-practice-based interventions was initiated. Height, weight, and pubertal development were measured at subsequent visits. *Results*. A total of 617 children or youths were included; 325 were girls and 292 were boys. At entry, the mean age was 11.6 years and the mean body mass index (BMI) standard deviation score (SDS) was 3.0. Seventy stopped treatment, 547 were in treatment, 125 had 1 examination, and 492 had two or more examinations, with a mean visit interval of six weeks. After 12 months, the mean BMI SDS decreased by 0.23 ($P < 0.0001$) in girls and by 0.32 ($P < 0.0001$) in boys. After one year, the retention rate was 90.2%, and 68.7% had reduced BMI SDS. After two years, the retention rate was 75.0%, of which 62.5% had reduced BMI SDS. The reductions in BMI SDS were independent of baseline adiposity, age (in boys), puberty stage, and social class, but were dependent on sex, age (girls), and place of referral. *Conclusions*. This clinical obesity treatment was safe and effective in reducing BMI SDS independent of baseline adiposity, age (boys), or social class in these young people.

Key words: *Adolescent, BMI SDS, child, longitudinal study, obesity, puberty, treatment, weight gain, weight loss*

Introduction

The alarming worldwide increase in the prevalence of childhood obesity and its associated range of complications threatens societies in terms of its effect on education, the workforce and health costs, as well as individuals because of the associated stigmatization, morbidity, and mortality (1).

As an example, a recent study examined 5 063 622 person-years from childhood to adulthood and showed that adiposity in childhood translates to a higher risk of coronary heart disease in adulthood (2). This association was linear, and the risk increased across the entire body mass index (BMI) distribution (2), showing the long-term health consequences of childhood obesity.

Weight loss seems difficult to achieve in severely obese children, and the potential long-term effects show why efforts to optimize outcomes are warranted (3). As the need for treatments increases, childhood may be the time to initiate chronic care treatments for obese youths (4) to provide state-of-the-art interventions so that young people can enter adulthood with a healthy body weight. Besides severe obesity, increasing age, puberty, low social class, and associated diseases have been associated with less effective childhood obesity treatment. Furthermore, most, if not all, treatment studies incorporate highly selective entry criteria for study; such criteria may bias results from these childhood obesity interventions.

In order to counter childhood obesity, The American Academy of Pediatrics (AAP), The American Medical Association (AMA), and the Centers for Disease Control and Prevention (CDC) have provided expert committee recommendations that comprehensively seek to establish the foundation of best practice advice concerning the prophylaxis and treatment of childhood obesity (5–7).

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However, childhood obesity is such an overwhelming problem, that action must be taken even though the body of evidence about prophylaxis and treatment approaches is inconsistent (1,5–7). Based on these recommendations (1,5–7) and systematic reviews (8,9), we developed *The Children's Obesity Clinic's Treatment* (TCOCT) protocol. In this protocol, we adopted a structured pedagogical approach to implement, at the first contact, lifestyle changes aimed to achieve reduction in obesity. The overall aim was to establish a protocol that was efficient in reducing the degree of childhood obesity irrespective of baseline adiposity, age, puberty, gender, social class, or associated diseases and, at the same time, maintain patients' compliance with the treatment. In this protocol, we sought to integrate recommended advice into a best-practice based chronic care model, i.e., treatment regimens that are individualized and family-based with no time limits.

The purpose of this article is to present our results using TCOCT Protocol to treat overweight and obese children and adolescents. The protocol has no eligibility selection criteria apart from a BMI above the 90th percentile for age and sex and an age less than 22 years.

Methods

Patients

Children were referred from their general practitioners, school- and community- based doctors, or the department of pediatrics of Holbæk University Hospital. No prior evaluation was performed to exclude children with mental or physical handicaps, other conditions or diseases, medications, low social class, massive adiposity, difficult communication, or any other eligibility criteria, and patients could remain in treatment until the age of 24 years.

