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ORIGINAL ARTICLE

Sustainable weight loss over three years in children with obesity: a pragmatic family-centered lifestyle intervention

Rasmus Møller Jørgensen[1] · Jens Meldgaard Bruun[2,3,4] · Britta Kremke[1] · Rikke Frederiksen Bahnsen[1] · Bent Windelborg Nielsen[1] · Esben Thyssen Vestergaard[1,3,4]

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Abstract

Introduction Childhood obesity has psychological consequences and increases the risk of continuous obesity into adulthood, associated with development of non-communicable disease (e.g. type 2 diabetes). Short-term weight loss intervention studies show good results but long-term studies are limited.

Methods One hundred ninety-nine obese children (4–18 years of age), with a BMI-SDS (standard deviation score) above + 2 SDS were enrolled into a multifactorial family-centered lifestyle intervention study. The children had yearly visits in the outpatient clinic for anthropometrics, blood samples and DXA-scans, and 6–8 meeting with community health workers between these visits. The children followed the intervention up to 3 years.

Results After a follow-up of 26.7 ± 17.5 months a reduction in BMI-SDS of − 0.25 SDS ($p < 0.001$) was observed. The 57 children who were adherent to the intervention for ≥ 2 years had significantly reduced BMI-SDS compared to the 142 children with shorter intervention (BMI-SDS: − 0.38 ± 0.67 vs. − 0.20 ± 0.50, $p = 0.036$). All weight loss was accompanied by decrease in fat mass and increase in muscle mass ($p < 0.001$).

Conclusion The intervention was found to induce long-term reduction in BMI-SDS in obese children, with beneficial change in body composition. Children who followed the intervention the longest had the greatest reduction in BMI-SDS.

Level of evidence Level III, longitudinal cohort study.

Keywords Children · Obesity · Lifestyle intervention · Weight loss · Long-term · Body composition

Abbreviations

BMI	Body mass index
CVD	Cardiovascular disease
T2D	Type 2 diabetes
SDS	Standard deviation score
TCOCT	The Children's Obesity Clinic's Treatment

Introduction

The prevalence of childhood obesity is very high and, unfortunately, in children and adolescents with obesity is highly predictive for continuous obesity into adulthood [1, 2]. The trend of obesity in Denmark is comparable to other countries and in 2018 the Danish Health Authorities estimated that approximately 2.7% of children at age 7–13 years, 3.2% at age 14–15 years, and 3.9% at age 16–18 years were obese with a body mass index (BMI, defined as the weight in kilograms divided by the height in meters squared) above the 99-percentile corrected for age and gender or an iso-BMI ≥ 30 kg/m^2 [3]. In adulthood, 16.8% of Danes are obese [4].

Obesity is a large economic burden for societies and as an example, total direct and indirect costs related to obesity in the United States are estimated to as much as 210 billion U.S. dollars per year [5, 6]. Future individual health effects and the societal economic burden of the obesity epidemic are unknown but referred to by some as a Health time-bomb

✉ Rasmus Møller Jørgensen
rasmujer@rm.dk

[1] Department of Pediatrics, Randers Regional Hospital, Skovlyvej 15, 8930 Randers NE, Denmark

[2] Department of Internal Medicine, Randers Regional Hospital, Randers NE, Denmark

[3] Steno Diabetes Center Aarhus, Aarhus, Denmark

[4] Department of Clinical Medicine, Aarhus University, Aarhus, Denmark

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[7]. In Denmark, health care costs are reported to increase approximately 4% for each BMI point above 30 kg/m^2 [8].

Reports have indicated a correlation between childhood obesity and a variety of psychological problems such as loneliness, poor self-esteem [9], anxiety, and depression [10] and their quality of life is lower as compared to lean peers [11] and is similar to the low quality of life reported in children with cancer [12]. In line with this, reduction of overweight improves quality of life in children [13]. In addition to the psychological problems, onset of obesity early in life is associated with an incremental risk of development of cardiovascular disease (CVD) and type 2 diabetes (T2D) in adulthood [14, 15].

Weight loss in children and adolescents can be obtained by lifestyle intervention, pharmacotherapy, and bariatric surgery. Lifestyle interventions are at least in short-term studies (~ 1 year) able to improve obesity-related conditions such as ectopic fat accumulation [16] and impaired glucose tolerance [17]. Despite the favorable early effects of lifestyle modification, the durability of the obtained weight losses is often limited and long-term (> 1 year) follow-up on the effects on the obesity-related conditions is sparse. A recent study reports a reduction in BMI standard deviation score (BMI-SDS) at 75.7% of the children and the median reduction was 0.24 after 12.4 months treatment. Divided in gender, a reduction in median BMI-SDS was 0.19 and 0.34 in girls and boys, respectively [18]. In one of the few studies with a family-centered approach and more than 1 year follow-up was the retention rate after 2 years 75%. After 18 months a reduction in mean BMI-SDS was 0.25 and 0.40 in girls and boys, respectively [19].

As an adjunct to lifestyle intervention, pharmacotherapy could be an option, but only a few short-term (< 6 months) studies have been performed and taking the possible adverse effects and the modest weight loss effects into account, these studies have had discouraging results [20].

Bariatric surgery is known from adult obesity treatment to be the most efficient weight loss as well as weight maintenance intervention [21]. Bariatric surgery is rarely performed in children and adolescents. In a study in adolescents with up to 5 years of follow-up, bariatric surgery was found to induce a weight reduction of 26%, comparable to the 29% found in adults [22]. Despite comparable weight change 5 years after bariatric surgery, adolescents were significantly more likely to obtain remission of diabetes and hypertension as compared to adults, although both groups remained severely obese (BMI ~ 37 kg/m^2) at that time point [22]. In the same study, the rate of reoperations and nutritional problems were significantly higher in the adolescents, a finding that is comparable to another study in which ~ 25% of the included subjects underwent additional abdominal surgery due to complications and ~ 70% displayed nutritional deficiencies [22, 23].

Thus, treatment of children and adolescents with obesity should preferably be non-invasive applying lifestyle modifications, which introduces sustainable changes into everyday-life for the whole family and not just for the child. Therefore, the purpose of this report is to present a 3-year follow-up data on weight loss from a multidisciplinary family-centered intervention study in children and adolescents with obesity.

Materials and methods

Study design

This trial was designed and conducted as a municipality-based treatment for children with obesity. According to Danish legislation no registration was required. The study was developed, designed, and conducted as a municipality-based treatment for children with obesity and not for research why it was found unethical not to include all children identified with obesity into the study.

Even though this trial was not a randomized study, the CONSORT-concept was followed.

Definition of overweight and obesity

Overweight and obesity in growing individuals are defined by an abnormal BMI standard deviation score (BMI-SDS or *z*-score) or as a BMI above a certain percentile. Even though no consensus exists, overweight and obesity in our study is reported as BMI-SDS's and defined using a validated Danish reference material as BMI above the 90 percentile and BMI above the 99 percentile, respectively [24].

Subjects

One hundred and ninety-nine children and adolescents between 4 and 18 years of age (mean 10.8 ± SD 3.1 years) with a BMI-SDS above + 2 were referred to our facility at The Regional Hospital Randers in Denmark and included into The Children's Obesity Clinic's Treatment (TCOCT) protocol from January 1st 2014 to December 31st 2017. Four children were enrolled weekly until 100 were included in the treatment protocol and if drop-out occurred new participants were allowed to be included. Drop-out occurred if the families wanted to withdraw from the project or failed to show up at appointments. The participants were referred from their general practitioner, other departments, or municipalities. Some participants were self-referred after having heard about the project, and were subsequently included.

The Children's Obesity Clinic's Treatment (TCOCT) protocol

The TCOCT protocol was developed at the Pediatric outpatient clinic in Holbæk, Denmark. The TCOCT protocol is a family-centered pedagogic multifactorial lifestyle intervention used for treating overweight in children as previously described in detail [19].

At the first (baseline) visit, participants were questioned concerning dispositions, previous weight loss attempts, parent's marital status, and parents height and weight (used to calculate parental BMI).