Children and youths were received from the age of three years if their BMI was above the 90th percentile for sex and age according to the Danish BMI charts (10). Children were seen in outpatient clinics by the same personnel who rotate between the hospitals in the regional cities of Holbæk, Ringsted, and Slagelse. The Children's Obesity Clinic was initiated January 1, 2008, and the results were evaluated after 31 December 2009.

TCOCT protocol

The protocol is based on a family-centered approach involving behaviour-changing techniques that can be considered best-practice on the basis of current evidence (1,5–7). Full details of the program are available from the authors. At inclusion, each patient is seen for one hour by a pediatrician who performs a general investigation and evaluate the patient to identify obesity and its complications, and differential diagnosis. The pediatrician then defines a future treatment and follow-up plan. Thereafter, each patient is seen quarterly, half-yearly, or annually for a 30-min appointment by the pediatrician. The patient is also seen by a dietician; the first contact is for one hour, and later contacts for 30 min. Some patients with special needs are also seen by a pediatric nurse (45-min contact). Support is offered by a psychologist and/or a social worker if significant socio-psychological problems are noted.

The patient is seen at individual intervals in the Clinic, depending on the problem, degree of treatment success, and practical requirements, such as limitations imposed by the parents' occupations, resources, parental or patient's wishes, and place of residence. In this program, overweight and obese children are followed until they have successfully reached their goal, which was defined, arbitrarily, as a BMI below the 75th percentile for sex and age, or exited the program having attained 22 years of age, or voluntarily wanted to disengage from the program. The structured pedagogical approach adopted involves all relevant lifestyle changes being initiated at baseline (full details are available from the authors). This strategy seeks to: (a) Establish a long-term trusting relationship between the health-care professional and the patient and family, (b) optimize diagnosis, evaluation, follow-up, and treatment success in every patient, and (c) teach the patients and their families how to control their environment.

The programs' recommendations aim to control the environment in childhood obesity (7). We emphasize this control by applying a tailored treatment plan established between the patient, family, and the pediatrician, and based upon information about the patient's and family's daily routines and lifestyle. The agreed upon treatment plan is delivered in writing to secure lifestyle and behavioral changes. The treatment plan incorporates interventions according to best-practice (1,5–9). Ninety items of advice and advice strategies are defined in our database (Table I), and these are applied to each patient individually. A typical treatment plan included 10–20 items at the first visit.

The treatment plan included the following advice strategies.

- *All sweet beverages are avoided* (both with and without sugar) to avoid dependence on the taste of sugar.
- The dinner functions as *meal practice*, i.e., portions are arranged as indicated in the *plate*

model (11). If another serving is desired, *the second serving is given 20 minutes after the first serving* so that the patient learns to recognize satiation. This is important because many obese patients have developed an eating disturbance involving large meals, rapid eating, in-between-meal eating, and meal skipping.

- The patient should be *satiated at all meals*, which when combined with the advice mentioned above, improves satiation and helps control food intake over the following 4–8 weeks (and thereby avoid overeating, rapid eating, meal skipping, and in-between eating).
- The patient should *go to bed at no later than ……o'clock* to ensure he or she can arise in time for breakfast in the morning.
- *Pocket money should be placed in a bank account* (so the patient does not spend money spontaneously if this has been a problem).
- If the child or youth is a finicky eater, he or she and the family is *encouraged to slowly* (*months*, *years*) *elaborate the variation in food intakes*, especially towards food items like vegetables and low fat or low carbohydrate food items.

However, all contacts including the treatment plan was conducted to provide understanding and empathy in order to establish trust between the healthcare professional and the patient and family. The cost of the treatment program was met by the Danish public health system.

Table I. List of items of lifestyle advice offered by TCOCT Protocol.