At baseline, anthropometry (height, weight and waist and hip circumference) was performed and BMI and BMI-SDS were calculated in GrowthXP (PC Pal, Wissous, France). Height measurements were performed without footwear and weight were obtained with the child wearing only underwear. Body composition was assessed using DXA-scanning (GE Lunar iDXA 2007) and bio-impedance technique (Tanita BC-420MA). Blood pressure was measured and blood samples obtained (i.e. thyroid hormones, liver enzymes, lipids, plasma glucose, urate, and kidney status). Finally, the baseline visit included the generation of an individualized treatment plan for each child.

Participants were invited to our outpatient clinic for one yearly visit, at which anthropometry, assessment of body composition, blood pressure and blood samples were obtained. The duration of the intervention was maximum 3 years which equals to four visits in our outpatient clinic (the initial baseline visit and one visit after 1, 2, and 3 years each). In between these visits, participants visited the community health workers for 6–8 times each year.

In December 2018 all participants were invited to a follow-up visit for renewed height and weight approximately one year after the intervention had ended. Fifty participants accepted our invitation, ten of the participants contacted the clinic by email and reported their height and weight measured at home, and 18 participants visited during same time period the municipalities or our hospital in another errand, whereby data on weight and height were recorded and reported to us.

Statistics

Study data were collected and managed using REDCap electronic data capture tools hosted at Aarhus University [25, 26]. The statistical analyses were performed in Stata 15 (StataCorp, College Station, Texas). Normal distributed data were analysed by ANOVA and non-normal distributed data were analysed by Wilcoxon rank-sum (2 groups) or Kruskal–Wallis (more than 2 groups). Categorical variables were compared using Pearson's chi-squared or Fisher's exact test. A p-value of < 0.05 was considered to be statistically significant. Restricted cubic splines and random intercept regression group on individuals was used to generate the curves for expected BMI.

Results

Baseline characteristics

As outlined in Table 1, approximately 90% of participants had a predisposition to overweight and 38% had engaged in previous weight loss attempts. Forty-two percent and 62% were predisposed to T2D and hypertension, respectively, and 33% lived with at least one parent that suffered of mental illness (Table 1).

Only one child was due to adoption unaware of any predispositions.

At baseline, boys were significantly heavier than girls (BMI-SDS 3.3 ± 0.7 vs. 2.9 ± 0.6, $p < 0.001$, Table 2) with higher lean body mass (DXA muscle mass percentage:

Table 1 Dispositions and social conditions at baseline

Factor	Value
N	199
Parents' relationship	
Cohabiting, shared custody	120 (60.3%)
Not cohabiting, shared custody	48 (24.1%)
Not cohabiting, not shared custody	25 (12.6%)
The child is not living at home with his parents	6 (3.0%)
Disposition—overweight	
One parent	77 (38.7%)
Both parents	103 (51.8%)
No dispositions	18 (9.0%)
Unknown	1 (0.5%)
Disposition—diabetes type 2	
Predisposed	83 (41.7%)
No dispositions	115 (57.8%)
Unknown	1 (0.5%)
Disposition—hypertension	
Predisposed	123 (61.8%)
No dispositions	75 (37.7%)
Unknown	1 (0.5%)
Disposition—mental illness	
One parent	56 (28.1%)
Both parents	11 (5.5%)
No dispositions	130 (65.3%)
Unknown	2 (1.0%)
Previous unsuccessful weight loss attempt	
Yes	77 (38.7%)
No	120 (60.3%)
Unknown	2 (1.0%)

Table 2 Baseline characteristics

	All children	Boys	Girls	*p* values
N	199	107 (53.8%)	92 (46.2%)	
Age, first consultation	10.8 (3.1)	11.1 (3.3)	10.4 (2.8)	0.13
Height, cm	149.9 (17.6)	152.1 (19.3)	147.3 (15.0)	0.054
Weight, kg	63.1 (24.0)	65.9 (25.9)	59.8 (21.4)	0.072
BMI-SDS	3.1 (0.7)	3.3 (0.7)	2.9 (0.6)	< 0.001
TANITA, adipose tissue mass percentage	35.4 (6.2)	33.3 (6.2)	37.7 (5.4)	< 0.001
TANITA, muscle mass percentage	61.4 (6.0)	63.4 (6.0)	59.2 (5.1)	< 0.001
Blood pressure systolic, mmHg	119.7 (13.2)	121.2 (14.6)	117.8 (11.1)	0.079
Blood pressure diastolic, mmHg	66.8 (9.3)	68.0 (9.0)	65.4 (9.5)	0.051
Waist circumference, cm	91.4 (15.3)	93.9 (15.9)	88.6 (14.2)	0.015
Hip circumference, cm	95.9 (15.0)	96.6 (15.2)	95.2 (14.7)	0.50
DEXA-scan, adipose tissue mass percentage	42.4 (4.8)	41.6 (4.8)	43.3 (4.6)	0.018
DEXA-scan, muscle mass percentage	54.8 (4.6)	55.6 (4.6)	54.0 (4.4)	0.012
Total cholesterol, mmol/L	4.3 (0.7)	4.3 (0.7)	4.3 (0.7)	0.90
LDL, mmol/L	2.6 (0.7)	2.6 (0.7)	2.6 (0.7)	0.92
Fasting plasma glucose, mmol/L	5.1 (0.3)	5.2 (0.3)	5.1 (0.3)	0.036
HbA1c, mmol/mol	5.6 (0.4)	5.6 (0.4)	5.6 (0.4)	0.56
Urate, mmol/L	0.29 (0.1)	0.30 (0.1)	0.27 (0.1)	0.033

P values represent differences between boys and girls. All data is reported as mean value with standard deviations (SD)

55.6 ± 4.6 vs. 54.0 ± 4.4, $p = 0.012$; Table 2) and lower fat mass (DXA fat mass percentage: 41.6 ± 4.8 vs. 43.3 ± 4.6, $p = 0.018$; Table 2). A similar gender difference was observed when applying TANITA body-scans (both muscle and fat mass percentage, $p < 0.001$; Table 2). Systolic (121.2 ± 14.6 mmHg vs. 117.8 ± 11.1 mmHg, $p = 0.079$) and diastolic blood pressure (68.2 ± 9.0 mmHg vs. 65.4 ± 9.5 mmHg, $p = 0.051$) were similar in boys and girls (Table 2). Moreover, no gender differences were observed in total and LDL cholesterol, or in HbA_{1c} but boys had higher fasting plasma glucose (5.2 ± 0.4 mmol/L vs. 5.1 ± 0.3 mmol/L, $p = 0.036$) and urate levels (0.30 ± 0.1 mmol/L vs. 0.27 ± 0.1 mmol/L, $p = 0.033$) as compared to girls (Table 2).

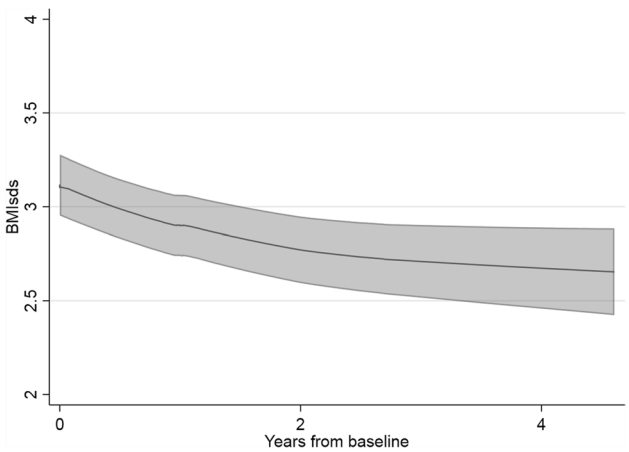

Fig. 1 Development of BMI-SDS for all 199 participants. Data are shown with 95% confident interval

Anthropometry: changes in BMI-SDS during the intervention

For all of the 199 children included in the study, the mean follow-up time was 26.7 ± 17.6 months and during that time BMI-SDS was reduced by 0.25 ± 0.56 SDS ($p < 0.001$, Fig. 1). As outlined in Fig. 2a, both boys and girls reduced BMI-SDS scores during the intervention, with no gender difference ($p = 0.48$; Fig. 2a). However, boys had a continuous decrease in BMI-SDS − 0.28 ± 0.63 SDS, while girls demonstrated a biphasic BMI-SDS response with an initial reduction by − 0.22 ± 0.47 SDS during the first two years followed by a period of gradual weight stabilization (Fig. 2a).