Breakfast	Lunch	Afternoon	Dinner	Activity	General
Eat breakfast	*Bring* and eat lunch	*Eat* in the afternoon	*Eat* dinner	*Seek* to increase physical activity to one hour daily	*1–2* pieces of fruit per day
Reduce eating at TV/PC	*Reduce* eating at TV/PC	*Reduce* eating at TV/PC	*Reduce* eating at TV/PC	*Decrease* TV/PC to 2 hours	*Reduce* fast food
Reduce toast/white bread	*Reduce* toast/white bread	*Reduce* toast/white bread	*Reduce* toast/white bread	*Decrease* TV/PC to 3 hours	*Fast food* once per month
Reduce fatty/sweet yoghurt	*Reduce* food high in fat and sugar	*Reduce* food high in fat and sugar	*Reduce* food high in fat and sugar	*Reduce* TV/PC before 6 pm	*Reduce* candy
Instead dark bread or cereals high in fibers and low in fat and sugar	*Instead* eat dark bread high in fibers	*Instead* eat dark bread high in fibers	I*nstead*, dinner should be low-fat, low in sugar and high in fibers	*Bicycle* to school	*Candy* once a week for $1 (under age 11) or $2 (over age 11)
Reduce chocolate in either drink or on bread	*Reduce* chocolate in either drink or on bread	*Reduce* chocolate in either drink or on bread	*Reduce* chocolate in either drink or on bread	*Dance* to music at home	*Reduce* ice-cream
Reduce jam or honey	*Reduce* jam or honey	*Reduce* jam or honey	*Portions* arranged in the kitchen	*Play*	*Ice cream* once a week
Reduce high-fat cheese, max 13%	*Reduce* high-fat cheese, max 13%	*Reduce* high-fat cheese, max 13%	Normal size of Portions; 1/5 meat/fish, 2/5 potatoes, rice, or pasta, 2/5 salad and vegetables	*Bicycle*	*Reduce* cake
Instead low-fat fish, meat, and vegetables	*Instead* low-fat fish, meat, and vegetables	*Instead* low-fat fish, meat, and vegetables	*Second* portion after 20 minutes	*Gymnastics*	*Cake* once a week
Reduce butter	*Reduce* butter	*Reduce* butter	*Gravy* max 5%	*Swim*	*Reduce* snacking
Instead margarine (max 35% fat)	*Instead* margarine (max 35% fat)	*Instead* margarine (max 35% fat)	*Instead* margarine (max 35% fat)	*Basketball*	*Snacking* once a week
Reduce high-fat milk	*Reduce* high-fat milk	*Reduce* high-fat milk	*Reduce* high-fat milk	*Handball*	*Reduce* soda, juice, iced tea, or cocoa
Reduce soda, juice or iced tea	*Reduce* soda, juice or iced tea	*Reduce* soda, juice or iced tea	*Reduce* soda, juice or iced tea	*Tennis*	*Soda*, juice, iced tea, and cocoa once a week
Instead water or low-fat milk	*Instead* water or low-fat milk	*Instead* water or low-fat milk	*Instead* water or low-fat milk	*Ice-hockey*	*Instead* water or low-fat milk
Reduce candy or snacking	*Reduce* candy or snacking	*Reduce* candy or snacking	Reduce candy or snacking	*Attend* other organized discipline	*Reduce* smoking and alcohol

Program evaluation

Patients were excluded and considered as dropouts if they missed several scheduled contacts. This policy is similar to our practice involving patients with other diagnoses in our outpatient clinics.

We developed 3 criteria to define clinical success: (1) the patient showed up at appointments; (2) the patient's weight stabilized so that the BMI standard deviation score (BMI SDS) decreased with time; and (3) if a patient who had achieved adult height and reduced weight but was still considered obese, the degree of obesity was less than that at entry. When the patient met any of these criteria, positive reinforcement was initiated.

All processes were subjected to quality control to identify whether appointments were kept and whether the treatment plan and criteria of success were met. All healthcare professionals received training and engaged in supervised consultations. Monthly meetings were held to optimize treatment for particular patients and to optimize the treatment skills of the personnel.