The participants who adhered to the intervention for more than two years as compared to less than two years had a larger reduction in BMI-SDS (BMI-SDS: − 0.38 ± 0.67 vs. − 0.20 ± 0.50, $p = 0.036$; Fig. 2b). Both groups demonstrated an initial and comparable decrease in BMI-SDS scores followed by a continuous decrease in the group with treatment for two years or more as opposed to the group with treatment for less than two years who plateaued after ~ 1.5 years and then gradually increased their BMI-SDS scores (Fig. 2b).

The boys who adhered to the intervention for two years or more had continuous reduction in BMI-SDS during the

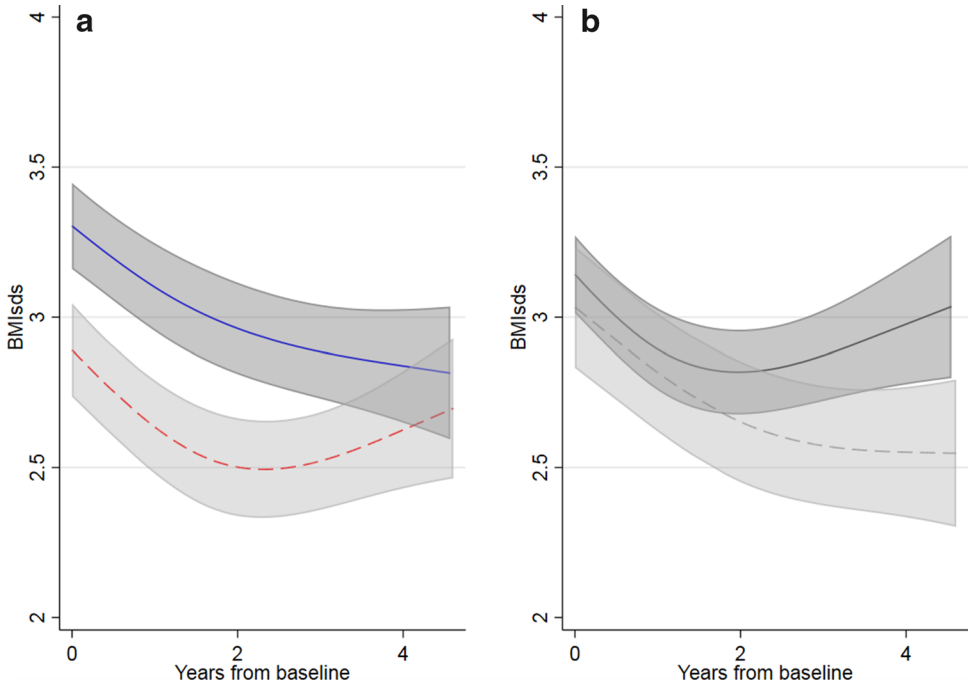

Fig. 2 Development of BMI-SDS over time divided between gender (**a**) and length of intervention (**b**). Data are shown with 95% confident interval. **a** Boys $N = 107$; solid blue line and girls $N = 92$; dotted red line. **b** Length of intervention < 2 years $N = 142$; straight line and ≥ 2 years $N = 57$; dotted line

follow-up, while the boys with intervention less than two years initially developed a smaller reduction in BMI-SDS and then a plateau after less than one year of treatment (Fig. 3a). The girls who received treatment for two years or more, experienced a reduction in BMI-SDS and then a plateau after ~ 1 year. The girls who received treatment for less than two years had a biphasic weight loss response with an initial minor reduction in BMI-SDS and afterwards an increasing BMI-SDS to beyond the starting point (Fig. 3b).