Procedures

Height was measured by stadiometer to the nearest 1 mm. Weight was measured to the nearest 0.1 kg on a Tanita Quality Control Seal, WB-100 MA, (Tanita Corp. Japan) in light indoor clothes. Puberty stage was rated according to Tanner stages after evaluation of pubic hair and breasts. Testicular size was measured by Prader's orchidometer.

Social class was defined into 1 of 5 socio-economic groups and classified according to the modified National Statistics Socio-economic Classification in accordance with the occupation of the parent(s) with whom the child lived (see the Statistics of Denmark (12). The definition of the social group index is based on types of labor. Socioeconomic group 1 refers to self-employed persons and persons whose job functions require higher education. Group 5 refers to parents who are out of work or who have taken early health-related retirement, etc.

Statistical methods

As BMI develops during childhood (10) the degree of obesity at each time of measurement is assessed using body mass index (BMI) standard deviation scores (SDS). BMI SDS was calculated by the LMS method comparing the calculated BMI with the distribution of BMI in a Danish standard population with the same age and gender (10).

The longitudinal development of BMI SDS during treatment was modelled using a generalized linear mixed model (13). The covariance structure includes a random intercept, allowing each child to have its own overall level of BMI SDS, and an exponential residual structure, allowing the covariance between two measurements on the same child to decrease as the time between measurements increases. The mean value of BMI SDS was modelled as a function of time since initiation of treatment, using a cubic spline with three *a priori*-chosen knots (at 2, 7, and 16 months, respectively) (14).

The historical change in degrees of obesity is assessed using height and weight measures from family and school based nurses and doctors. Additional knot points were introduced at 7 and 2 month prior to treatment and at initiation of treatment.

The associations between change in obesity and baseline characteristics were assessed by performing a test for interaction between a dichotomized version of the baseline characteristic and time since treatment initiation in the generalized linear mixed model.

The retention and treatment success rates were evaluated at three-month intervals relative to all patients included at the given time intervals. Owing to ongoing inclusion in this study the number of included patients is decreasing as follow-up time increases in the period 2008–2009 (Supplementary Figure 1, available online). The retention rate was calculated as the percentage of patients not dismissed from the study at three-monthly intervals up to 24 month after their baseline visit. The response rate was similarly calculated as percentage of all patients who decreased their BMI SDS each three months of treatment. The associations between retention rates and baseline characteristics were analyzed by performing Chi-squared and *t*-tests.

Results

Of the 617 subjects included, 325 were girls and 292 were boys. The mean visit interval was 6 weeks (2–28 weeks), and the average time offered by healthcare professionals was 5.4 hours per child per year. After referral, 27 children did not attend their first appointment. Most children were Caucasian Danish children, but 71 were of other ethnic origin; 59 from the middle-east area, six from Asia, and six from sub-Saharan Africa.

In all, 4082 visits were offered in the period from 1 January 2008 to 31 December 2009. A total of 326 (7.6%) visits were rescheduled on request by the family and 728 scheduled visits were missed (17.1%). The remaining 3028 visits were distributed on 934 visits to pediatricians, 544 visits to nurses, 1113 visits to dieticians, and 437 visits at the psychologist. Of the 70 patients who stopped treatment, 5 children

Table II. Clinical characteristics at baseline of the patients in TCOCT Protocol.

	Boys *N*, 292		Girls *N*, 325		Total *N*, 617	
	Median	Range	Median	Range	Median	Range
Age (years)	11.9	3.2–21.4	11.3	3.4–24.7	11.6	3.2–24.7
Height (m)	1.54	0.99–1.95	1.52	1.02–1.80	1.53	0.99–1.95
Weight (kg)	64.7	18.9–160.8	59.6	23.2–186.0	62.3	18.9–186.0
BMI SDS	3.24	1.38–5.58	2.80	1.48–5.76	3.0	1.38–5.76
Tanner breast			2	1–5		
Tanner pubertal			2	1–5		
Entered menarche			50.2%			
Tanner pubertal	2	1–5				
Tanner gonadal	2	1–5				
Testis left (ml)	4	1–20				
Testis right (ml)	4	1–20				
Social class	3	1–5	3	1–5		

N, number of patients; m, meter; kg, kilogram; BMI SDS, body mass index standard deviation score; ml, milliliters.

stopped because they achieved a BMI below the 75th percentile for age and sex, 8 stopped because they moved away, 15 requested to stop, and 42 neglected appointments (8.5%).

Table III. Number of patients admitted into TCOCT Protocol by referring authority and diagnosis.

	By the pediatric department *N*	By the general practitioner or school-based doctor *N*
Number of children (*Number of diagnoses*)	192(214)	425(126)
Asthma	58	26
Allergy	53	47
*Neurologic diseases		
ADHD	11	7
Asperger	4	3
CP	7	2
Epilepsy	5	
Other neurological	15	7
#Orthopedic	7	2
^Cardiologic	5	2
Endocrine		
DM type 1	3	1
Hyperthyroidism	3	1
Hypothyroidism	6	2
Other endocrine	10	3
Undescended testis	2	
Enuresis nocturna	11	10
Dermatitis	5	11
+Abdominal	9	2

ADHD, attention deficit/Hyperactivity disorder; CP, cerebral palsy; DM, diabetes mellitus; *other neurological diseases included obsessive compulsive disease, autism, hydrocephalus, fragile X syndrome, Down syndrome, headache, Tourette syndrome, blindness, dyslexia, Duchenne-Erb palsy, Klumpke's paralysis; #orthopedic diagnoses included: Scheuerman disease, Osgood-Schlatter disease, epiphysiolysis; ^cardiac diseases included: hypercholesterolemia, hypertension, heart murmur; @endocrine: Beckwieth Weidemann syndrome, testis agenesi, gynecomastia, polycystic ovary syndrome, pseudoparathyroidism, precocious puberty praecox; +abdominal: sprue, reflux, obstipation.

Baseline characteristics of those dropping out compared to those continuing treatment were that they were older (drop-outs were on average 1 year older, $P = 0.015$), but did not differ in baseline BMI SDS ($P = 0.71$).

There was also no difference ($P = 0.76$) in drop-out rate between the sexes. Table II shows the baseline characteristics of the children included in TCOCT Protocol. Table III shows the number of children with associated diagnoses other than obesity. Some 492 patients had more than one contact and the average follow-up was nine months.

Figure 1 shows the changes in mean BMI SDS in all children for up to 18 months of treatment in both boys and girls, separately. After 12 months of treatment, the mean BMI SDS change was 0.23 (confidence interval 0.17–0.29, $P < 0.001$) in girls and 0.32 (CI 0.24–0.40, $P < 0.001$) in boys. After 18 months of treatment, the mean BMI SDS change was 0.25 (CI 0.16–0.35, $P < 0.001$) and 0.40 (CI 0.27–0.52, $P < 0.001$) in girls and boys, respectively.

The overall treatment response corresponds to a boy aged 11.9 years weighing an average 61.1 kg and being 148 cm tall with a BMI of 27.9 (BMI SDS of 3.24) at baseline decreasing his BMI to 27.2 (BMI SDS of 2.92 with average weight 64.5 kg and height 154 cm) one year later. Similarly, a girl aged 11.3 years weighing an average 57.0 kg and being 146 cm tall with a BMI of 26.7 (BMI SDS of 2.80) at baseline decreasing her BMI to 26.5 (BMI SDS of 2.57 with average weight 61.3 kg and height 152 cm) one year later. Figure 2 shows the historical changes in mean BMI SDS before inclusion in TCOCT Protocol compared with the values in the same 230 patients during treatment. BMI SDS had started to decline three months before the first consultation, i.e., at the time of referral.