In total, 178 children attended more than one visit at the outpatient clinic and at the community health workers. They had a mean BMI-SDS reduction of -0.28 ± 0.59 SDS ($p < 0.001$) with a mean follow-up on 29.8 ± 15.8 months (data not shown). For the boys and girls who attended more than one visit we observed a reduction in BMI-SDS by − 0.32 ± 0.67 SDS ($p = 0.008$) for boys and − 0.24 ± 0.49 SDS ($p = 0.027$) for girls, with no gender difference ($p = 0.40$). For these children with more

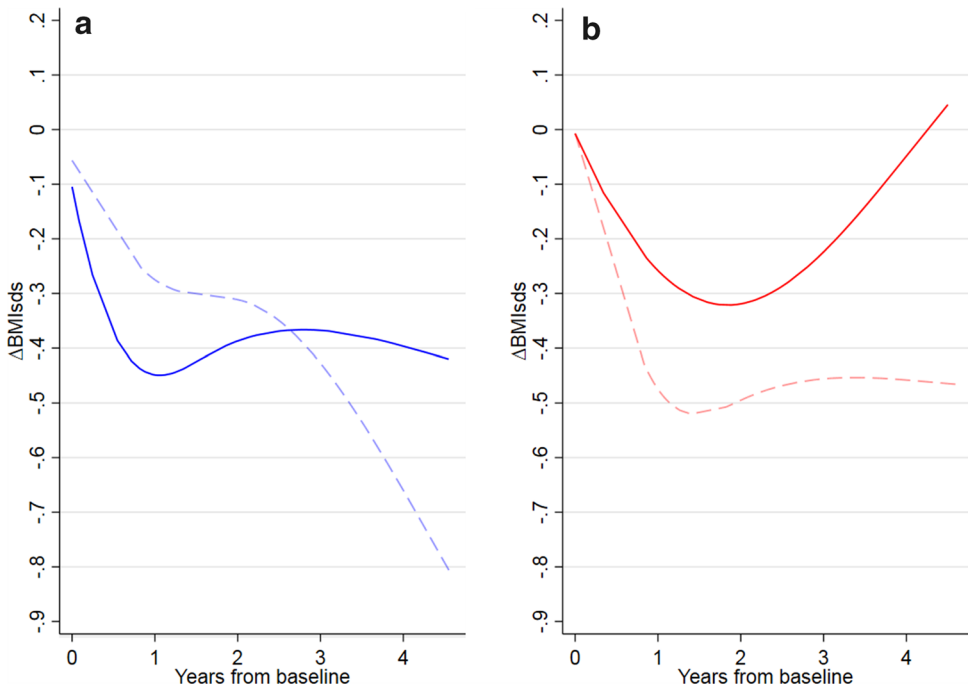

Fig. 3 **a** The relative development of BMI-SDS for the 107 boys divided into length of intervention; < 2 years ($N = 80$; straight line) and ≥ 2 years ($N = 27$; dotted line). **b** The relative development of BMI-SDS for the 92 girls divided into length of intervention; < 2 years ($N = 60$; straight line) and ≥ 2 years ($N = 32$; dotted line)

than one visit to the outpatient clinic, no significant differences in BMI-SDS development were observed between the groups with < 2 years (− 0.23 SDS ± 0.54) and ≥ 2 years (− 0.38 ± 0.67 SDS) intervention period ($p = 0.11$) (data not shown).

The 108 children followed for a minimum of two years (mean follow-up of 40.5 ± 9.5 months), displayed a reduction in BMI-SDS of − 0.33 ± 0.67 SDS ($p = 0.005$). There were no statistical differences in BMI-SDS between boys (− 0.38 ± 0.82 SDS) and girls (− 0.30 ± 0.52 SDS) ($p = 0.53$) and between children who received intervention < 2 years (− 0.25 ± 0.68 SDS) and intervention ≥ 2 years (− 0.41 ± 0.65 SDS) ($p = 0.22$) (data not shown).

Changes in body composition during the intervention

As outlined in Table 3, body composition as assessed by DXA scan and the TANITA scale displayed significant reductions in fat mass percentage and increases in muscle mass percentage from baseline to all other visits ($p < 0.001$ for all; Table 3). The changes were in parallel to the reduction in BMI-SDS during the intervention (Table 3).

Changes in biochemical markers

Blood samples from baseline to the last visit showed a significant reduction in free T3 ($p < 0.001$). In addition, small but significant elevations in creatinine ($p = 0.026$), bilirubin ($p = 0.013$), and HbA1c ($p = 0.015$) were observed. However, none of these changes were considered to be of clinical importance.

No other significant changes were observed in the remaining blood samples including lipid, glycemic parameters, and urate (Table 3).

Discussion

The aim of the present study was to investigate the long-term results of a non-invasive non-pharmacological family-centered lifestyle intervention on weight loss and weight loss maintenance in 199 children. We present for the first time 3-year data from this method on BMI-SDS in boys and girls and document that this type of intervention can induce a significant reduction in BMI in children and adolescents with obesity. In addition this study describes BMI-SDS development after the intervention ended, due to renewed examination of the participants in December 2018. The children who were adherent to the intervention for more than two years had the largest reduction in

Table 3 Changes in body composition, BMI-SDS and blood samples at the yearly visit at the outpatient clinic

	Baseline	1. year	2. year	3. year
N	199	113	56	18
Age, years, mean (SD)	10.8 (3.1)	11.3 (2.9)	11.9 (2.8)	13.4 (2.8)
Male	107 (53.8%)	53	26	11
Female	92 (46.2%)	60	30	7
BMI sds, mean (SD)	3.1 (0.7)	2.7 (0.9)	2.7 (1.1)	2.4 (1.3)
DEXA-scan, fat percentage, mean (SD)	42.4 (4.8)	39.8 (6.3)	39.6 (7.6)	36.0 (9.0)
DEXA-scan, muscle percentage, mean (SD)	54.8 (4.6)	57.2 (6.0)	57.5 (7.2)	60.7 (8.5)
TANITA, fat percentage, mean (SD)	35.4 (6.2)	33.4 (7.1)	33.9 (8.3)	28.0 (9.0)
TANITA, muscle percentage, mean (SD)	61.4 (6.0)	63.2 (6.9)	62.5 (8.2)	69.1 (8.4)
Total cholesterol, mmol/L, mean (SD)	4.3 (0.7)	4.2 (0.7)	4.3 (0.8)	4.2 (0.8)
HDL, mmol/L, mean (SD)	1.3 (0.3)	1.4 (0.3)	1.4 (0.3)	1.4 (0.4)
LDL, mmol/L, mean (SD)	2.6 (0.7)	2.5 (0.7)	2.5 (0.7)	2.4 (0.6)
Triglycerides, mmol/L, mean (SD)	1.0 (0.6)	1.0 (0.7)	1.1 (1.0)	1.0 (0.5)
Bilirubin, umol/L, mean (SD)	7.3 (3.8)	7.5 (3.7)	8.9 (4.4)	10.1 (4.2)
ALAT, IU/L, mean (SD)	24.1 (14.9)	22.6 (15.7)	22.8 (16.6)	30.5 (29.7)
TSH, 10^-3 IU/L, median (IQR)	2.36 (1.9,3.2)	2.4 (1.8,3.2)	2.1 (1.6,2.7)	2.4 (1.7,2.81)
T3, pmol/L, mean (SD)	6.4 (0.8)	6.3 (0.7)	6.0 (0.8)	5.6 (0.8)
Fasting plasma glucose, mmol/L, mean (SD)	5.1 (0.3)	5.1 (0.3)	5.1 (0.5)	5.1 (0.5)
HbA1c, mmol/mol, mean (SD)	5.6 (0.4)	5.5 (0.4)	5.5 (0.4)	5.8 (0.4)
Creatinine, umol/L, mean (SD)	46.5 (11.3)	48.0 (12.9)	49.6 (12.3)	56.1 (14.8)
Carbamide, mmol/L, mean (SD)	4.3 (1.0)	4.5 (1.1)	4.5 (1.0)	4.7 (1.2)
Urate, mmol/L, mean (SD)	0.3 (0.1)	0.3 (0.1)	0.3 (0.1)	0.3 (0.1)

BMI-SDS, with no gender difference. Importantly, the decrease in BMI-SDS was accompanied by a reduction in fat mass and a parallel increase in muscle mass as assessed by both DXA scan and bioimpedance measurements. In relation to the observed beneficial changes in body composition there was a good correspondence between our results obtained by either DXA or bioimpedance (Table 3). Our results showing a similar ability of these two modalities to accurately assess changes in body composition, are in line with recent studies [27], further suggesting that bioimpedance is a simple and reliable way to accurately assess changes in body composition in children and adolescents. A significant reduction in free T3 was observed, probably induced by increasing age but could also be induced by weight loss.