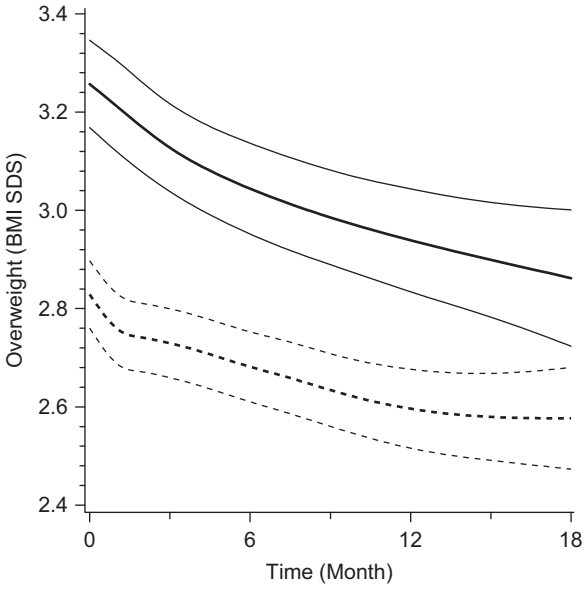

Figure 1. Mean changes in BMI SDS with 95% confidence intervals in boys (top graph) and girls (lower graph) included in TCOCT protocol who were seen at two visits or more according to a generalized linear mixed model incorporating all visits from all patients. BMI SDS, body mass index standard deviation score.

Table IV shows the relative treatment and retention rates up to 24 months of treatment. After one year of treatment, non-responders tended to drop out, giving a cumulative dropout rate of 9.8% (90.2% retention rate) with BMI SDS decreased in 68.7% of patients. After two years, the dropout rate was 25% (75.0% retention rate), with a BMI SDS decrease in 62.5% of patients.

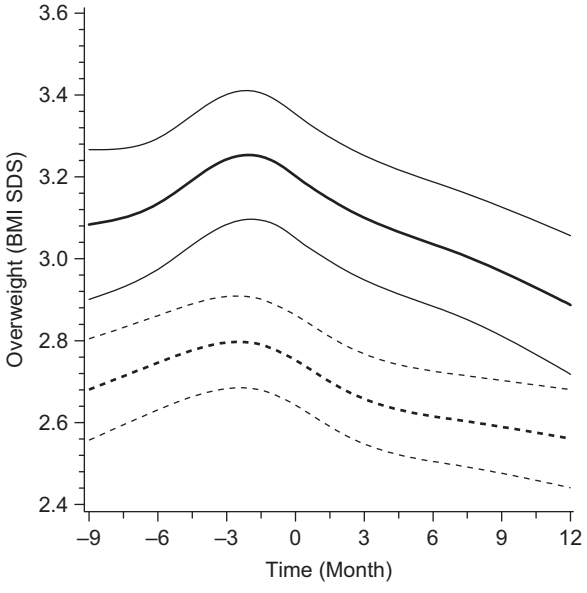

Figure 2. Mean changes in BMI SDS with 95% confidence intervals starting nine months before and extending for 12 months after inclusion in TCOCT Protocol in 230 children and youths. Historic BMI SDS values obtained before inclusion are compared with BMI SDS after inclusion in the obesity treatment program. Only patients with at least one historic, one baseline, and one treatment measurement of height and weight are included in these data. BMI SDS, body mass index standard deviation score.

The reduction in BMI SDS was independent of age in boys ($P = 0.55$), pubertal development in both boys ($P = 0.74$) and girls ($P = 0.11$), baseline adiposity ($P = 0.96$) and ($P = 0.31$) in boys and girls respectively, and social class ($P = 0.41$) in girls and ($P = 0.65$) in boys.

Boys lost more body weight than did girls ($P = 0.02$) but younger girls (<11.6 years) lost more weight ($P = 0.005$) than older girls (>11.6 years) although the weight loss was still significant among older girls ($P < 0.0001$). Children referred by community-based doctors lost more weight (boys; $P = 0.003$ and girls; $P = 0.069$) than those referred by the hospital department of pediatrics. This was reflected in a reduction of 0.36 BMI SDS (CI, 0.29–0.44) occurring after one year in children referred by community-based doctors compared with a reduction of 0.23 BMI SDS (CI, 0.13–0.34) in children referred by the department of pediatrics.

Retention rates were comparable in both sexes ($P = 0.18$) and in patients referred from the department of pediatrics versus those from community-based doctors ($P = 0.75$). None of the children reported anorexia nervosa or bulimia during TCOCT.

Discussion

TCOCT Protocol achieved reduction in the degree of childhood obesity with only a modest investment in manpower. This was achieved without applying prior eligibility selection that might have biased the outcome. Reductions in BMI SDS were maintained during treatment and were achieved independently of baseline adiposity, age, pubertal development, and social class. The rates of retention were acceptable, although children whose BMI SDS increased had a tendency to drop out. The program was more successful in boys than in girls, and in children or youths referred from the community than those referred from the hospital department of pediatrics. The latter may reflect that children referred by the department of pediatrics had other conditions, which may limit the ability to lose weight. It is noteworthy that the children started to reduce BMI SDS 3 months before their referral, suggesting that referral alone increased their awareness of the need to lose weight. This observation, however, is confounded by the many possible interacting factors that may have contributed to the weight loss seen prior their first appointment in TCOCT. A heightened awareness of their problem and the availability of a new treatment option, due to the initiation of TCOCT, may have increased their motivation and

Table IV. Absolute and relative changes in the treatment groups defined as responding, non-responding, and drop-outs, respectively, during the two years of treatment in TCOCT Protocol. The percentages are of all available children for each observation period.

	N	Percentage		*N*	Percentage
3 months treatment			*15 months treatment*		
Drop-outs	6	1.2	Drop-outs	31	14.4
Non-responders	126	26.0	Non-responders	42	19.5
Responders	353	72.8	Responders	142	66.0
Total	485	100.0	Total	215	100.0
6 months treatment			*18 months treatment*		
Drop-outs	11	2.6	Drop-outs	37	22.2
Non-responders	104	24.4	Non-responders	28	16.8
Responders	311	73.0	Responders	102	61.1
Total	426	100.0	Total	167	100.0
9 months treatment			*21 months treatment*		
Drop-outs	23	6.5	Drop-outs	19	21.8
Non-responders	84	23.7	Non-responders	13	14.9
Responders	247	69.8	Responders	55	63.2
Total	354	100.0	Total	87	100.0
12 months treatment			*24 months treatment*		
Drop-outs	26	9.8	Drop-outs	6	25.0
Non-responders	57	21.5	Non-responders	3	12.5
Responders	182	68.7	Responders	15	62.5
Total	265	100.0	Total	24	100.0

N, number of children; drop-outs, those children who dropped out of treatment; non-responders, those children increasing their BMI-z-scores; responders, those children decreasing their BMI-z-scores.

focus upon their lifestyle, which may have resulted in decreasing BMI SDS.

Weight regain is prevalent in childhood obesity treatment studies (7,15,16) with relatively low rates of retention (1,17). In a large study, Reinehr *et al.* reported treatment results for 21 784 overweight or obese children from 129 specialized treatment centers (18). After two years of follow-up, only 8% of the children had complete data, although out of those, 7% reduced their BMI SDS (18). In some single institutions, sustained weight loss in up to 51% of the children after two years can be achieved, but it seems uncertain whether this can translate into cost-effective treatment of childhood obesity (18). One solution is to offer longer and more intensive treatment because longer treatment is associated with better treatment outcomes in adults and children (19,20). In this perspective, we chose a chronic care treatment model with no time limits apart from an age of 22 years in the present clinical study.