This study demonstrates a sustainable BMI-SDS reduction after 26.7 months and a time-dependent effect on BMI-SDS, so children who were adherent to the intervention reduced their BMI-SDS the most is. This is to our knowledge, one of the longest follow-up studies on treatment of children and adolescent with overweight and obesity [28]. Our study is in accordance with the few studies with a follow-up for more than 2 years [29] emphasizing the importance of the length of the intervention on the reduction in BMI-SDS and weight loss in children with severely obese.

One of the caveats when comparing the data from the present study with results from other studies is, that in children and adolescents the definition of overweight and obesity varies and is not defined identically and consistently in the literature [12, 24, 30]. In addition, calculation of standard deviation score (SDS) for BMI also differs [12]. Even though this is an important point in relation to direct comparison between studies, the results from the present study are robust and significant.

One of the strengths of the present study is that our data are derived from both a specialized pediatric outpatient clinic and also from an intervention performed in municipalities. Given that the children only visited the pediatric outpatient clinic once a year makes our results transferable to a standard-of care setting and therefore less costly.

One of the obvious weaknesses and limitations is that no control group was included. However, given the set-up of our study and the long inclusion period this was not possible.

This point is related to the second limitation, namely that a large percentage of the children failed to complete the project either because of a late inclusion due to the running inclusion combined with a pre-defined end date for the trial, but also prematurely leaving the project because of the complexity of the treatment and interference with daily life for participants and families. This issue was to some point overcome by inviting the families and children in for a follow-up visit after the intervention was terminated and it was possible to obtain anthropometrics for approximately a third of the children at the renewed visit in the outpatient clinic a year after the project ended.

Although the overall effect on the BMI-SDS is low in absolute terms, even small reductions of BMI-SDS, similar to the findings in our study, have been shown significantly to reduce the cardiovascular risk factors such as blood pressure, lipids, and glycemia. Therefore, it has been claimed that small reductions in BMI-SDS also are worth aiming for [30]. Our data do, however, not support the notion that even small reductions in BMI-SDS impact positively on cardiovascular risk factors and the reason for lack of effect in our study remains obscure.

In conclusion, the TCOCT method efficiently and continuously induces long-term reduction of BMI in children with BMI above 2 SDS. The effect of the weight loss intervention is most effective in children remaining in the program for more than two years, who continue their weight loss although even more extended intervention period remains to be studied. Future studies are also warranted to examine the effect of the TCOCT method in a randomized controlled clinical trial. This study provides important and new insight on long-term adherence to a family-centered lifestyle intervention in children with obesity but also call on future research on why participants (children and families) prematurely leave a lifestyle intervention.

What is already known on this subject?

It's already known that the prevalence of childhood obesity is high and continuously increasing, and is highly predictive for both continuous obesity into adulthood, with high risk of development of psychological problems and somatic diseases (i.e. type 2 diabetes and cardiovascular disease). Several weight loss intervention studies describe a promising short term (< 12 months) effect for weight reduction, but studies with long-term follow-up are scarce.

What your study adds?

This study describes one of the longest follow-up after a weight loss intervention. All participants were summoned for a last visit after the project ended. This trial evaluates the effect for children dropping out and children adherent to the intervention.

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Authors contributions JMB, EVT and RMJ conceived the original idea for the study. RMJ and RBF were responsible for data collection. RMJ analyzed data and all authors had access to the data during the process.

RMJ wrote first draft of the manuscript and all authors were involved in revision and final approval of the manuscript.

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Compliance with ethical standards

Conflict of interest None of the authors had any conflict of interest to declare. All authors completed an ICMJE "disclosure of potential conflicts of interest" form.

Ethical approval This project was meant as a treatment option for children with obesity, and for that reason it was not necessary with ethical approval. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Written information was handed out to the families and written consent was obtained for each participant completed by a parent or a legal guardian.

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