Reports from controlled randomized trials show the long-term efficacy of lifestyle interventions in group programs for obese children under the controlled conditions of such studies (8). A meta-analysis of 14 randomized controlled trials of lifestyle interventions for pediatric obesity documented an average decrease in percent overweight of 8.2% after treatment (21), but such study conditions may not be equivalent to those encountered in daily clinical practice. Other randomized controlled trials have also shown no significant effect on BMI SDS when compared with standard care of overweight children (15,22).

Reinehr *et al.* investigated 170 children (mean BMI SDS of 2.5) with a mean age of 10.5 years at baseline where a mean BMI SDS reduction of 0.48 was achieved with a retention rate of 84% (23). BMI SDS declined primarily in the first three months, after which children maintained their lower BMI SDS for four years (23). Korsten-Reck *et al.* also reported effective treatment results after 8 months in 496 overweight children (baseline BMI SDS of 2.08) seen by 31 outpatient clinics; 72.8% lost weight and there was a high rate of retention (92.9%) (24). However, these studies have focused primarily on moderately overweight children and youths (15,22–24). In contrast, the children and adolescents in the present study were more obese; their BMI SDS tended to decrease throughout the treatment, and they were not selected by eligibility criteria except for a BMI above the 90th percentile for age and sex.

Other studies have reported difficulty in treating severely obese children. Nowicka *et al.* was unable to reduce BMI SDS in children with a BMI SDS greater than 3.5 (25). After following 192 children, aged 8–12 years (mean 99th percentile for BMI at entry), for 18 months, Kalarchian *et al.* concluded that the heaviest children may require different strategies for engagement and treatment (3).

A recent study by Reinehr *et al.* showed efficient childhood obesity treatment results in 663 children with a decrease in BMI SDS of 0.46 four years after the intervention (26). However, the oldest children (>13 years) experienced the smallest decreases in BMI-SDS (26).

In order to improve the efficacy of childhood obesity treatment, a chronic care model including a structured pedagogical approach that introduced many lifestyle changes at the onset was introduced in the present study. This approach resulted in weight loss in children with a BMI SDS greater than 3.5 and irrespective of age in boys, puberty, and social class.

Several possible confounding influences on the findings in the present study should be acknowledged. One limitation of our study was that the follow-up interval was only two years and the average follow-up was nine months. A second limitation was that the cumulative drop-rate increased to 25% after 24 months; a finding that was biased by the fact that the inclusion was continuous during the years 2008–2009, therefore, only 24 children attained 24 months of follow-up. However, the drop-out rate also included patients that stopped due to having achieved their goals of success, moved to another geographic residence, or wanted to stop for other reasons. Therefore, the childhood obesity treatment estimates in the present study are actually conservative estimates. A third limitation was that there was no control group. It was deemed unethical to allocate obese children or youth to no treatment options, especially so if such a chronic care model were to be evaluated over several years. Fourthly, the children included in the present study exhibited a large age range with concomitant growth and development changes. We attempted to adjust for this by using BMI SDS and adjusting for pubertal development, but it should be recognized that a wide age range is the reality in clinical pediatric practice. Finally, the present study was unable to pinpoint which aspect of the multidisciplinary treatment was most effective in reducing the degree of obesity in these children. On the contrary, we believe that it is not any single part of the intervention that is important, but instead the collective impact of these actions that is effective and needed for the treating the complexity of the obese child or youth.

The present findings need to be confirmed by studies using longer follow-up intervals. In particular, the focus should be on helping those children whose BMI SDS increased since these seem to be more prone to drop out.

This study shows that it is possible to treat obese children and youths effectively irrespective of their degree of adiposity, age in boys, puberty, and social class with a modest investment in manpower. Treatment for childhood obesity based on this protocol could be implemented in other settings increasing availability for more young people.

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Supplementary material available online

Supplementary Figure 1